Room 103-104
15/April/2016

New technology to minimize radiation

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- Disclosure
  - NONE
  - I have no experience using Carto Univu or Mediguide

effective dose, mSv

	AF		AFL		AVNRT	
	Men	Women	Men	Women	Men	Women
Estimation	49.76±20.90	31.88±5.57	6.71±3.52	15.74	5.27±2.90	1.48±1.09
Extrapolation	47.17±17.88	29.85±2.99	6.42±1.57	23.72	4.07±1.16	2.23±1.98
Direct	27.25±8.93	18.74±4.75	3.79±1.24	15.84	3.37±1.47	0.91±0.70

Mean fluoroscopy durations for AF procedures
- 67.8±21 minutes in the right anterior oblique (RAO)
- 61.9±16.6 minutes in the left anterior oblique (LAO) projection,

The lifetime risk of excess fatal malignancies normalized to 60 minutes of fluoroscopy was 0.07% for women and 0.1% for men.

Lickfett L. Circulation 2004;110;3003-3010

Estimates of effective doses for selected cardiac imaging procedures (mSv)

Myocardial perfusion imaging study with ejection fraction	15.6
Diagnostic coronary angiography	7.0
Percutaneous coronary intervention	15.0
Cardiac blood pool imaging, gated equilibrium; planar, single study at rest or stress	7.8
Cardiac computed tomography (without contrast, for assessment of coronary calcium)	3.0
Cardiac computed tomography (with contrast, for assessment of coronary arteries, without assessment for coronary calcium)	16.0
Pacemaker insertion	1.5
Comprehensive electrophysiological evaluation	5.7

Chen J et al. J Am Coll Cardiol 2010;56:702-11

Table 2 Reports of cancer incidence in interventionists

Study	Methods	Findings
Finkelstein[10]	Report of a case cluster	Brain cancer in two interventionalists
Preston et al[21]	Review of solid cancers in atomic bomb survivors	Radiation dose response for nervous system tumors; exposure to dose $<$ 1 Sv associated with increased risk
Matanoski et al[23]	Cohort study of mortality in radiologists over a 50-year period	Excess cancer risk among radiologists consistent with other physicians (especially for leukemia and lymphoma)
Carozza et al[25]	Case-control study of occupation and glioma	Physicians at increased risk of glioma
Andersen et al[26]	Population-based study of occupation and cancer incidence	Brain cancer increased among physicians in general; no breakdown by specialty

Radiation-induced Dermatitis

1347 patients after RFCA

↓

Skin problems in 12 patients (0.89%)

↓

6; most likely RID
4; probable RID

↓

Right back and upper arm

3 Surgery

BMI 29.3 vs 23.9 kg/m2 (p <0.001)
Fluorotime 180±31.0 vs 47 ±49.9 min

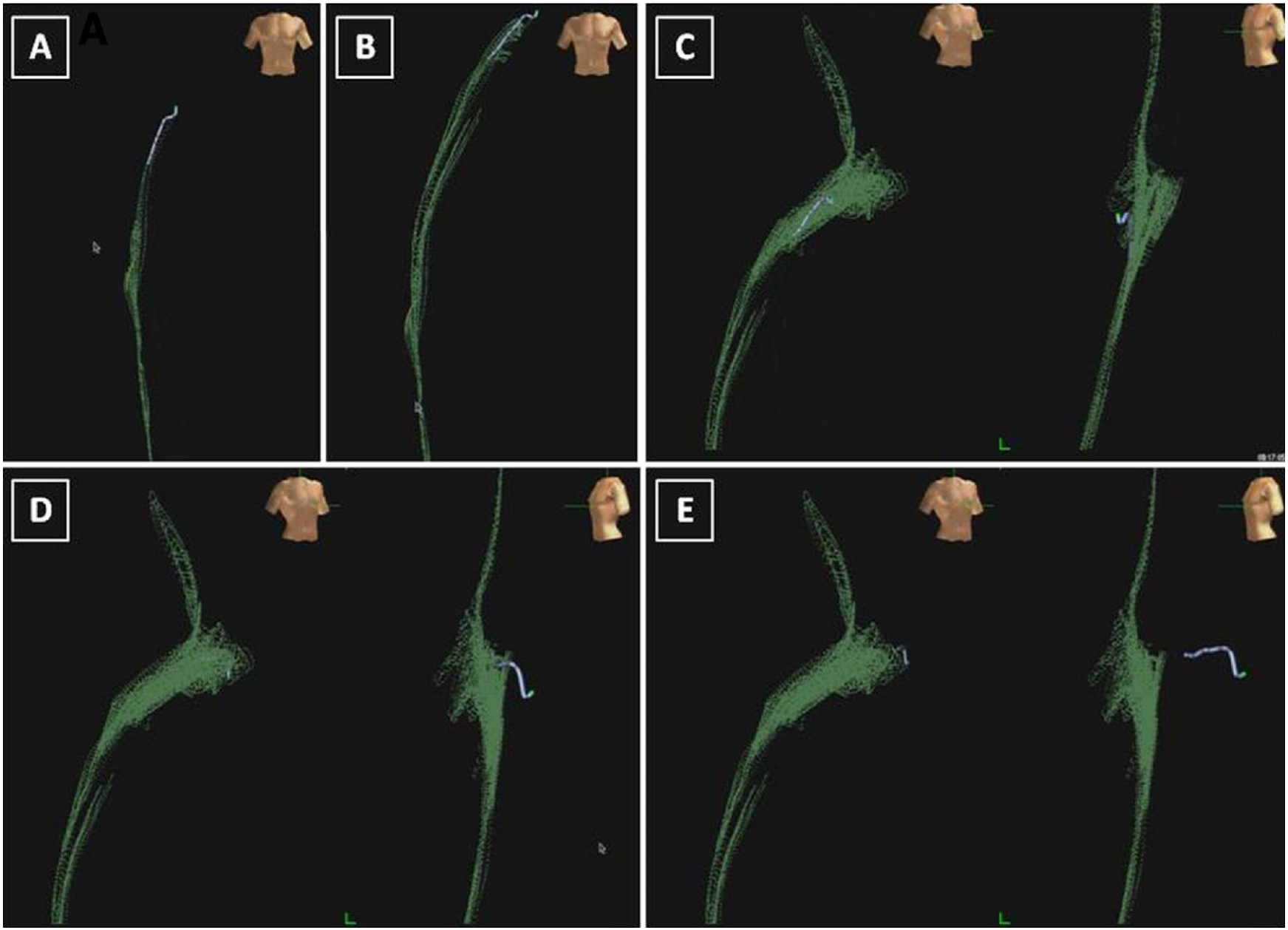
MJ Cha, S Oh, K Circ J (accepted)

