ANGIOPLASTY SUMMIT

April 28 – 30 Seoul, Korea

TCTAP2010

TRANSCATHETER CARDIOVASCULAR THERAPIES ASIA PACIFIC

MDCT & MRI: Where We Are

April 29, 2010

CT / MR: Clinical Results and Usefulness for the Interventional Cardiologist

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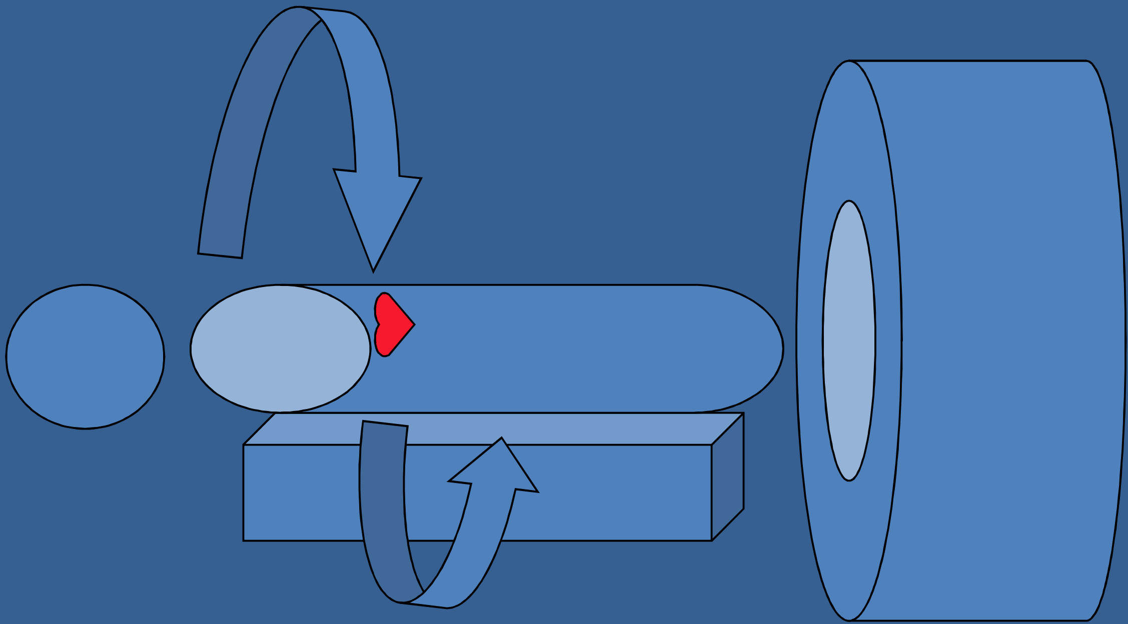
CVCT / CVMR: Clinical Innovation

- Acquisition
- Transmission
- Interpretation / Post – Processing
- Storage and Retrieval

- Diagnosis
- Treatment planning
- Intraprocedural
  - Guidance
  - Monitoring



Advanced visualization techniques

	Display	Principal use	Advantages	Disadvantages
MIP	2D	•Structural overview	•"Slice" through dataset in axial, coronal, sagittal, & oblique proj •Real-time multiplanar interrogation •Depict small caliber structures •Depict lower enhanced structures •Communicate findings	•Anatomical overlap •Visualization degraded by high density (CT)/Intensity (MRI) structures •Loss of structural detail with ↑ slab thickness
VR	3D	•Structural overview	•"Slice" through dataset in axial, coronal, sagittal, & oblique proj •Real-time multiplanar interrogation •Depict structural relationships •Accurate spatial perception •Communicate findings	•Opacity-transfer function dependent •Anatomical overlap •Loss of structural detail with ↑ slab thickness

Advanced visualization techniques

	Display	Principal use	Advantages	Disadvantages
MPR	2D	• Structural details • Quantitative analysis	•“Slice” through dataset in coronal, sagittal, & oblique projections •Real-time multiplanar interrogation •Simplify image interpretation •Single anatomical display	Limited spatial perception
CPR	2D	•Structural details •Centerline display •Simplify MPR	Single anatomical display Longitudinal cross-sectional anatomical display	Operator dependent
Ray sum	2D	•Structural overview	•“Slice” through dataset in axial, coronal, sagittal, & oblique projections •Real-time multiplanar interrogation •Radiograph like display	Loss of structural detail with ↑ slab thickness

CCT: Early Performance

MDCTA DETECTION OF <50% CORONARY ARTERY STENOSIS

Author	Collimation	N	β-Blocker	Diagnostic Segments	Sensitivity	Specificity	Accuracy
Nieman et al. (2001)	4 x 1.0	35	No	73%	81%	97%	95%
Achenbach et al. (2001)	4 x 1.0	64	No	68%	85%	76%	79%
Kopp et al. (2002)*	4 x 1.0	102	No	87%	90–95%	95–96%	94–96%
Vogl et al. (2002)	4 x 1.0	64	No	72%	75%	99%	98%
Nieman et al. (2002	4 x 1.0	78	No	68%	84%	95%	93%
Knez et al. (2001)	4 x 1.0	44	Yes	94%	83%	98%	[illegible]
Becker et al. (2002)	4 x 1.0	28	Yes	95%	81%	90%	89%
Maruyama et al. (2004)	8 x 1.25	25	No	74%	90%	99%	98%
Nieman et al. (2002)	12 x 0.75	59	Yes	100%	95%	86%	90%
Ropers et al. (2002)	12 x 0.75	77	Yes	88%	92%	93%	93%
Mollett et al. (2004)	16 x 0.75	128	Yes	100%	92%	95%	95%
Kuettner et al. (2004)	12 x 0.7.5	60	Yes	79%	72%	97%	NA

MDCTA CORONARY BYPASS GRAFT EVALUATION

Author	Collimation	N	β-Blocker	Diagnostic Segments	Sensitivity	Specificity	Accuracy
Ropers et al. (2001)	4 x 1.0	65	Yes				
• Occlusion				100%	97%	98%	98%
• >50% Stenosis				62%	75%	92%	88%
Nieman et al. (2003)*‡	4 x 1.0	20	No				
• Occlusion				95–100%	100%	97.7–97.5%	98%
• >50% Stenosis				90–95%	60–83%	88–90%	84–89%
Marano et al. (2004)	4 x 2.5	57	Yes				
• Occlusion				100%	93%	98%	
• >50% Stenosis				67%	80%	96%	97% 94%
Willmann et al. (2004)*	4 x 2.5	20	No				
• Occlusion				100%	83%	96–98%	94–95%

Accuracy of 64-MDCT in the Diagnosis of Ischemic Heart Disease

AJR:187, July 2006

Konstantin Nikolaou[1]

TABLE 1: Diagnostic Accuracy of 64-MDCT in Detecting Coronary Artery Stenoses in Assessable Segments Per Segment–Based Analysis: Consensus Reading

Artery	Assessable Segments	Sensitivity Stenoses > 50%	Sensitivity Stenoses > 75%	Sensitivity > 75% Proximal/ Middle Segment	Specificity	Diagnostic Accuracy	Error Rate	Positive Predictive Value	Negative Predictive Value
LM	100 (68/68)	100 (4/4)	100 (3/3)	100 (3/3)	100 (64/64)	100 (64/64)	0 (0/68)	100 (4/4)	100 (64/64)
LAD	91 (311/340)	78 (47/60)	83 (25/30)	88 (15/17)	92 (232/251)	90 (279/311)	10 (32/311)	70 (47/67)	95 (232/244)
RCA	92 (251/272)	87 (26/30)	92 (12/13)	90 (9/10)	96 (212/221)	95 (238/251)	5 (13/251)	74 (26/35)	98 (212/216)
LCX	86 (293/340)	[illegible] (20/24)	80 (8/10)	100 (5/5)	94 (254/269)	[illegible] (274/2[illegible])	6 (19/293)	71 (20/28)	96 (254/265)
All	90 (923/1,020)	82 (97/118)	86 (48/56)	91 (32/35)	95 (762/805)	93 (859/923)	7 (64/923)	72 (97/134)	97 (762/789)

Diagnostic value of multislice computed tomography angiography in coronary artery disease: A meta-analysis

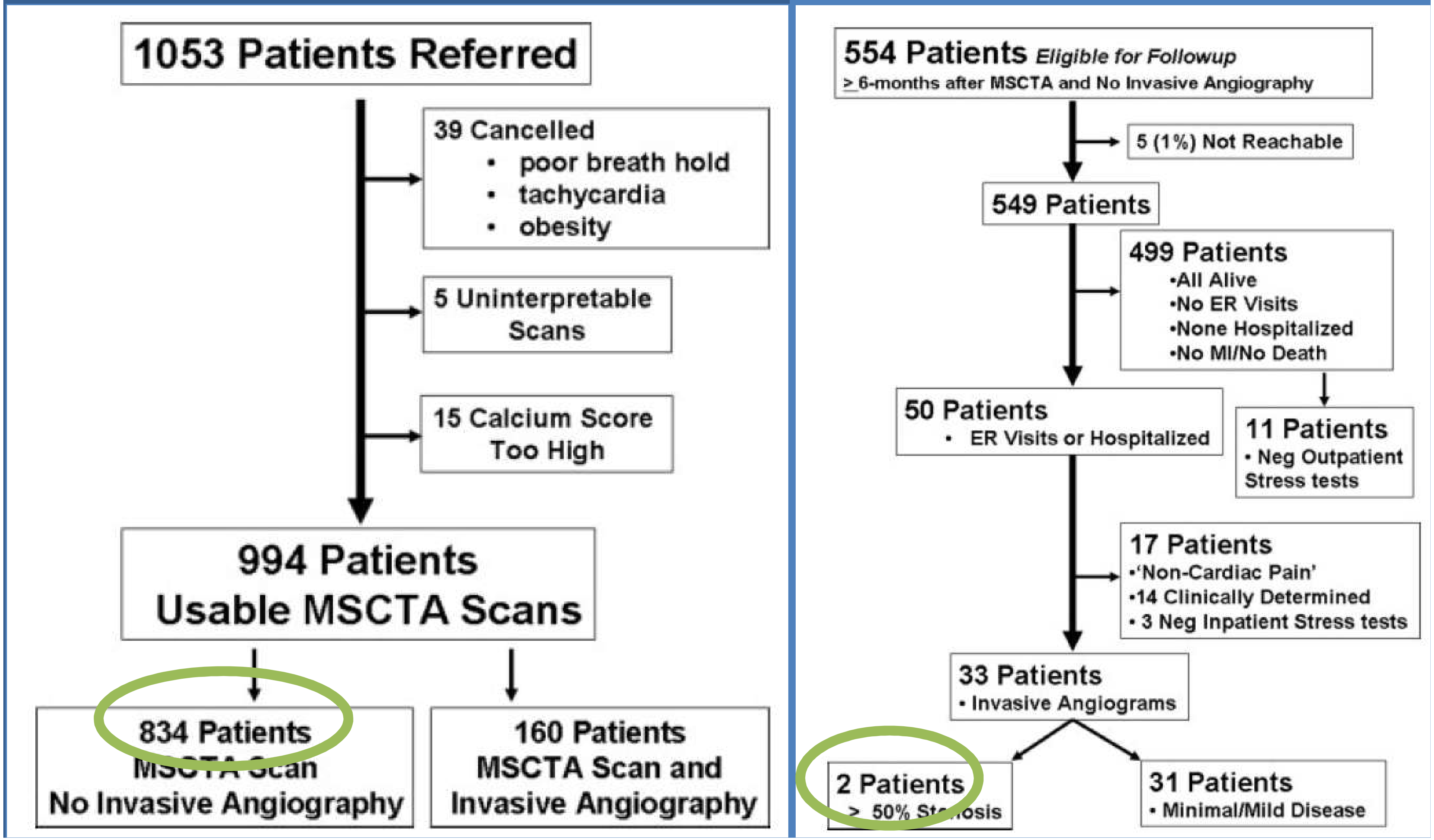
European Journal of Radiology 60 (2006) 279–286
Zhonghua Sun *, Wen Jiang

Summary of diagnostic accuracy of MSCT angiography in comparison to coronary angiography in the diagnosis of CAD

Analysis	Studies	Pooled sensitivity (95% CI)	Pooled specificity (95% CI)
Segment-based	34	83% (79%, 89%)	93% (91%, 96%)
LM	16	98% (94%, 100%)	99% (99%, 100%)
LAD	19	89% (84%, 93%)	92% (88%, 96%)
LCX	19	73% (61%, 84%)	95% (92%, 98%)
RCA	19	89% (83%, 95%)	94% (91%, 98%)
Vessel-based	16	90% (87%, 94%)	87% (80%, 93%)
Patient-based	21	91% (88%, 95%)	86% (81%, 92%)
4-slice CT	20	76% (70%, 82%)	93% (90%, 96%)
16-slice CT	19	82% (74%, 90%)	95% (92%, 98%)
64-slice CT	7	92% (85%, 100%)	94% (91%, 97%)
Proximal RCA	12	84% (74%, 95%)	96% (93%, 99%)
Middle RCA	12	86% (75%, 96%)	94% (89%, 98%)
Distal RCA	12	83% (67%, 98%)	96% (93%, 98%)
RPDA	11	67% (41%, 92%)	90% (70%, 99%)
Proximal LAD	12	87% (79%, 96%)	90% (84%, 97%)
Middle LAD	12	89% (79%, 99%)	90% (84%, 96%)
Distal LAD	12	69% (49%, 89%)	96% (92%, 99%)
Proximal LCX	12	83% (70%, 96%)	94% (90%, 99%)
Distal LCX	10	66% (35%, 96%)	91% (80%, 99%)
LPDA	9	49% (17%, 81%)	86% (61%, 99%)
DIA1	9	75% (53%, 97%)	92% (86%, 98%)
DIA2	6	55% (14%, 96%)	84% (49%, 99%)
OM	8	78% (51%, 99%)	93% (84%, 99%)
PLA	5	NA	77% (24%, 99%)