How to reduce radiation dose

- Table UP
- Tube DOWN
- Far from tube (no superior access)
- AP view
- SHEILDING
- COLLIMATION
- Low pulse rate (≤4)
- KEEP RECORDING
- Advanced mapping system
- Remote navigation system

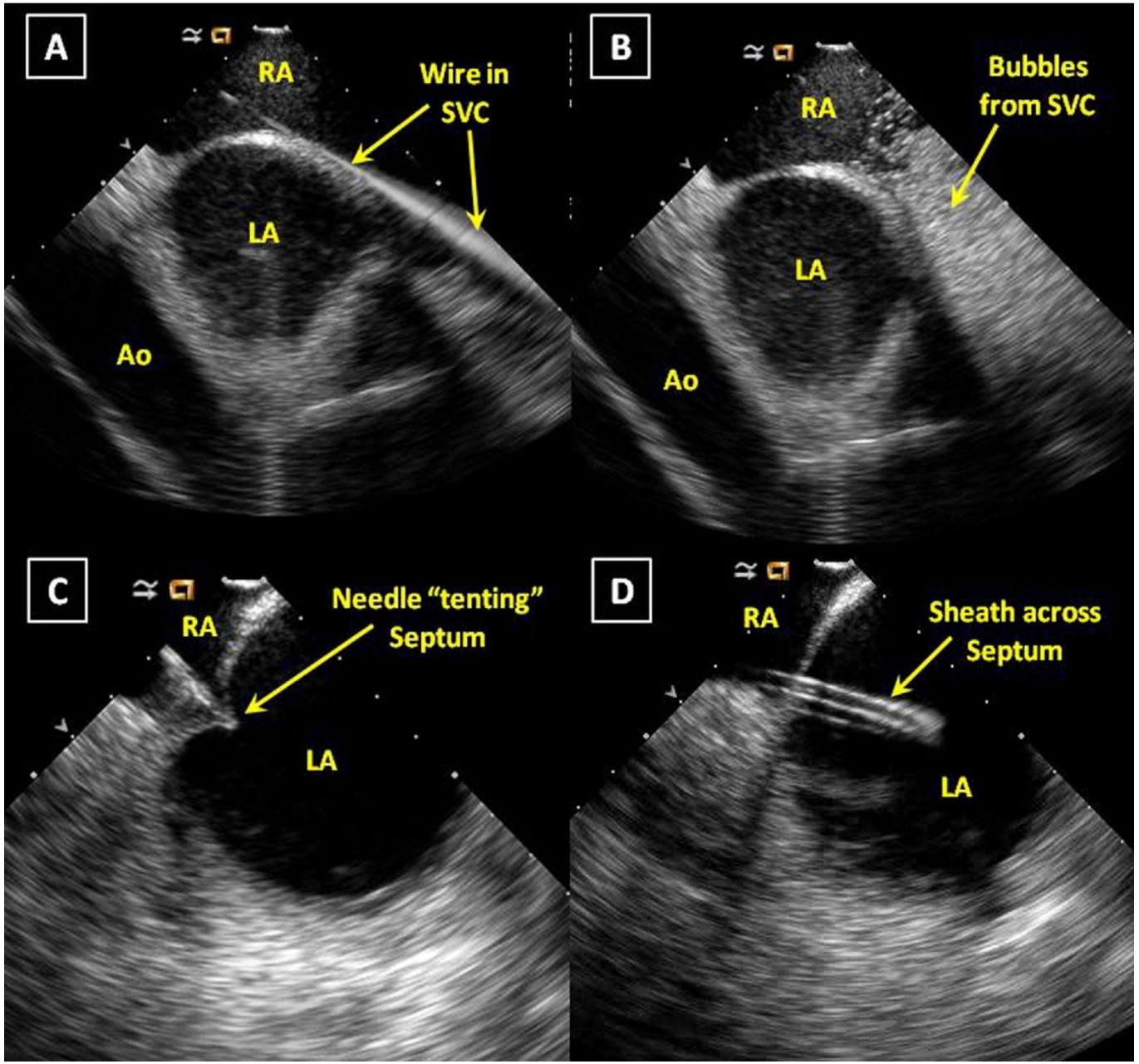
Published studies

AF ablation without the use of fluoroscopy



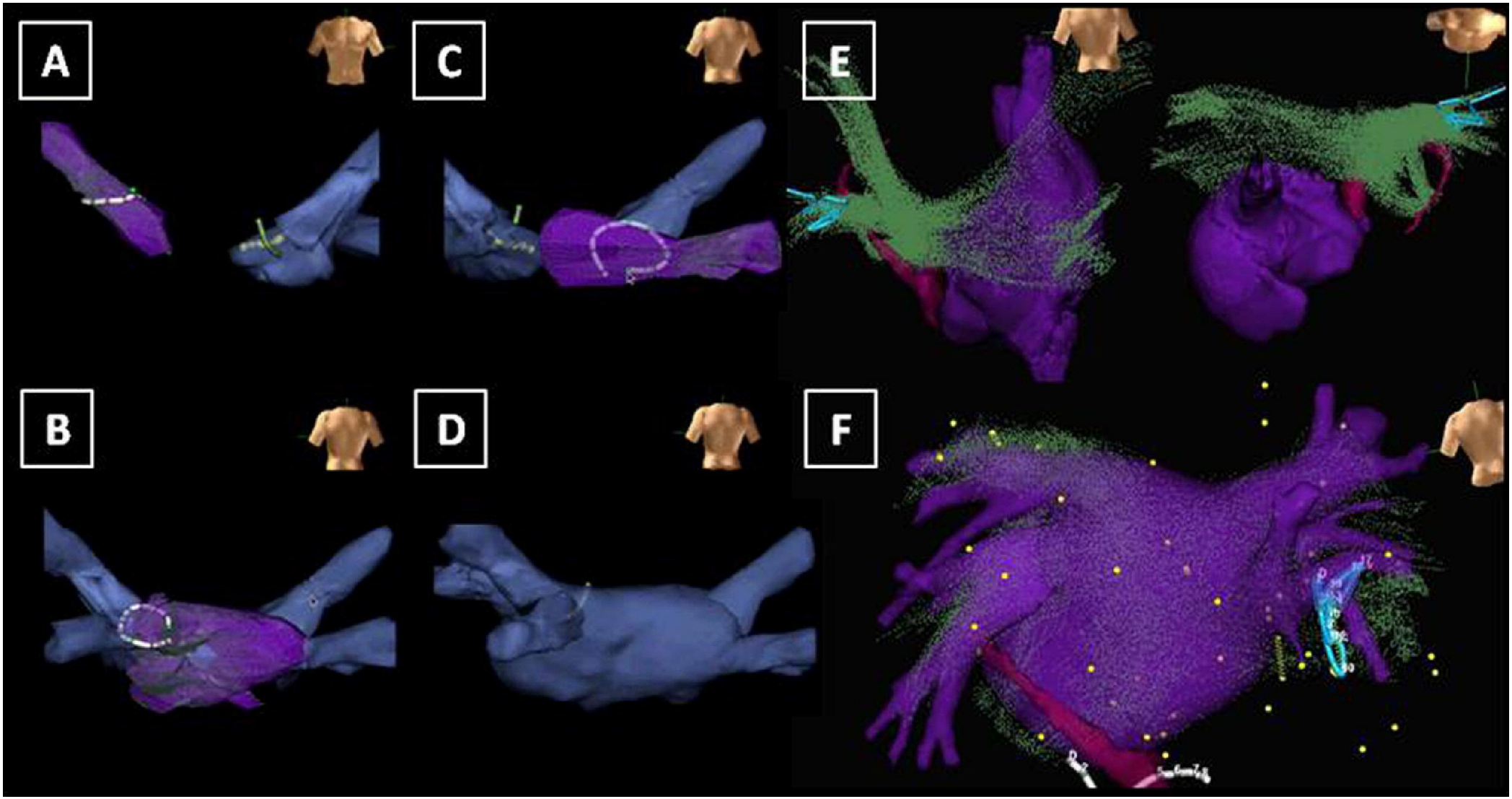
Reddy VY, Heart Rhythm 2010,7:1644-1653

AF ablation without the use of fluoroscopy



Reddy VY, Heart Rhythm 2010,7:1644-1653

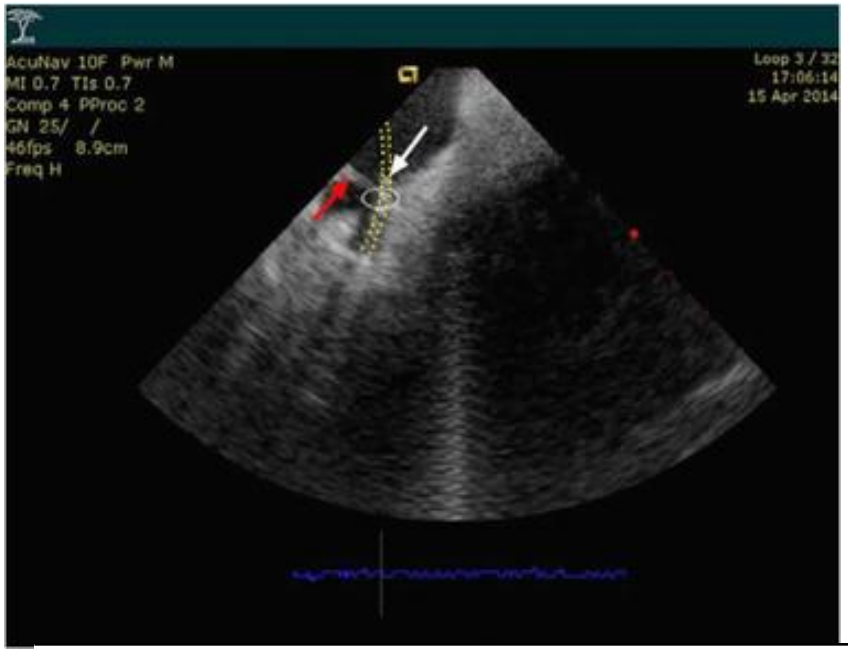
AF ablation without the use of fluoroscopy