Clinical Utility of Coronary CT Angiography: Coronary Stenosis Detection and Prognosis in Ambulatory Patients

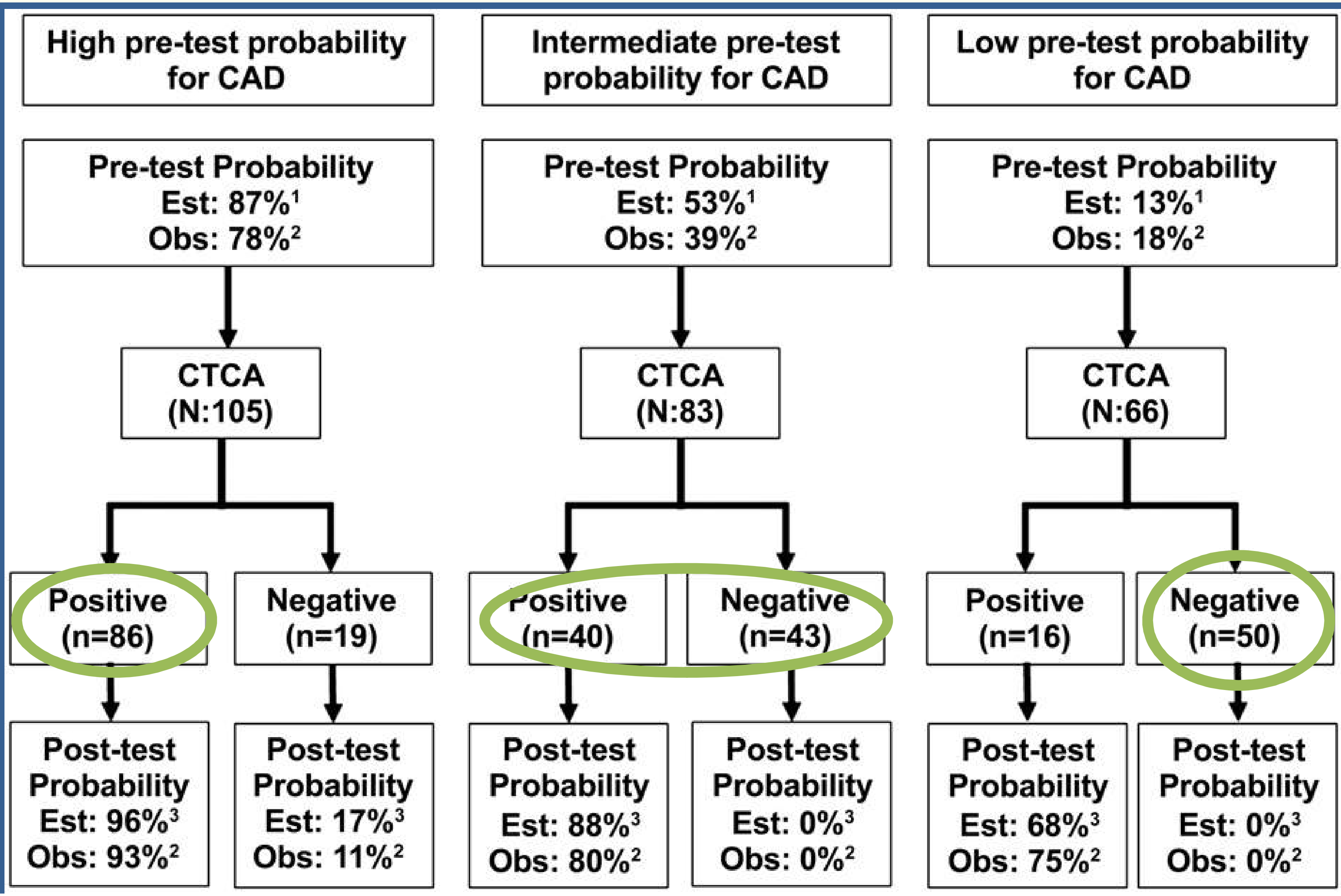
John R. Lesser, Catheterization and Cardiovascular Interventions 69:64–72 (2007)



64-Slice Computed Tomography Coronary Angiography in Patients With High, Intermediate, or Low Pretest Probability of Significant Coronary Artery Disease

W. Bob Meijboom,

JACC Vol. 50, No. 15, 2007



Computed Tomography Coronary Angiography for Rapid Disposition of Low-risk Emergency Department Patients with Chest Pain Syndromes

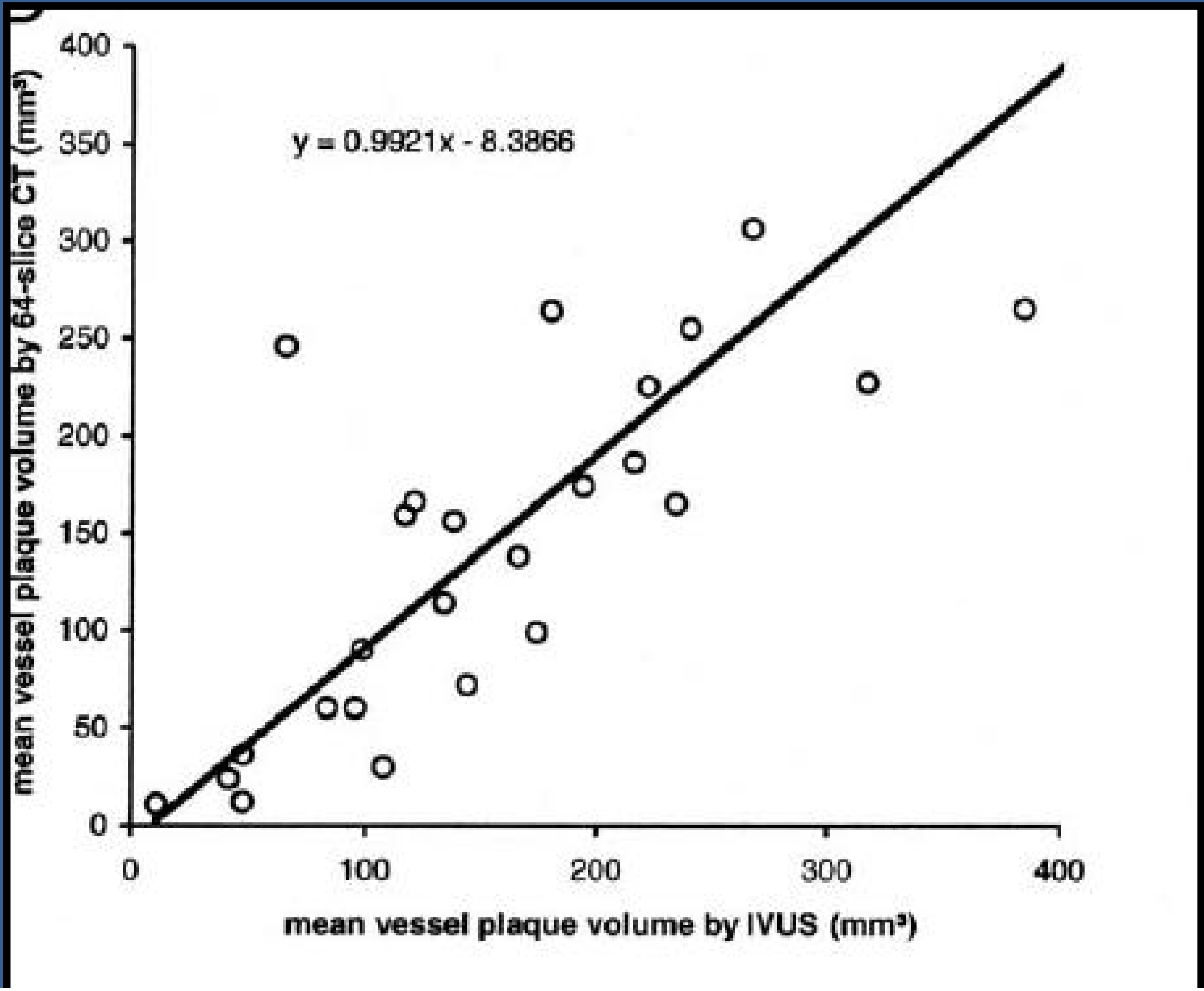
Judd E. Hollander,
ACADEMIC EMERGENCY MEDICINE 2007; 14:112–116 © 2007

N = 54
85% sent home from ER

Patient, Gender	TIMI Risk Score	CT Coronary Angiography	Stress Test	Cardiac Catheterization
53, M	2	50% LAD stenosis 50% RCA stenosis 60% Left circumflex stenosis Calcium score of 3[illegible]3	N/A	N/A
43, M	0	60% RCA stenosis 40% LAD stenosis Calcium score of 0	N/A	N/A
55, F	1	50% LAD stenosis 50% Left circumflex stenosis Calcium score of 0	Negative for ischemia	N/A
40, F	0	50% RCA stenosis Calcium score of 0	Negative for ischemia	N/A
63, F	1	60% LAD stenosis (ostial) Calcium score of 1[illegible]8	Positive for reversible ischemia	60% LAD stenosis (ostial)
43, M	1	80% LAD stenosis 70% Left circumflex stenosis Calcium score of 484	Positive for reversible ischemia	80% LAD stenosis 60% Left circumflex stenosis 80% OM1 stenosis

Accuracy of 64-Slice Computed Tomography to Classify and Quantify Plaque Volumes in the Proximal Coronary System

Journal of the American College of Cardiology Vol. 47, No. 3, 2006



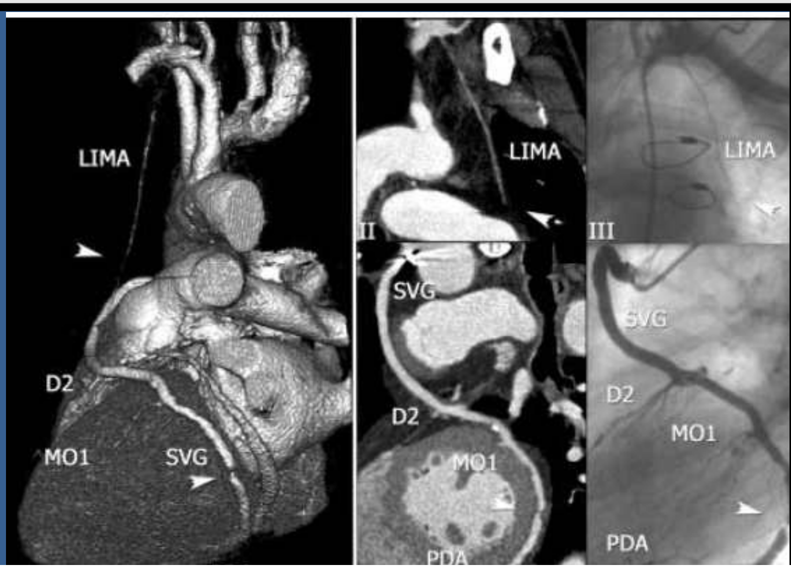
Use of 64-slice CT in symptomatic patients after coronary bypass surgery: evaluation of grafts and coronary arteries

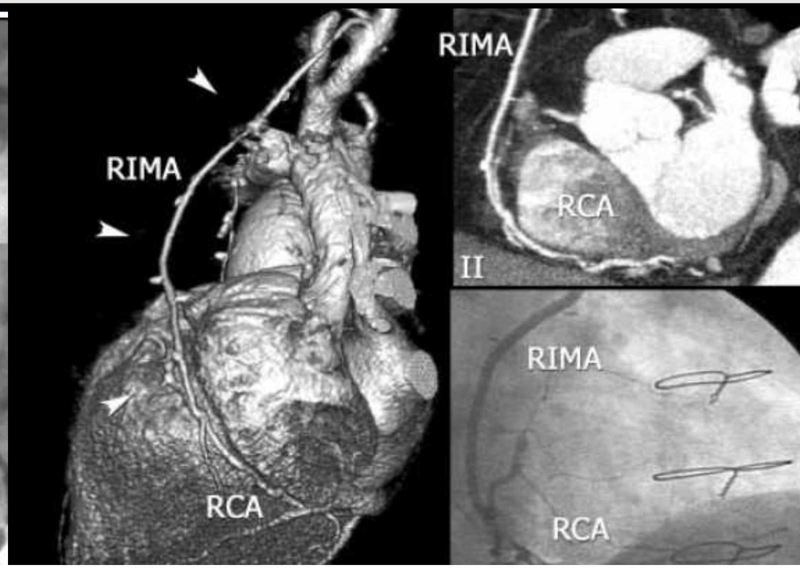
European Heart Journal

Table 2 Detection of significant graft and CAD

		TP	TN	FP	FN	κ	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
All grafts	109	49	59	1	0	0.96	100 (90.9–100)	98.3 (89.9–99.9)	98.0 (88.0–99.9)	100 (92.4–100)
Arterial grafts	45	10	35	0	0	1.0	100 (65.5–100)	100 (87.7–100)	100 (65.5–100)	100 (87.7–100)
Venous grafts	64	39	24	1	0	0.93	100 (88.8–100)	96.0 (77.7–99.8)	97.5 (85.3–99.9)	100 (82.8–100)
All graft segments	182	71	106	4	1	0.95	98.6 (91.5–99.9)	96.4 (90.4–98.8)	94.7 (86.2–98.3)	99.1 (94.2–99.9)
Arterial segments	57	14	43	0	0	1.0	100 (73.2–100)	100 (89.8–100)	100 (73.2–100)	100 (89.8–100)
Venous segments	125	57	63	4	1	0.93	98.3 (89.5–99.9)	94.0 (84.7–98.1)	93.4 (83.3–97.9)	98.4 (90.5–99.9)
Distal run-offs	123	8	106	8	1	0.92	88.8 (50.7–99.4)	93.0 (86.2–96.7)	50.0 (25.5–74.5)	99.0 (94.2–99.9)
Non-grafted native coronary arteries										
Coronary segments	288	62	192	32	2	0.86	96.9 (88.2–99.5)	85.7 (80.3–89.9)	66.0 (55.4–75.2)	99.0 (95.9–99.8)
Coronary vessels	116	42	50	24	0	0.83	100 (89.6–100)	68.4 (55.6–77.7)	63.6 (50.8–74.9)	100 (91.1–100)

True positive (TP); true negative (TN); false positive (FP); false negative (FN); interobserver variability (κ); Between brackets: 95% CI.