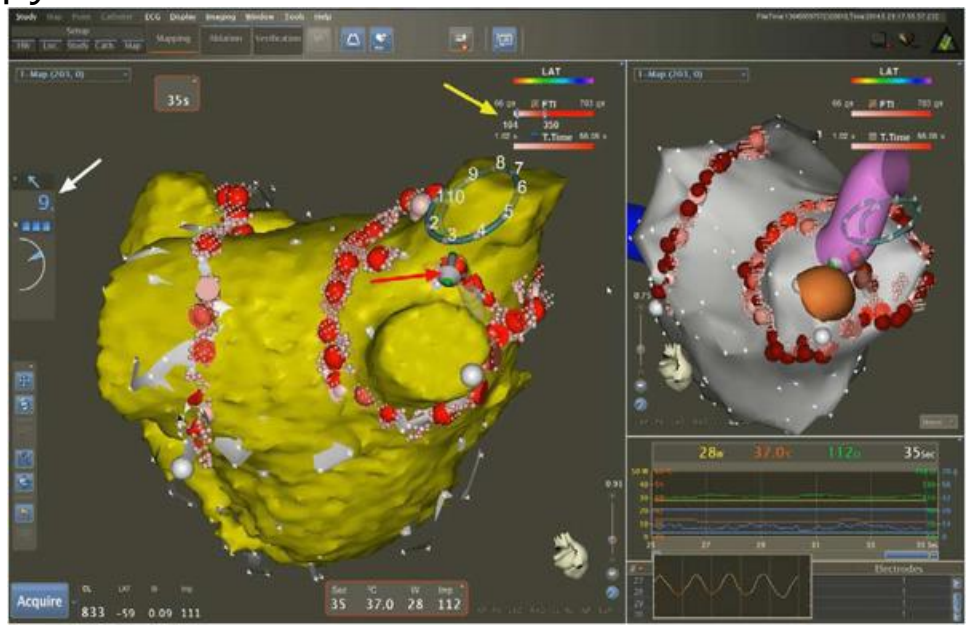


20 patients with PAF, CT image integration in 11, no complication

Reddy VY, Heart Rhythm 2010,7:1644-1653

AF ablation without the use of fluoroscopy : A randomized trial

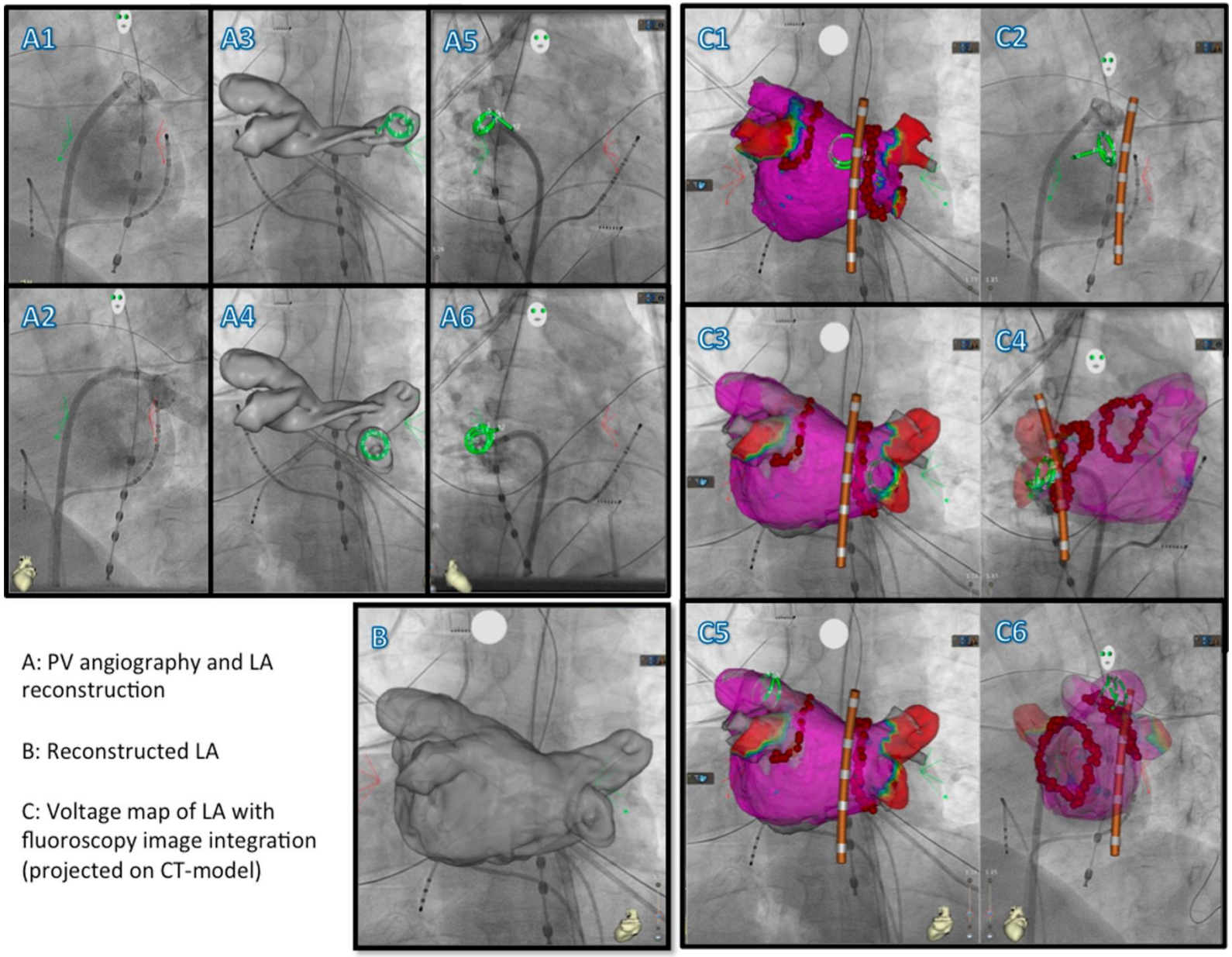




	X− Group	X+ Group	P
N	40	40	
PVI only	30 (75%)	33 (82.5%)	NS
PVI + CTI ablation	6 (15%)	5 (12.5%)	NS
PVI + LA lines	4 (10%)	1 (2.5%)	NS
PVI + CTI ablation + LA lines	0 (0%)	1 (2.5%)	NS
RF application time (seconds)	1785 ± 548	1755 ± 450	NS
X-ray time (minutes)	0.003 ± 0.016	3.0 ± 1.4	<0.000001
Radiation dose (mGy/cm^2)	5.6 ± 33	3062 ± 1585	<0.000001
Procedural time (minutes)	92.5 ± 22.9	99.9 ± 15.9	NS

Bulava A. PACE, 2015:38:797-806

Fluoroscopy integrated 3 D mapping (randomized, single blind and controlled study)



A: PV angiography and LA reconstruction

B: Reconstructed LA

C: Voltage map of LA with fluoroscopy image integration (projected on CT-model)

Huo Y, et al Hear Rhythm 2015;12:1945-55

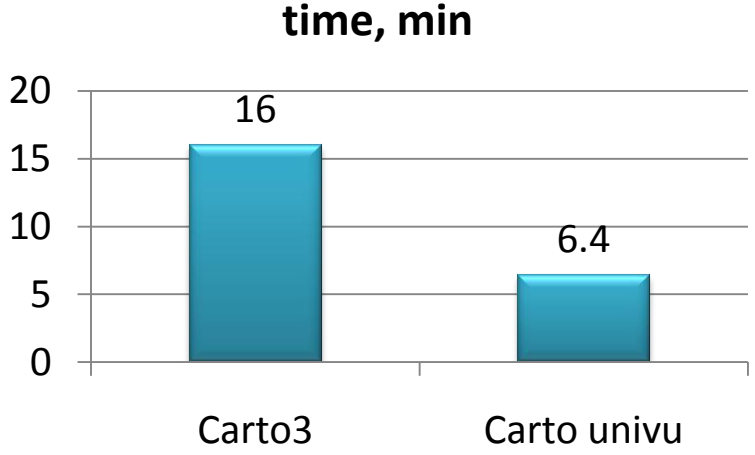
Fluoroscopy integrated 3 D mapping (randomized, single blind and controlled study)

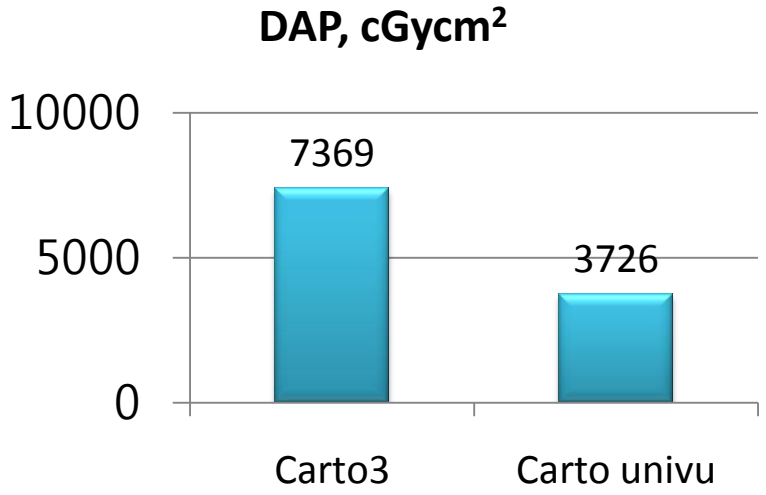
Radiation doses (cGy·cm^2)			
Variable	F-EAM (n = 40)	EAM (n = 40)	*P*
Puncture/catheter placement/TSP	510 (236–956)	742 (498–986)	.062
Registration of the CARTO-UNIVU system	9 (3–20)	–	–
LA reconstruction, PV angiography, and voltage map	115 (57–249)	620 (380–1052)	<.001
LPV isolation	0 (0–0)	214 (128–429)	<.001
LPVI confirmation	0 (0–0)	67 (28–150)	<.001
RPV isolation	0 (0–0)	159 (85–253)	<.001
RPVI confirmation	0 (0–0)	41 (17–66)	<.001
PVI reconfirmation	0 (0–0)	57 (20–113)	<.001
Total procedure (cGy·cm^2)	652 (326–1489)	2440 (1593–3091)	<.001