Coronary Stent Patency and In-Stent Restenosis: Determination with 64-Section Multidetector CT Coronary Angiography—Initial Experience[1]

N = 39
Sens = 89%
Spec = 95%
PPV = 94%
NPV = 90%

Image Quality Scores with Respect to Stent Size

Stent Diameter (mm)	No. of Stents	Image Quality Score*		
		1	2	3
2.75	5	0	4 (80)	1 (20)
3.0	18	0	6 (33)	12 (77)
3.5	16	0	0	16 (100)

CURRENT CONCEPTS

Computed Tomography — An Increasing Source of Radiation Exposure

David J. Brenner, Ph.D., D.Sc., and Eric J. Hall, D.Phil., D.Sc.

N Engl J Med 2007;357:2277-84.

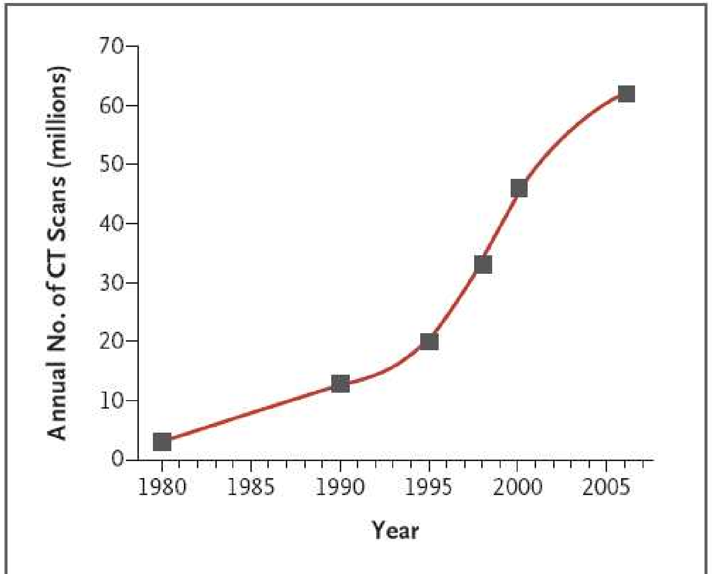
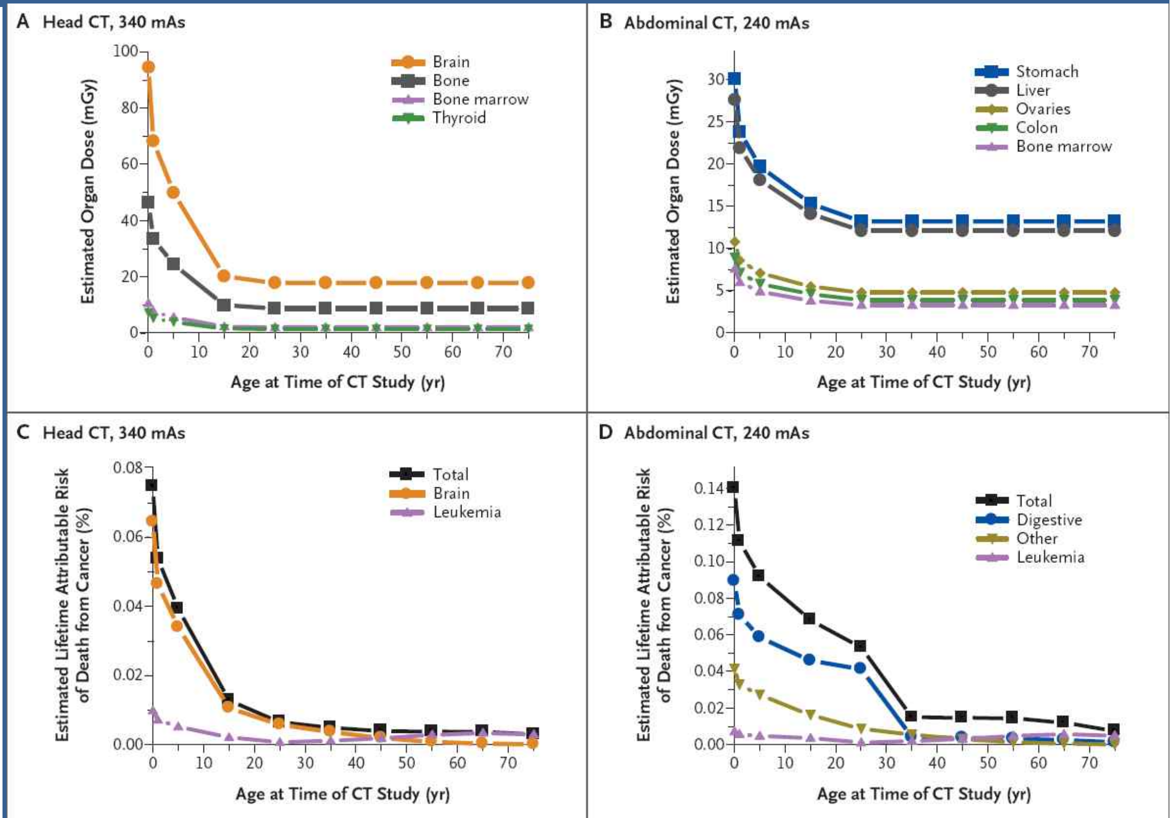


Figure 2. Estimated Number of CT Scans Performed Annually in the United States.

The most recent estimate of 62 million CT scans in 2006 is from an IMV CT Market Summary Report.[3]

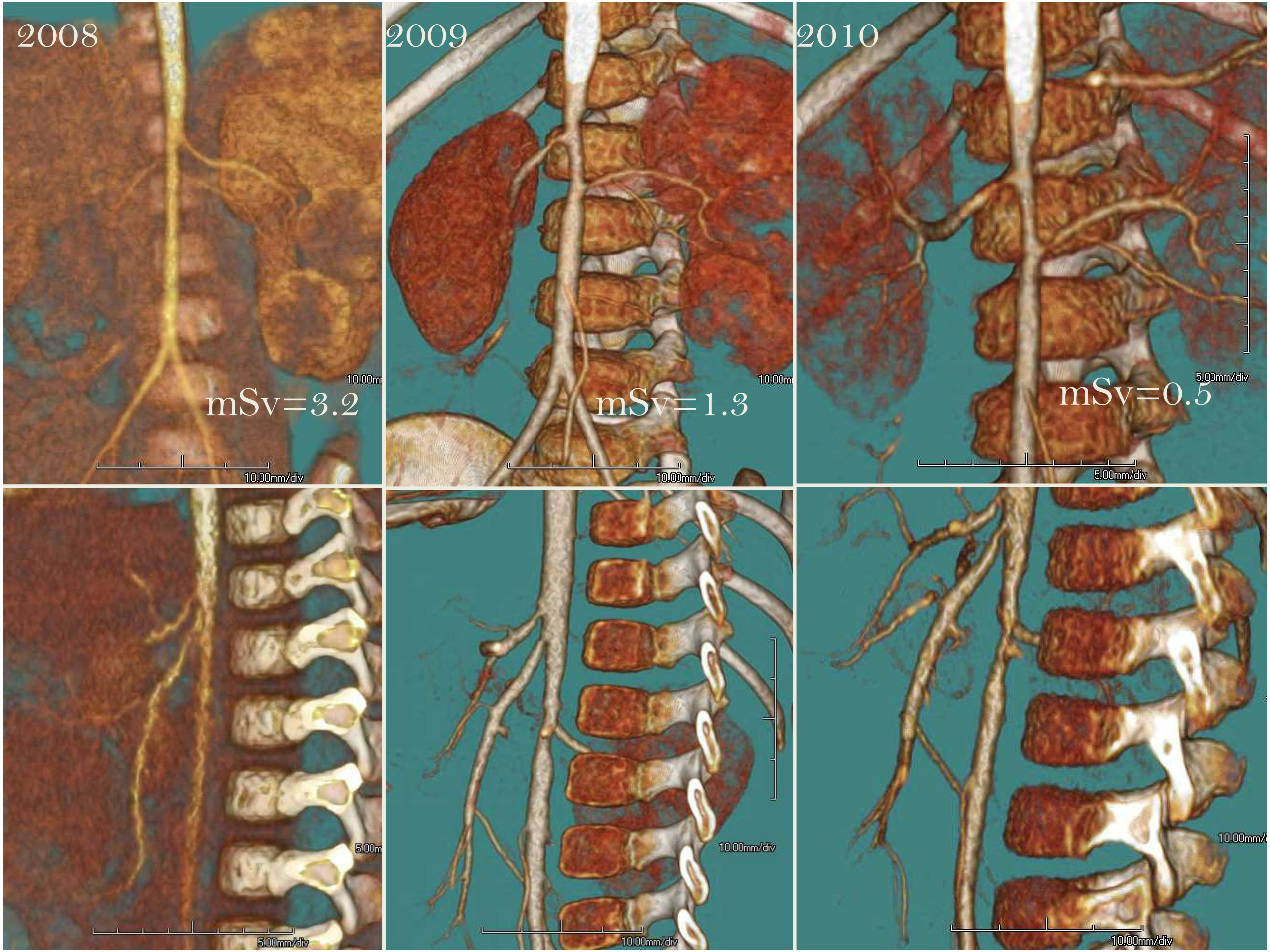


Low kVp imaging for dose reduction in dual-source cardiac CT

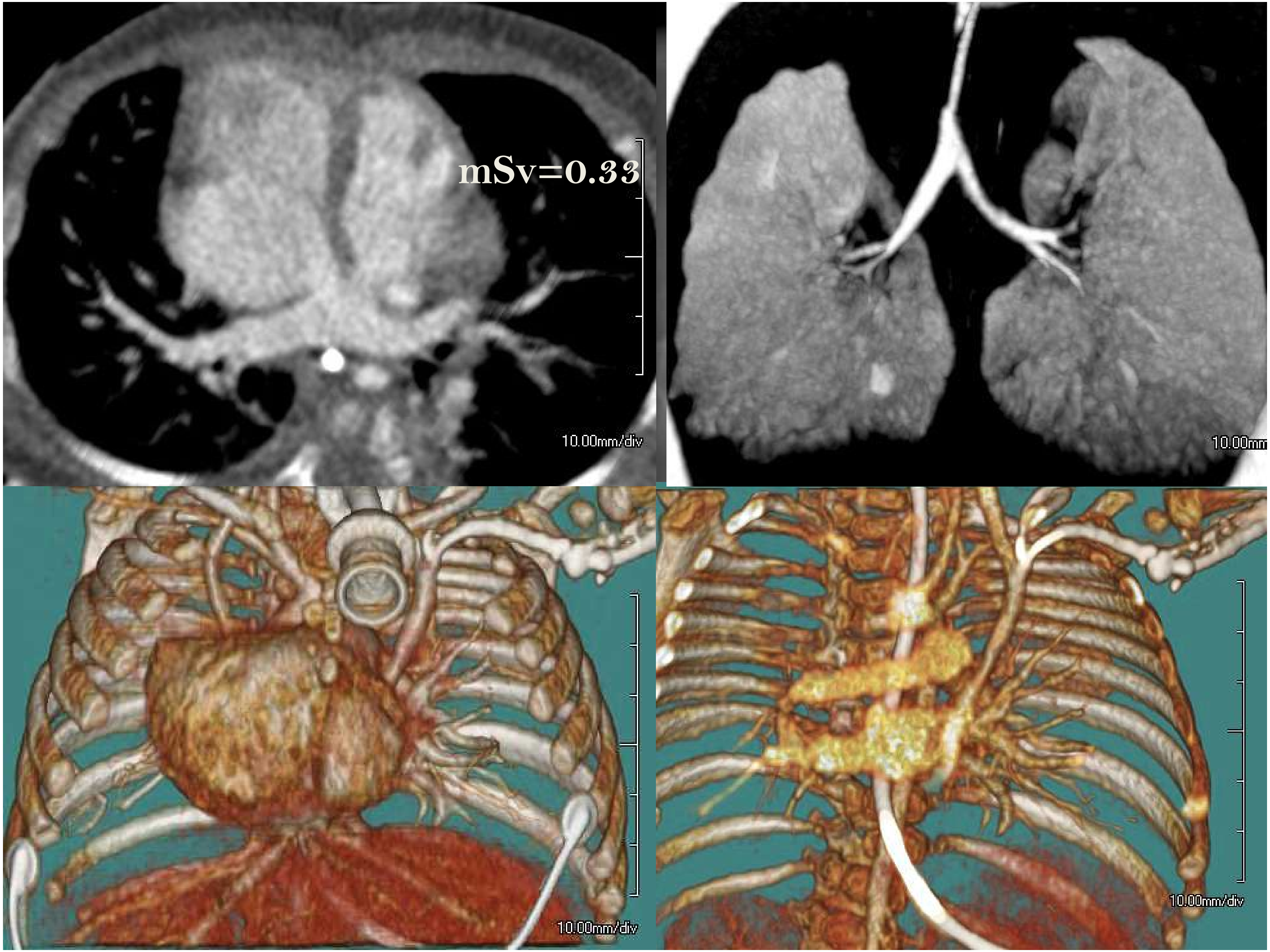
María Luaces Int J Cardiovasc Imaging March 2009