UNIVU+ UNIVU-

Huo Y, et al Hear Rhythm 2015;12:1945-55

Fluoroscopy integrated 3 D mapping



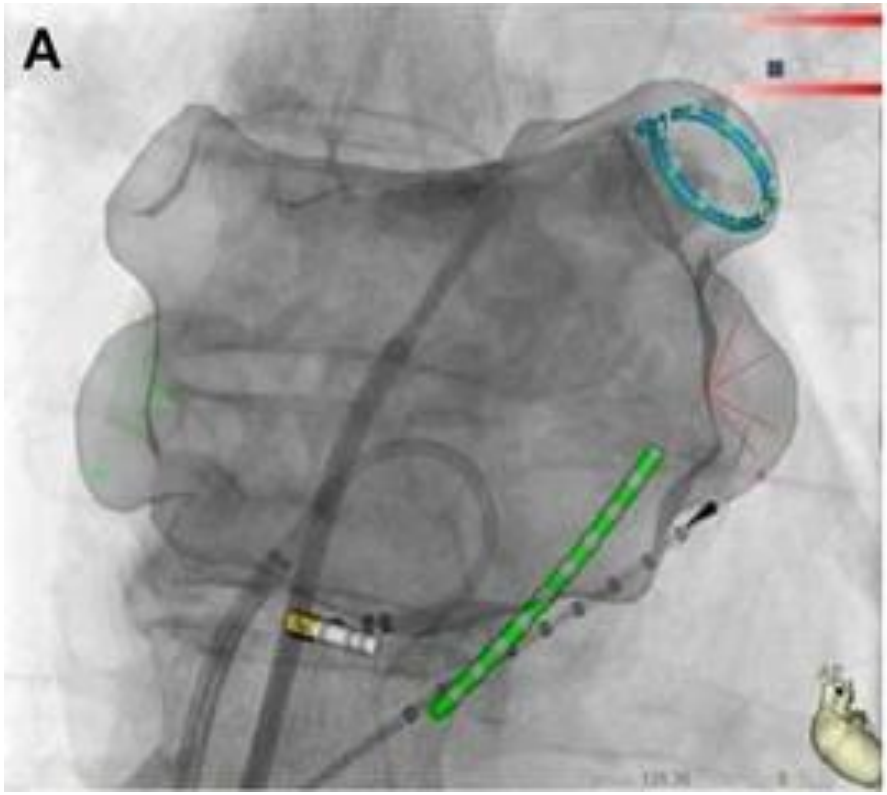


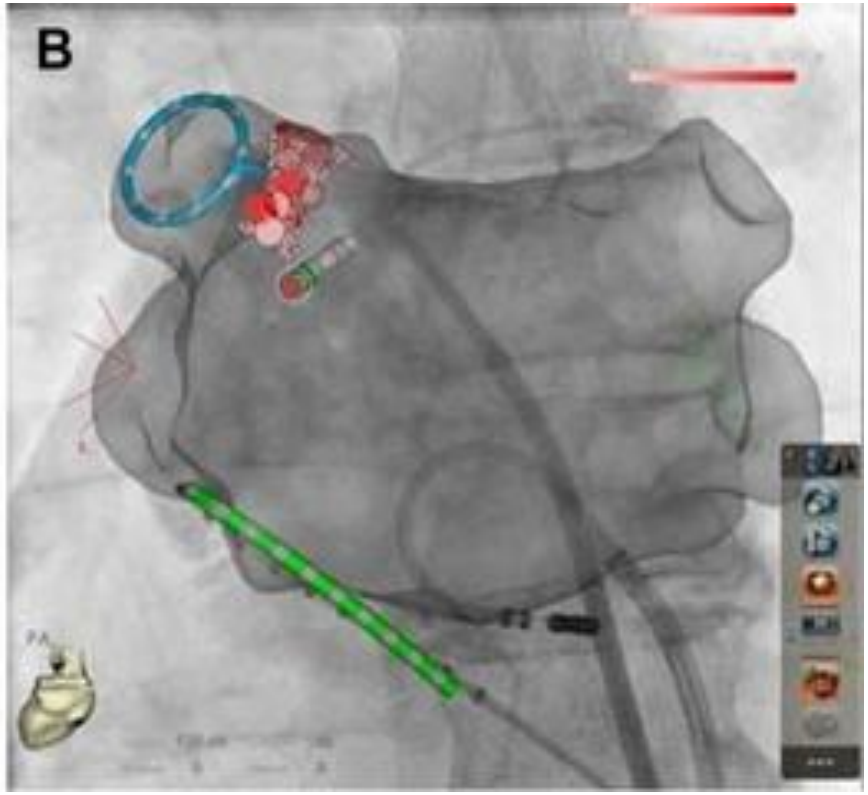
N	37	vs	44
BMI	28.9(4.1)	vs	29.1(5.6)
ED	13.26 mSv		6.7 mSv

Christoph M et al. Europace 2015;17:928-937

Fluoroscopy integrated 3 D mapping
(randomized, single blind and controlled study)