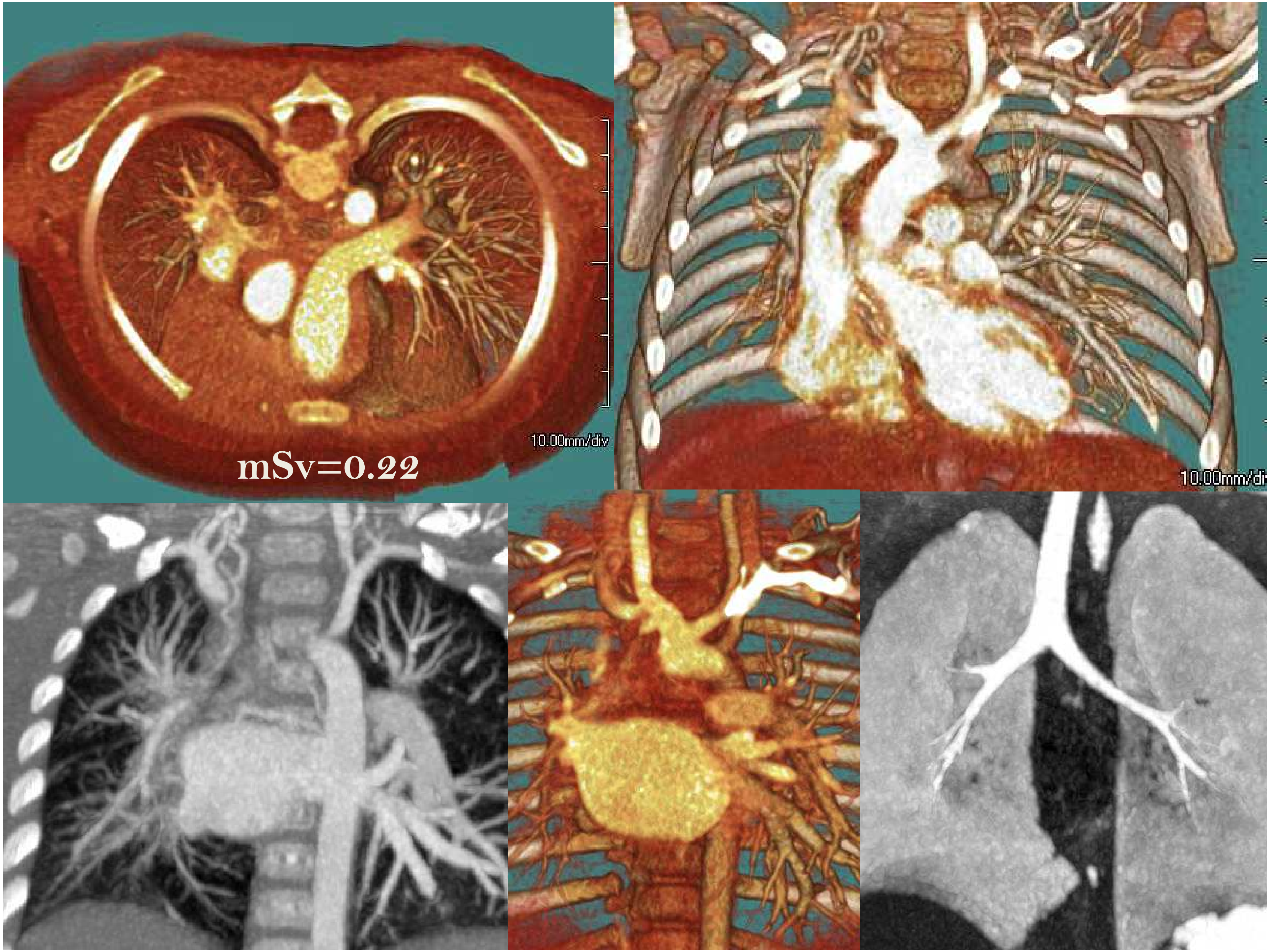
Table 1 Radiation dose and image quality parameters at 100 vs. 120 kVp in a group of 273 patients undergoing coronary CT

	100 kVp (n = 63)	120 kVp (n = 210)	P	100 vs. 120 kVp
ROI size (cm)	37.4 ± 3.35	40.3 ± 4.49	<0.001	Smaller patients
$CTDI_{vol}$	32.6 ± 6.85	68.9 ± 23.3	<0.001	52.6% ↓ in dose
mAs	245 ± 41.4	330 ± 48.7	<0.001	Effect of size based tube current modulation
SNR	9.88 ± 3.21	8.65 ± 3.31	0.01	12.5% ↑ in SNR
CNR	7.11 ± 2.67	5.93 ± 2.57	0.002	16.6% ↑ in CNR
E_{topo} (cm)	38.1 ± 3.57	41.6 ± 4.96	<0.001	



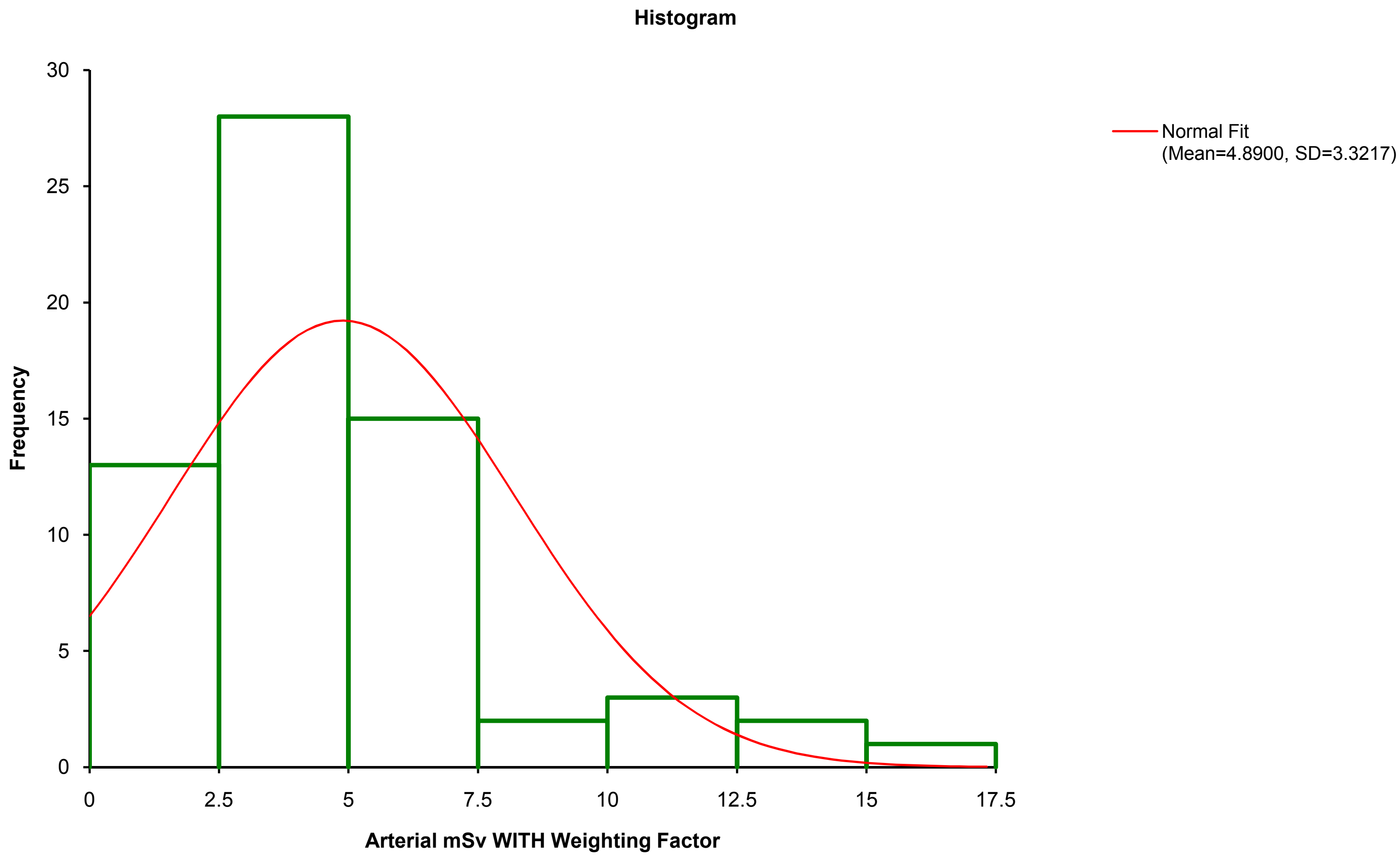
2008
2009
2010
mSv=3.2
mSv=1.3
mSv=0.5
10.00mm/div
10.00mm/div
5.00mm/div
5.00mm/div
10.00mm/div
10.00mm/div

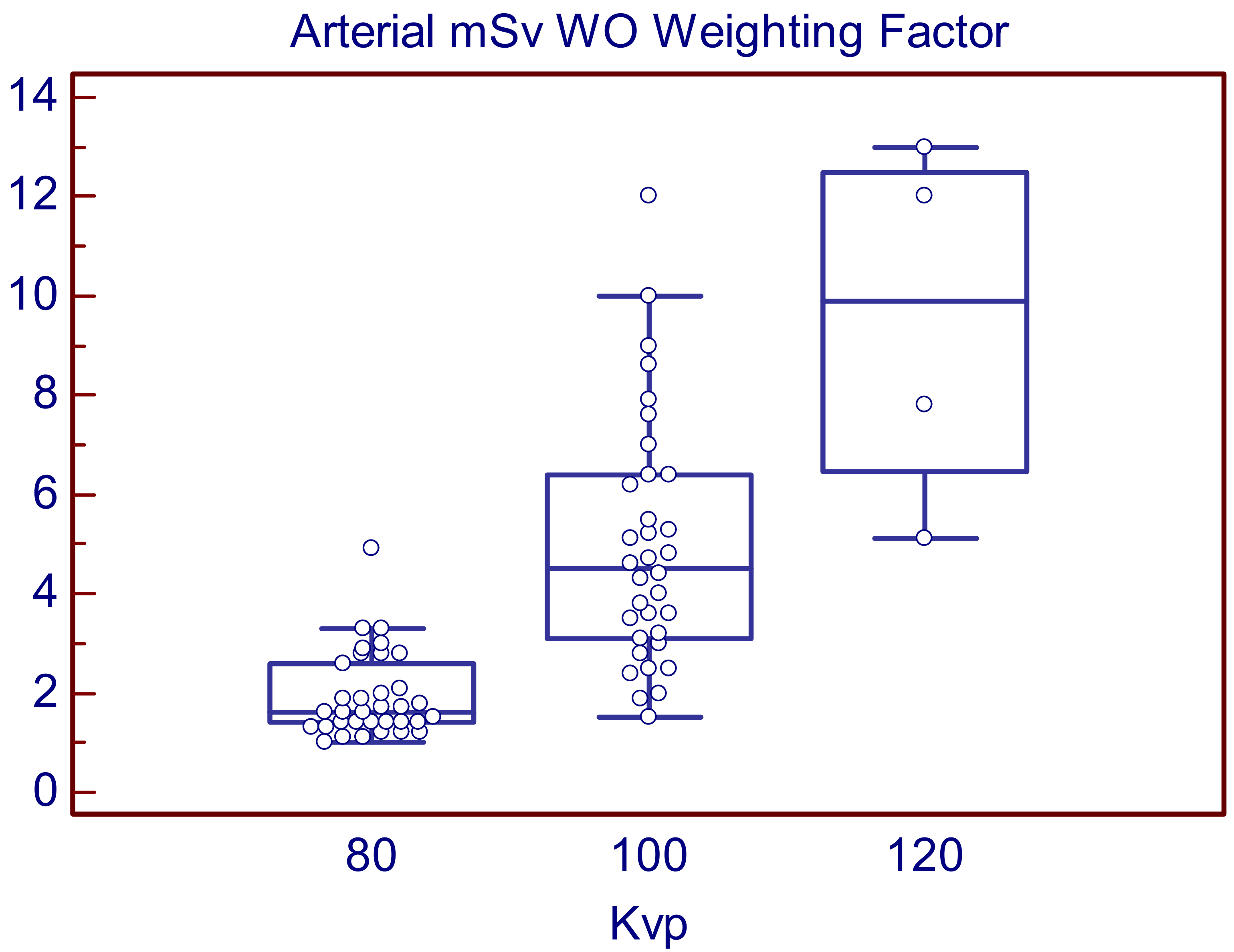

mSv=0.33
10.00mm/div
10.00mm
10.00mm/div
10.00mm/div


10.00mm/div
mSv=0.22
10.00mm/di

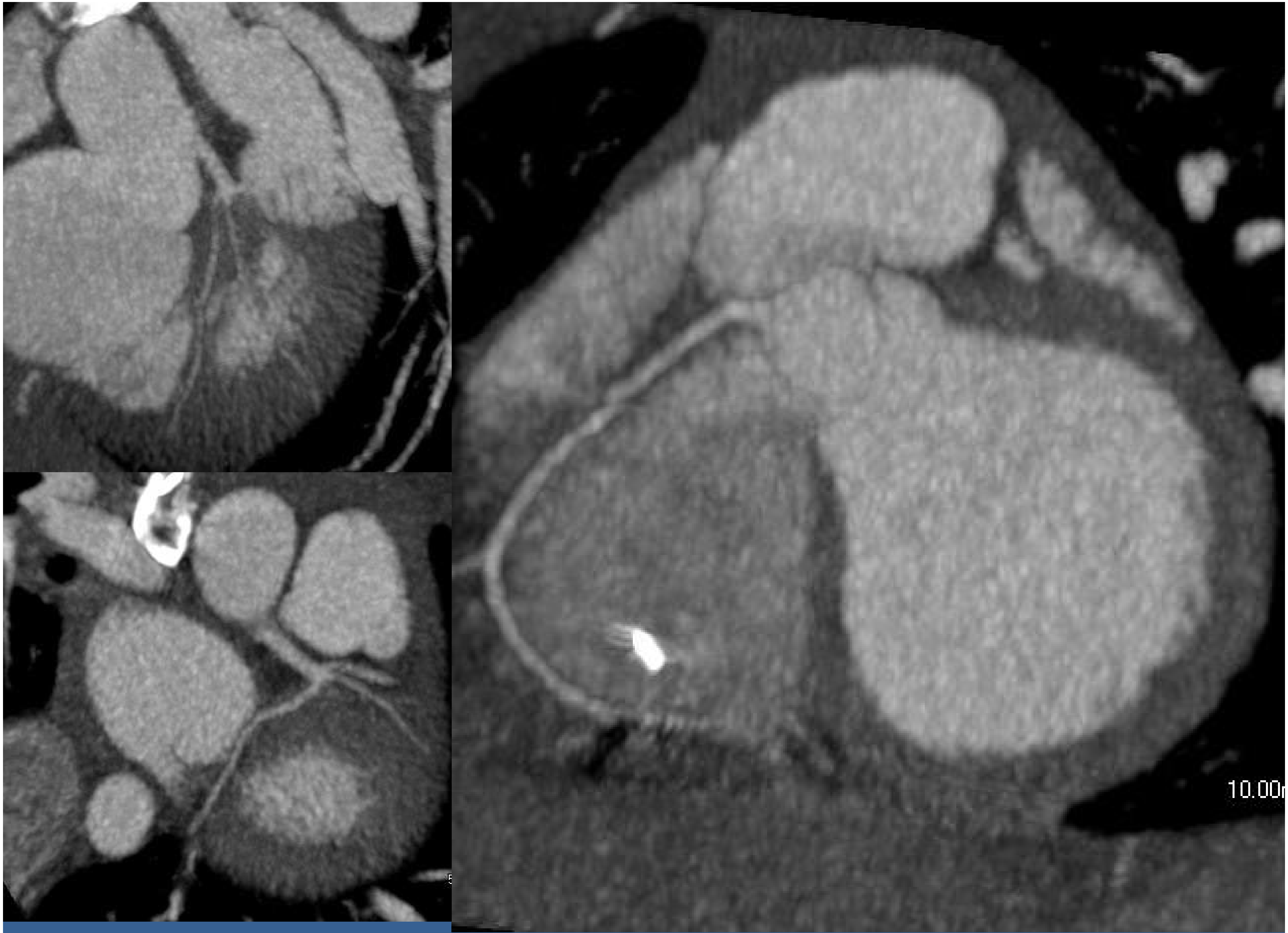
Pediatric CCT at 80KV

mSv: with age weighting Factor (4.9)

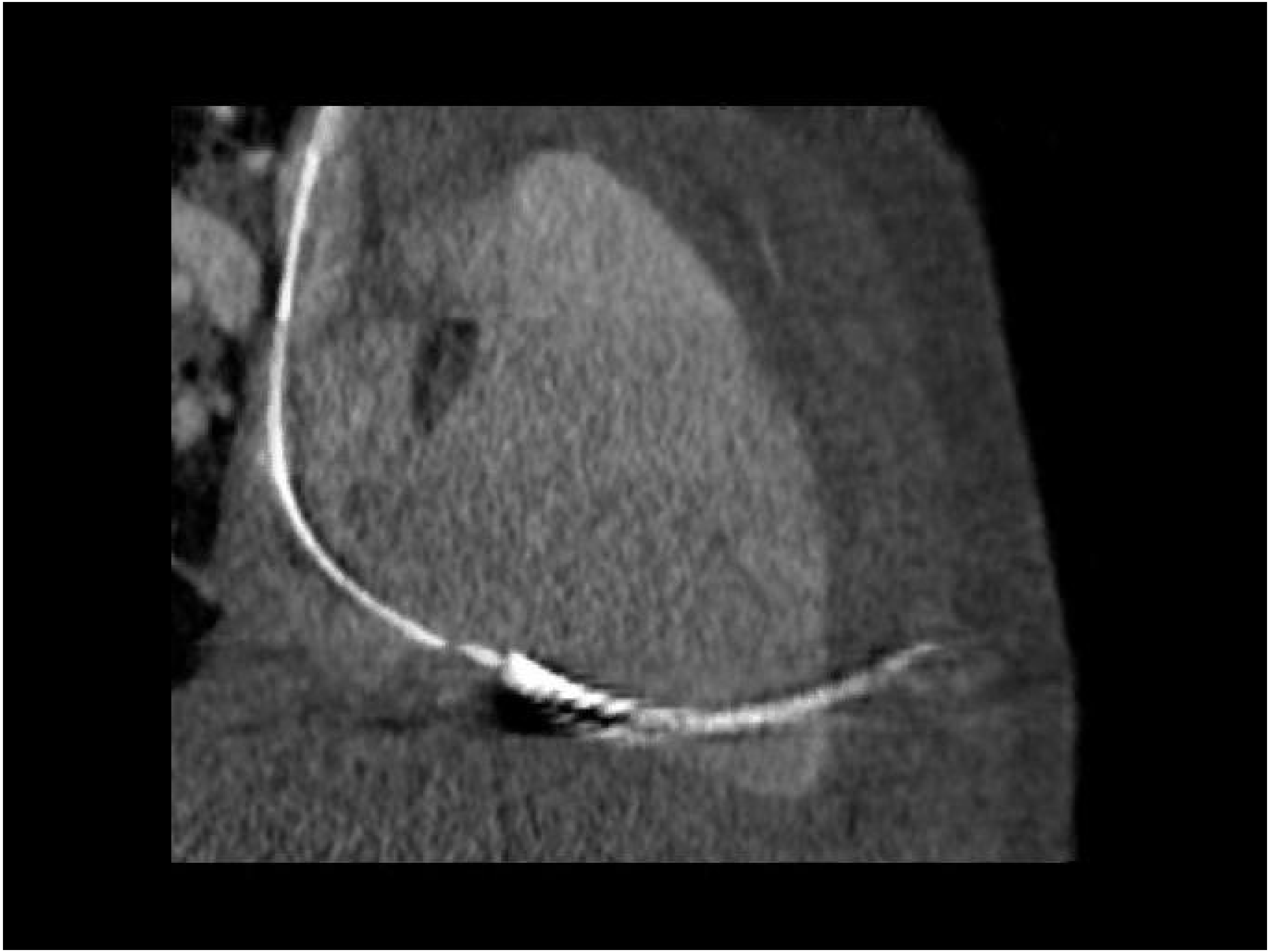


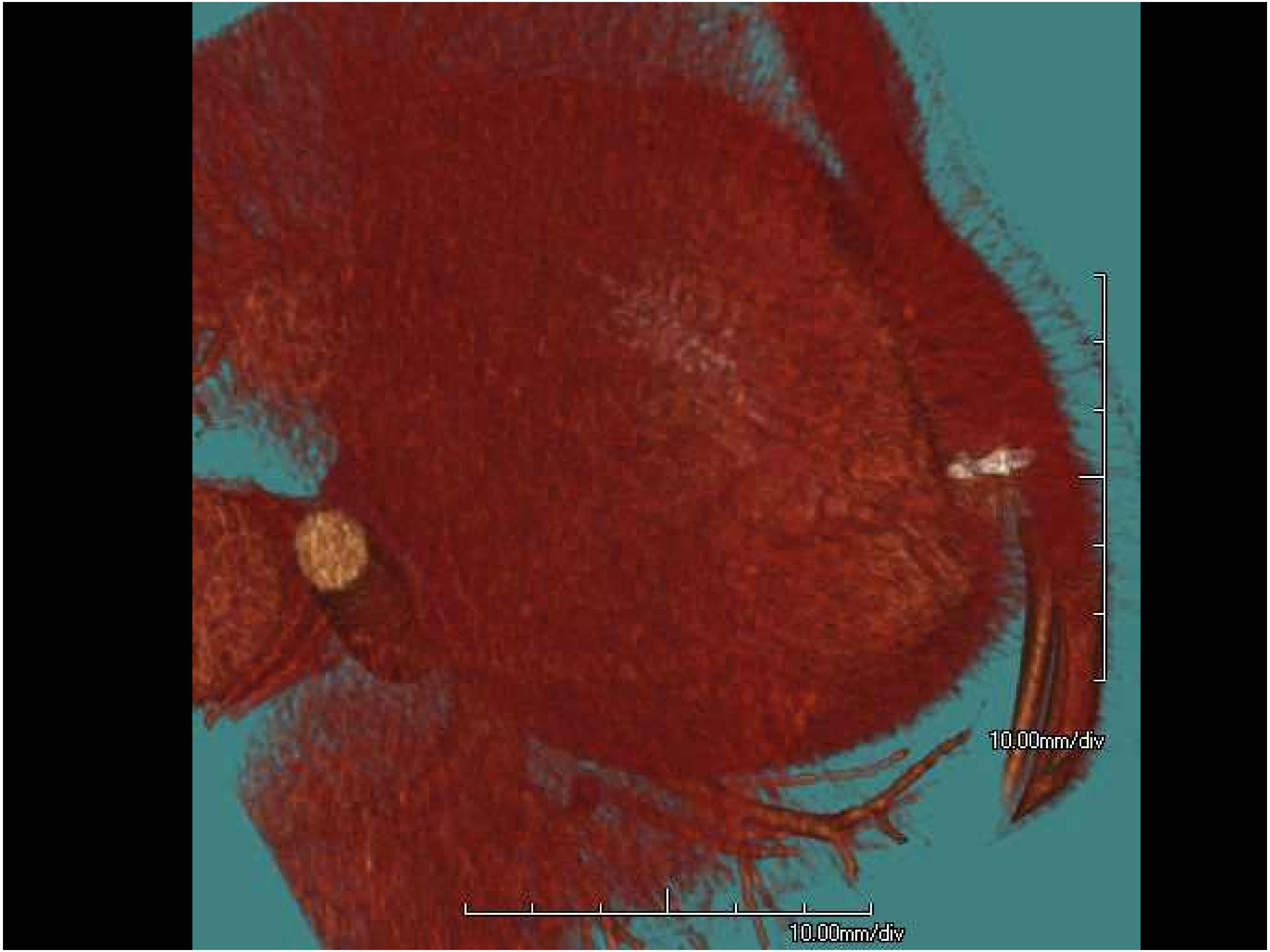


60% reduction




10.00



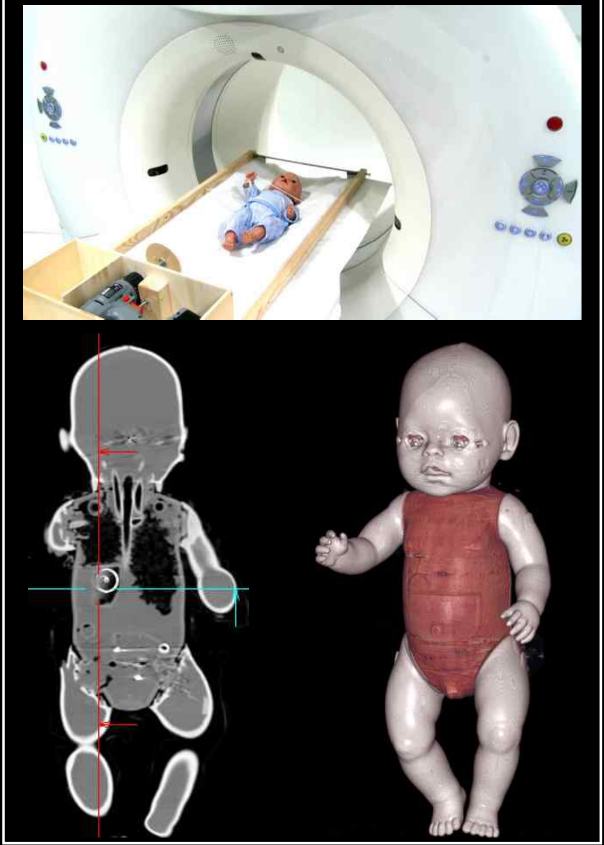

10.00mm/div
10.00mm/div

MDCT Scanner	Mode	Detector Configuration (Channels × mm)	Pitch	Gantry Rotation Time (s)	Table Speed (mm/s)	Scan Time (s)	Slice Thickness (mm)	RI (mm)	Number of Images
20-Channel									
Siemens	IR	20 × 0.6	1.2	0.5	29	31	0.75	0.5	1800
Siemens	HR	16 × 1.2	1.5	0.33	87	10	1.5	0.8	1125
32-Channel									
GE	IR	32 × 0.625	0.984	0.7	28	32	0.625	0.5	1800
Toshiba	IR	32 × 0.5	0.844	0.5	27	33	0..5	0.4	2250
GE	HR	32 × 1.25	1.375	0.35	157	6	1.25	0.8	1125
Toshiba	HR	32 × 1.0	1.5	0.4	120	7.5	1.0	0.8	1125
40-Channel									
Philips	IR	40 × 0.625	0.6	0.5	30	30	0.75	0.5	1800
Siemens	IR	(2) 20 × 0.6	1.2	0.5	29	31	0.75	0.5	1800
Philips	HR	32 × 1.25	1.5	0.4	150	6	1.5	0.8	1125
Siemens	HR	(2) 16 × 1.2	1.5	0.33	87	10	1.5	0.8	1125
64-Channel									
GE	IR	64 × 0.625	0.516	0.7	30	30	0.625	0.5	1800
Philips	IR	64 × 0.625	0.5	0.75	27	34	0.75	0.5	1800
Siemens	IR	(2) 32 × 0.6	0.7	0.5	27	33.5	0.75	0.5	1800
	IR[a]	(2) 32 × 0.6	0.7	0.5	27	33.5	0.75	0.5	1800
Toshiba	IR	64 × 0.5	0.5	0.6	27	33	0..5	0.4	2250
GE	HR	32 × 1.25	1.375	0.35	157	6	1.25	0.8	1125
Philips	HR	32 × 1.25	1.5	0.4	150	6	1.5	0.8	1125
Siemens	HR	(2) 24 × 1.2	1.5	0.33	131	7	1.5	0.8	1125
	HR[a]	(2) 24 × 1.2	3	0.33	262	3.5	1.5	0.8	1125
Toshiba	HR	32 × 1.0	1.5	0.4	120	7.5	1.0	0.8	1125

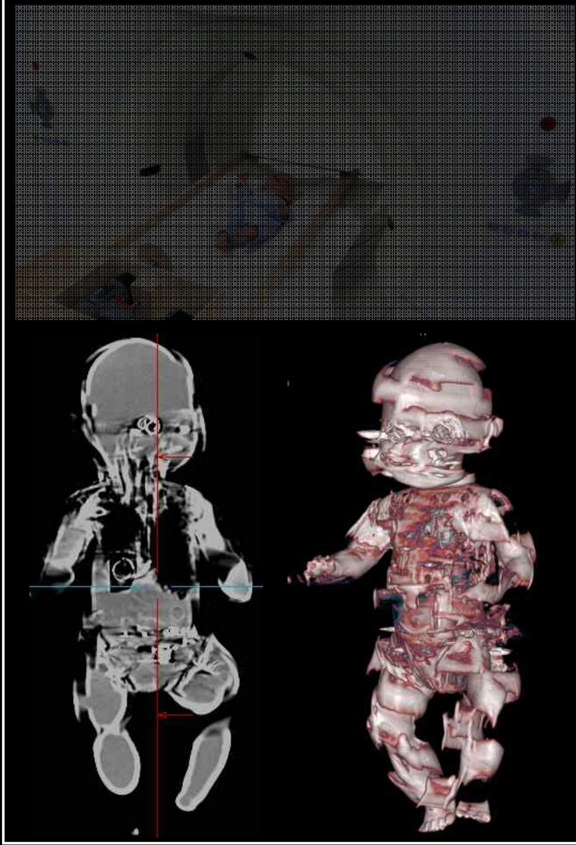
MDCT Scanner	Mode	Detector Configuration (Channels × mm)	Pitch	Gantry Rotation Time (s)	Table Speed (mm/s)	Scan Time (s)	Slice Thickness (mm)	RI (mm)	Number of Images
128-Channel									
Siemens	IR	(2) 64 × 0.6	0.4	0.5	30.7	29	0.75	0.5	1800
	IR[a]	(2) 64 × 0.6	0.4	0.5	30.7	29	0.75	0.5	1800
Siemens	HR	(2) 32 × 1.2	1.5	0.33	174.5	5	1.5	0.8	1125
	HR[a]	(2) 32 × 1.2	3.5	0.33	407	2.2	1.5	0.8	1125
160-Channel									
Toshiba	IR[b,c]	160 × 0.5	0.5	0.75	53	17	0.5	0.4	2250
Toshiba	HR[b,c]	80 × 1.0	1.5	0.4	300	3	1.0	0.8	1125
256-Channel									
Philips	IR	(2) 64 × 0.625	0.5	0.75	27	34	0.625	0.5	1800
	IR	(2) 128 × 0.625	0.5	0.75	53	17	0.625	0.5	1800
Philips	HR	(2) 64 × 1.25	1.5	0.27	444	2	1.25	0.8	1125
320-Channel									
Toshiba	IR[b,c]	160 × 0.5	0.5	0.75	53	17	0.5	0.4	2250
Toshiba	HR[b,c]	80 × 1.0	1.5	0.4	300	3	1.0	0.8	1125

Flash Spiral Scanning
Pediatric motion simulation

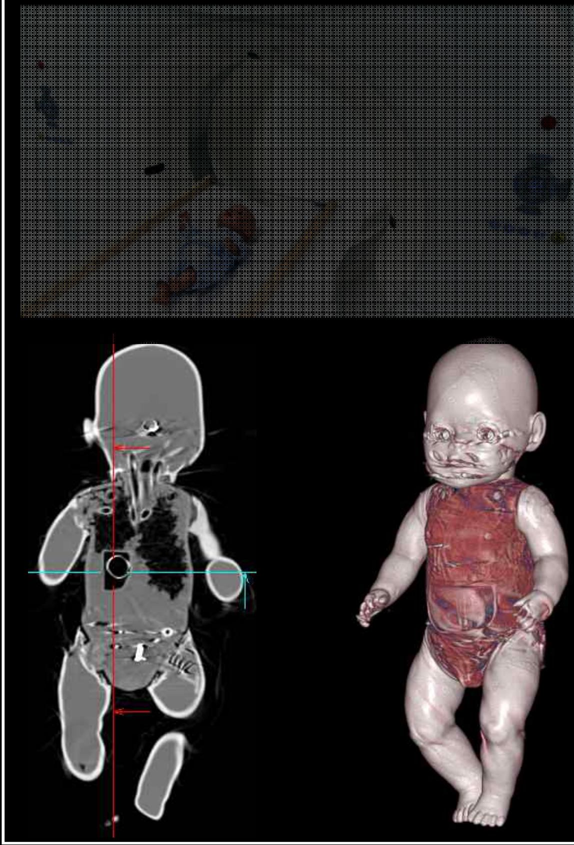
Standard Spiral
sedated



Standard Spiral
not sedated



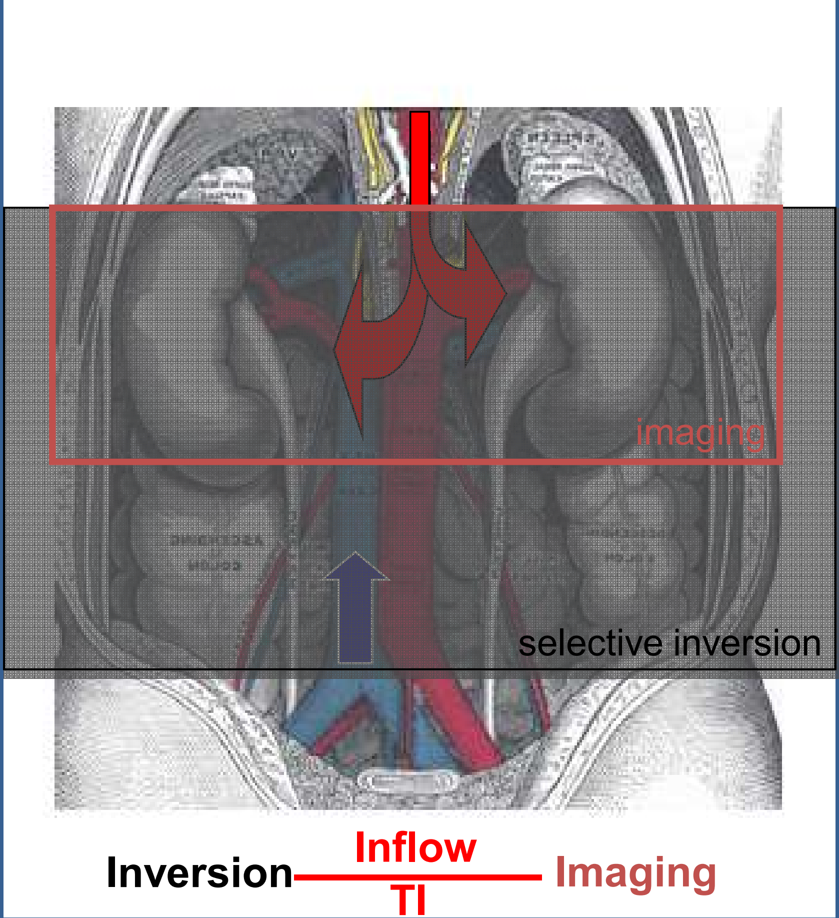
Flash Spiral
not sedated

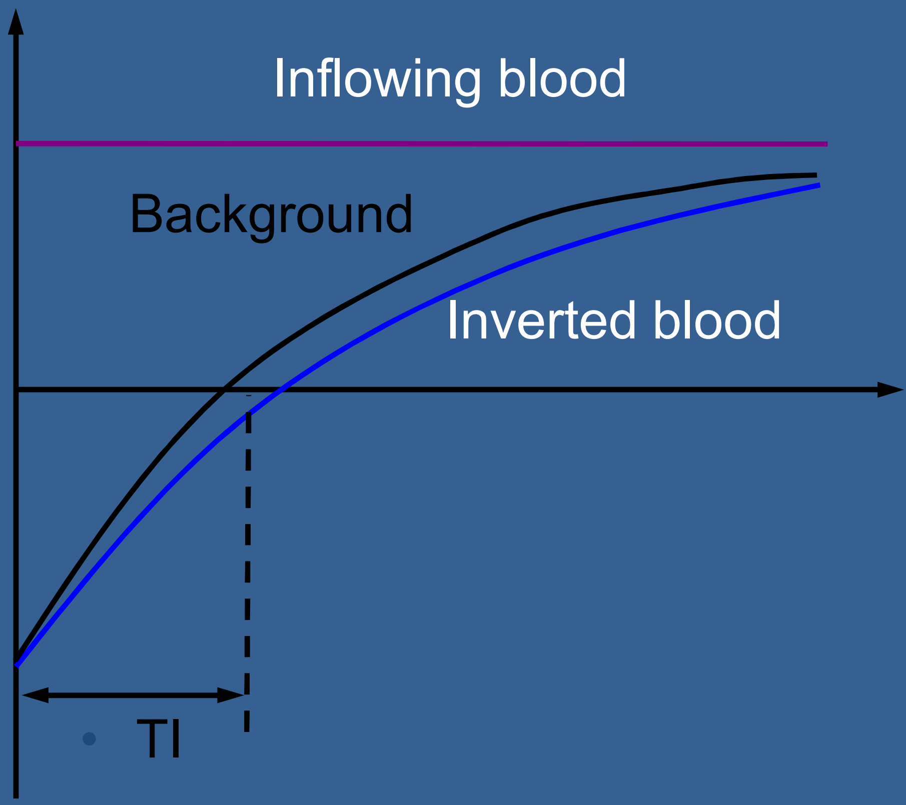


CVMR: Current Directions

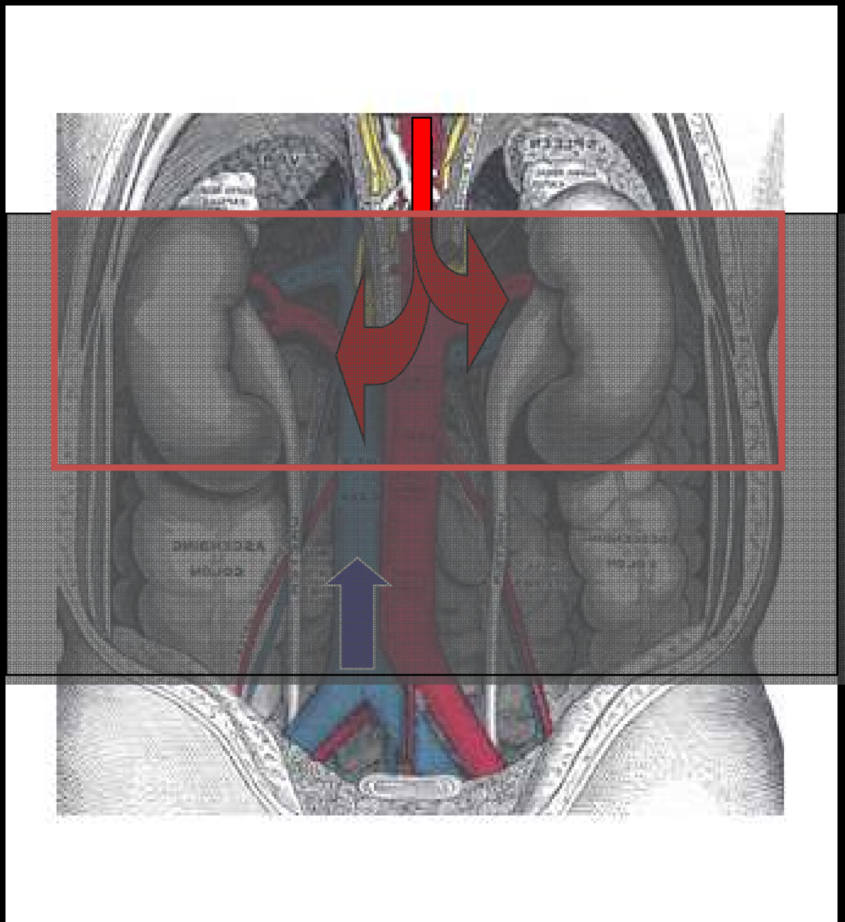
- Improving plaque characterization
- Increasing spatial resolution
- Simplifying workflow: improving efficiency
- Improving patient comfort

MRA NATIVE TrueFISP

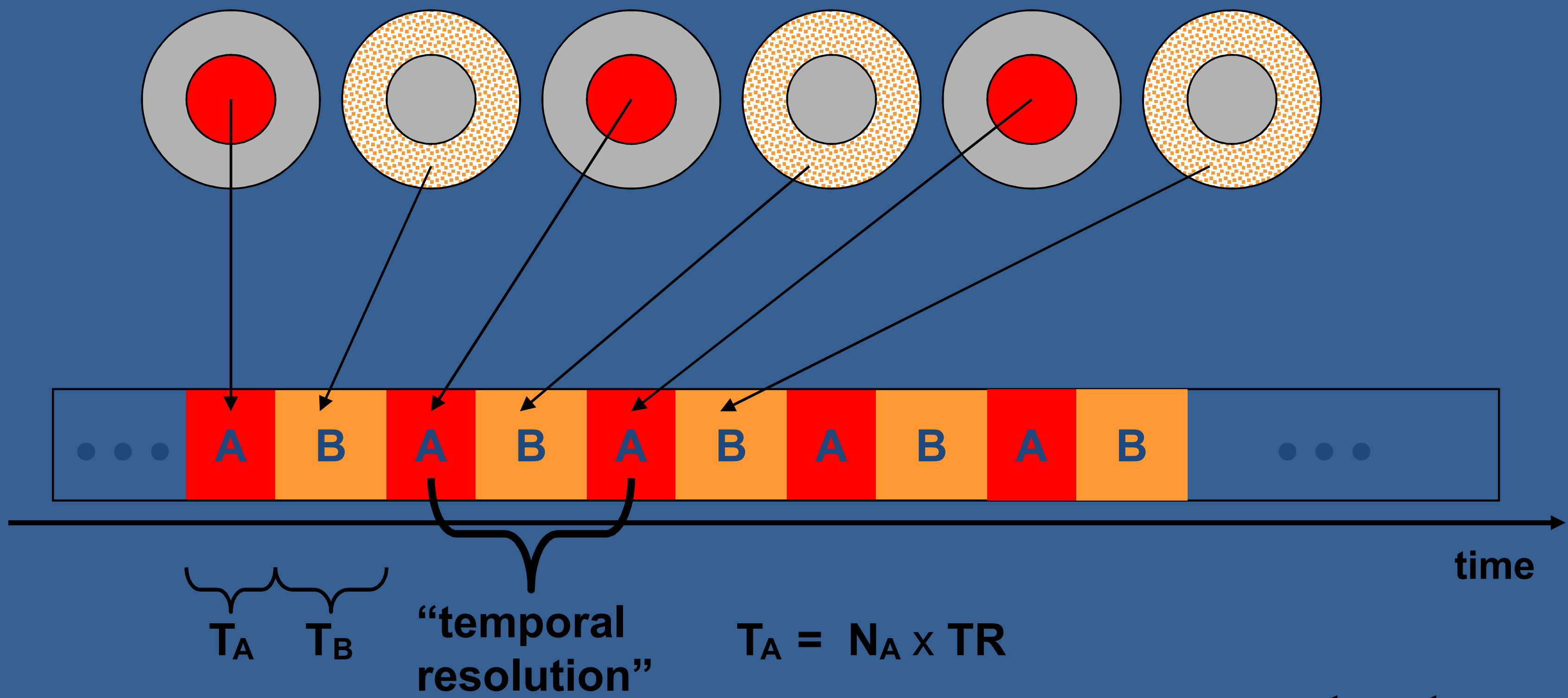




NATIVE TrueFISP



Time Resolved MR Angiography



$T_A = N_A \times TR$

$T_B = s \times N_B \times TR$ with $0 \leqq s \leqq 100[\%]$

TimCT Angiography

Conventional

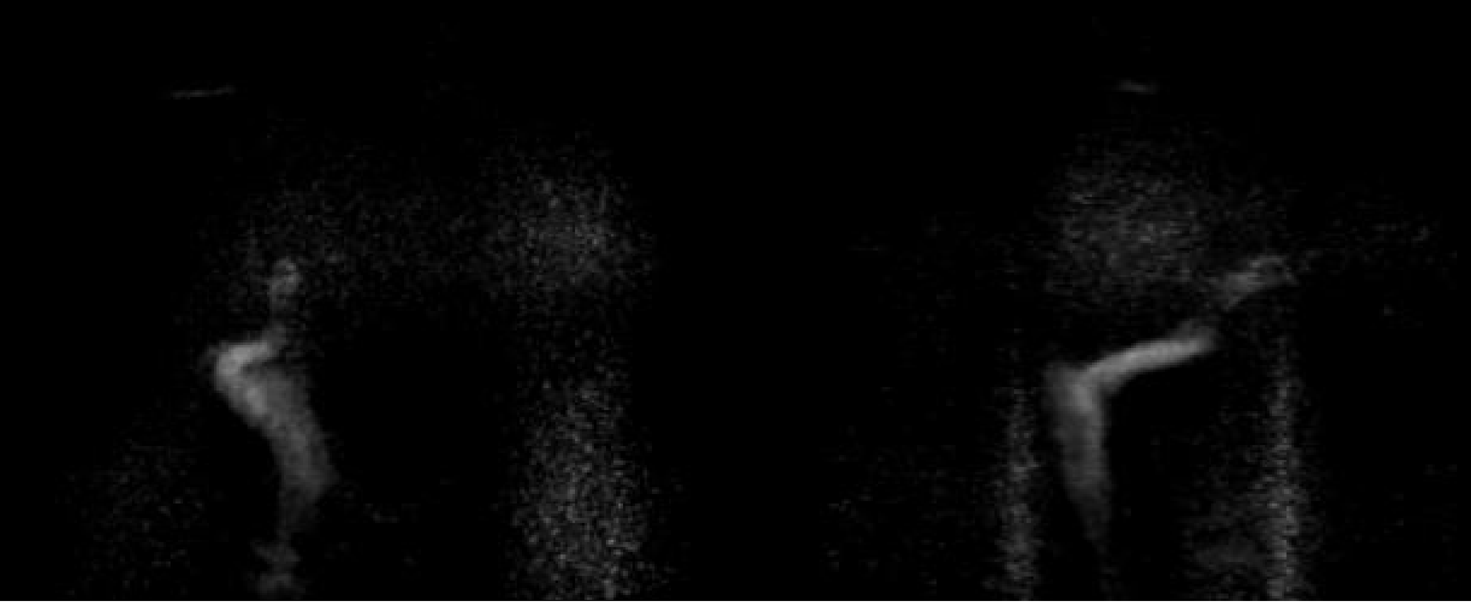
1			Position 230mm above feet
2			I_trufisp_feet
3			II_trufisp_legs
4			III_trufisp_abdomen
5			I_fl3d-cor_feet_pre
6			II_fl3d-cor_legs_pre
7			III_fl3d-cor_abdomen_pre
8			inject gad
9			III_care_bolus_cor
10			III_fl3d-cor_abdomen_post
11			II_fl3d-cor_legs_post
12			I_fl3d-cor_feet_post

TimCT

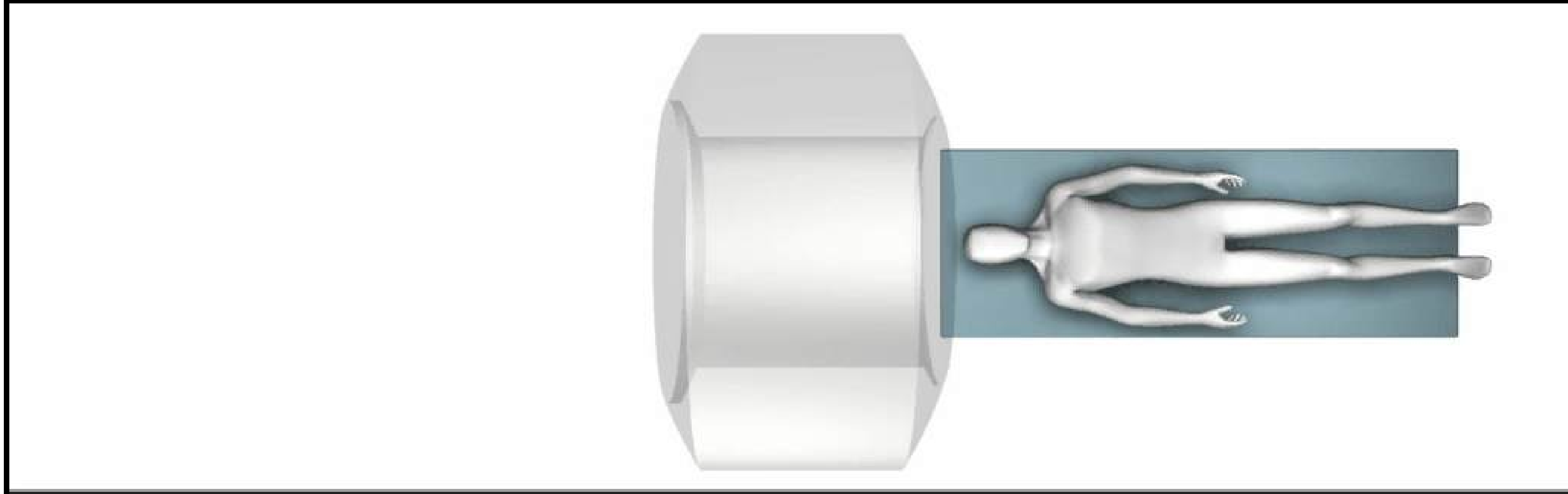
1		Fastview
2		TestBolus_tra
3		Vesselscout_1440mm
4		Angio_pre_1300mm
5		inject
6		Angio_post_1300mm

easier workflow

Time Resolved MR Angiography



TimCT Angiography
Continuous Table move



TimCT Angiography

Multi-step Angiography

TimCT Angiography

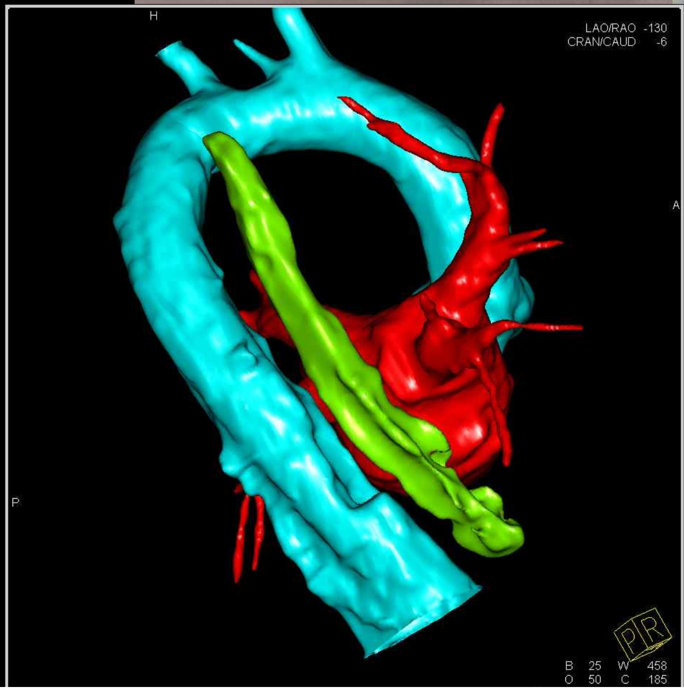
LMU, Munich, Germany

The Interventional Cardiology Suit

- C – Arm CT
- Interventional – MRI unit

  - Pre-procedural imaging
  - Intra-procedural guidance
  - Real – time monitoring


AXIOM Artis

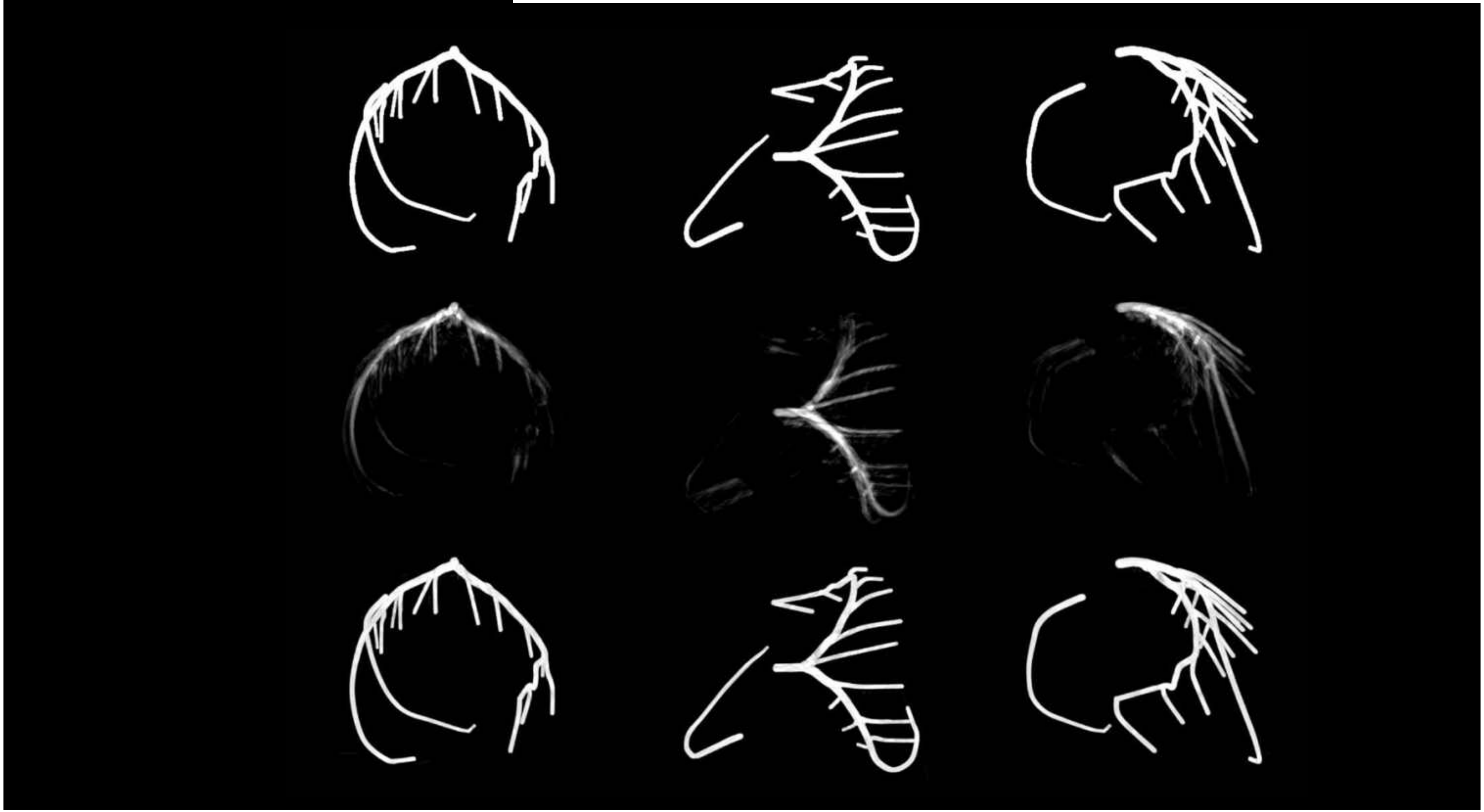

H
LAO/RAO -130
CRAN/CAUD -6
A
P
B 25 W 458
O 50 C 185


11 IMA 0
MPR
P

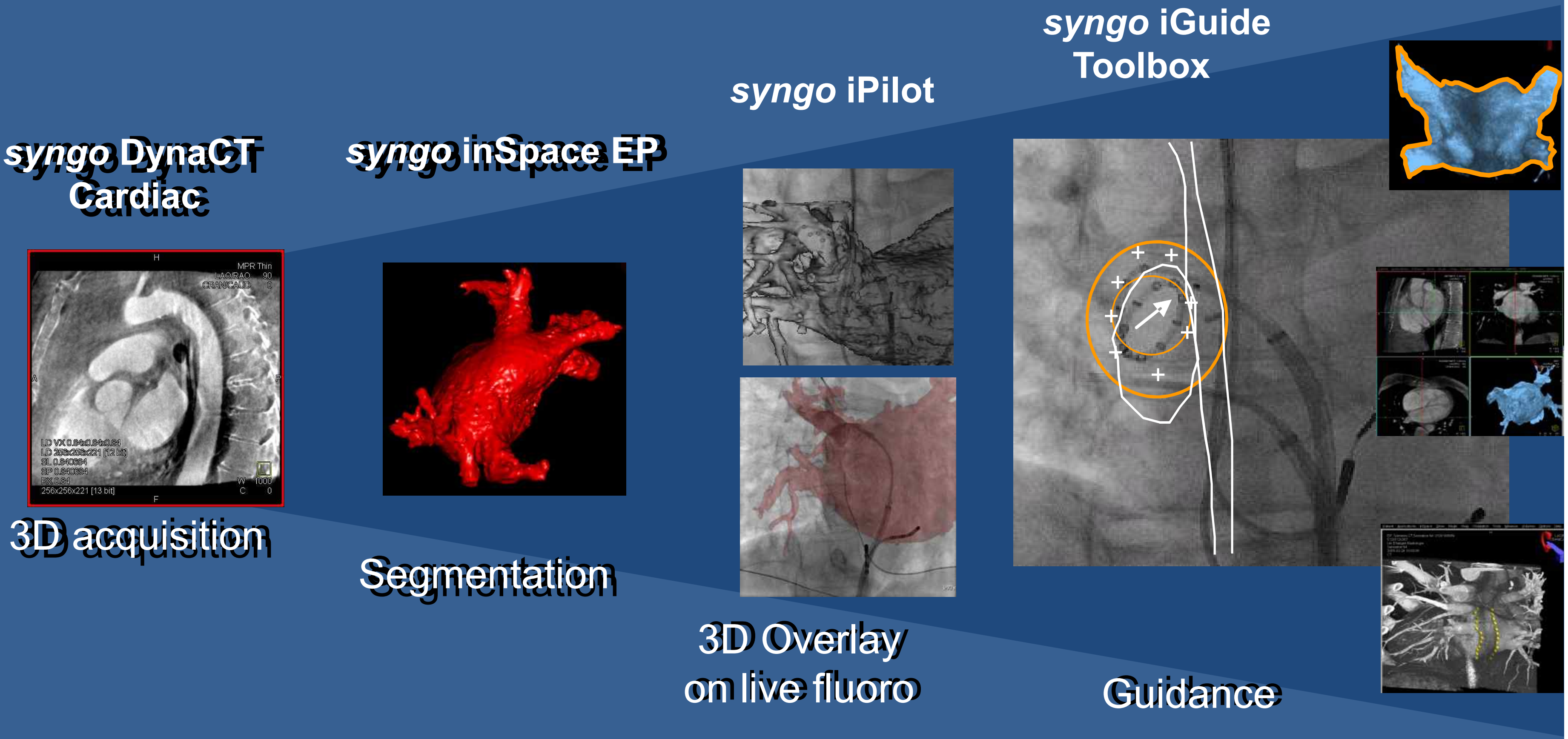
Motion-Compensated and Gated Cone Beam Filtered Back-Projection for 3-D Rotational X-Ray Angiography

Dirk Schäfer* , Jörn Borgert, Volker Rasche, and Michael Grass

IEEE TRANSACTIONS ON MEDICAL IMAGING, VOL. 25, NO. 7, JULY 2006

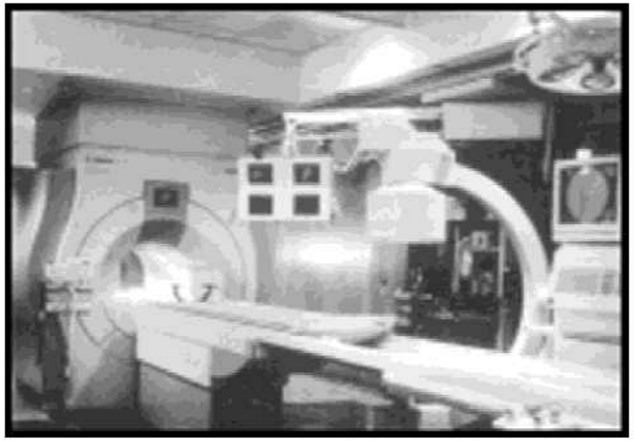


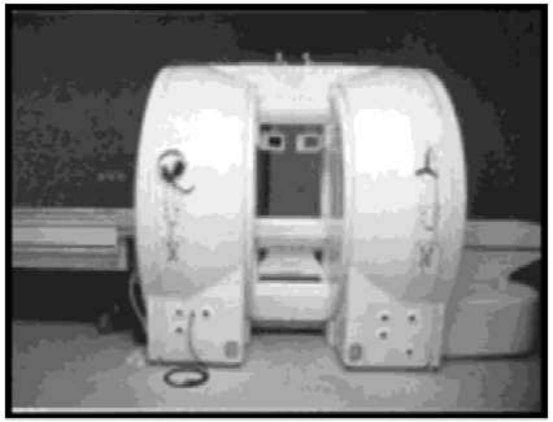
Workflow 3D guidance in EP

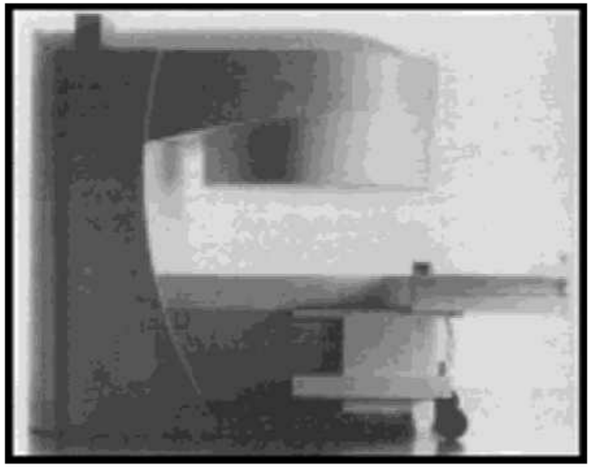


Real-Time Magnetic Resonance Imaging: Diagnostic and Interventional Applications

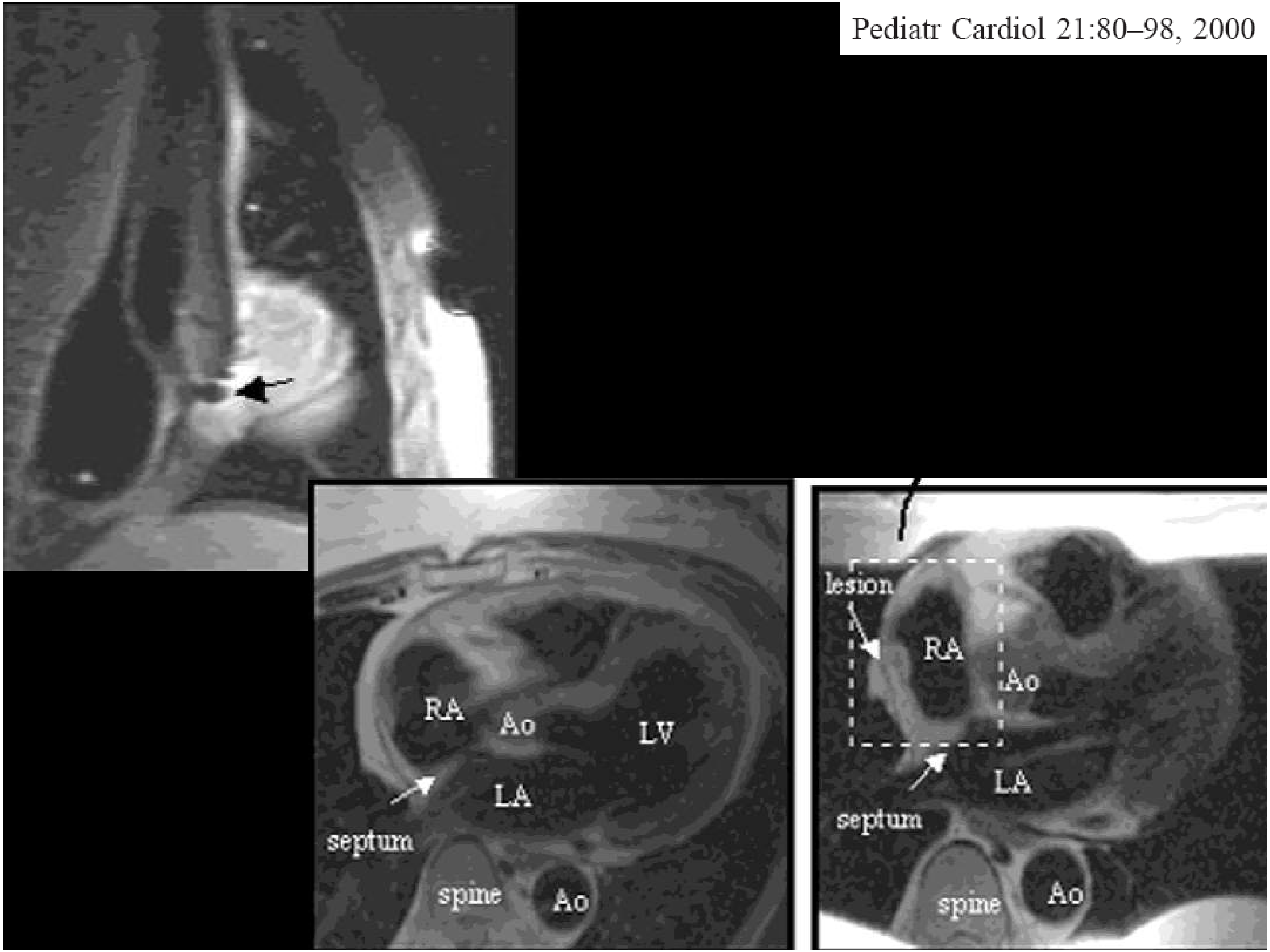
Pediatr Cardiol 21:80–98, 2000







Pediatr Cardiol 21:80–98, 2000



Conclusions

- Noninvasive CVCT and CVMR are useful adjuncts to interventional cardiology practice
- CCT has rapidly revolutionized clinical algorithms
- Latest 3rd Generation MDCT scanners will further advance clinical care. Lower radiation dose with high image quality is the goal. *New DATA is necessary*
- New advances in MRI: plaque characterization, MRA sequences will challenge MDCT
- Interventional Cardiology suit is actively changing: CT and MR multiplanar soft tissue and angiographic visualization capabilities

MDCT & MRI: Where We Are
April 29, 2010

Thank you for your attention