60 PAF patients randomized to UNIVU module vs Carto 3



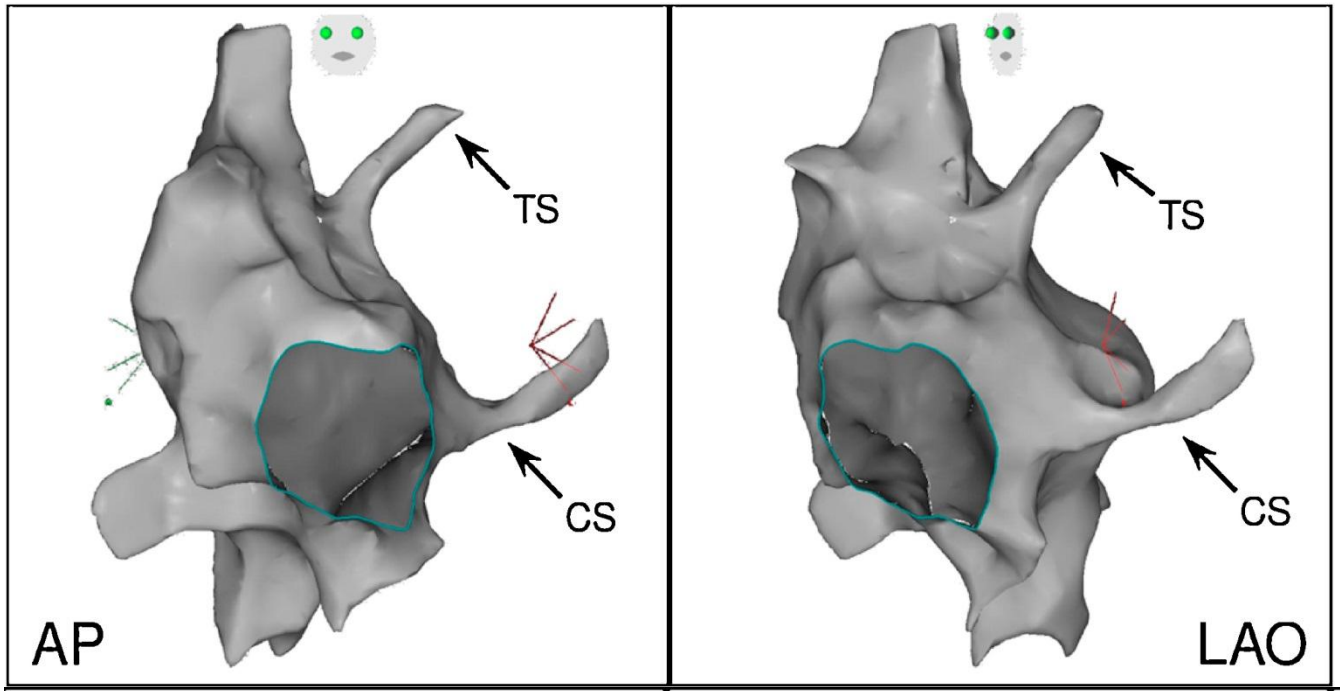


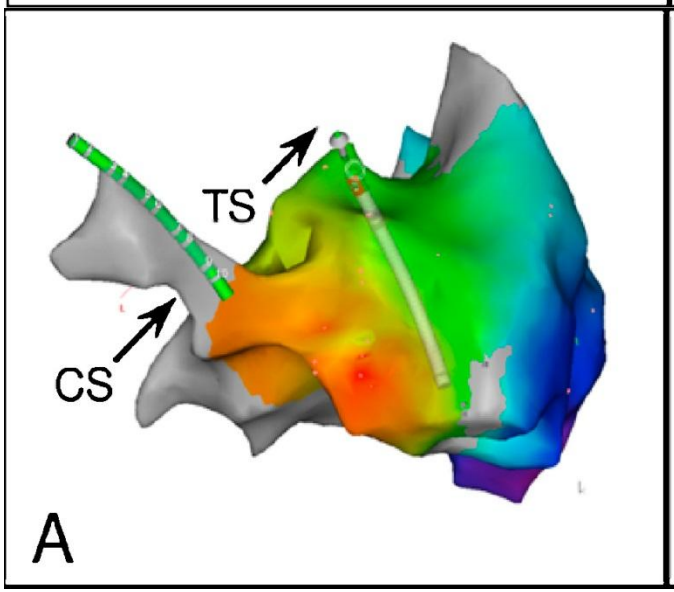
Akbulak RO. J Cardiovasc Electrophysiol 2015;26:747-53

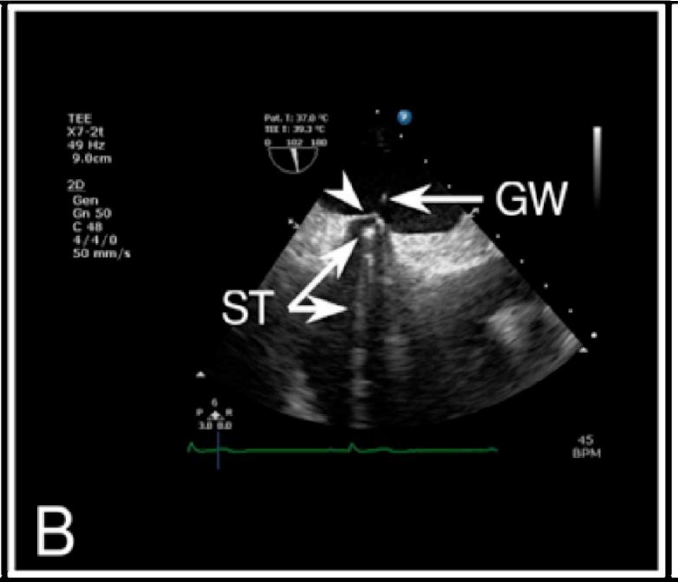
	CartoUnivu™ (Group 1)	Carto® 3 (Group 2)	P Value
Area dose product for the LA angiogram ($cGycm^2$)	137.5 ± 134.8	157.9 ± 141.1	0.35
Cumulative area dose product until map ($cGycm^2$)	299.1 ± 264.4	276.1 ± 182.0	0.40
Cumulative area dose product to 1^{st} RFC aplication ($cGycm^2$)	307.1 ± 194.1	564.0 ± 490.9	0.009
Total procedure duration (minutes)	140.7 ± 27.8	140.8 ± 39.5	0.851
Total fluoroscopy time (minutes)	7.4 ± 2.6	11.9 ± 2.1	0.0006
Total area dose product ($cGycm^2$)	476.5 ± 282.0	882.9 ± 550.4	0.001
Estimated ED (mSV)	0.87 ± 0.47	1.83 ± 1.49	0.005

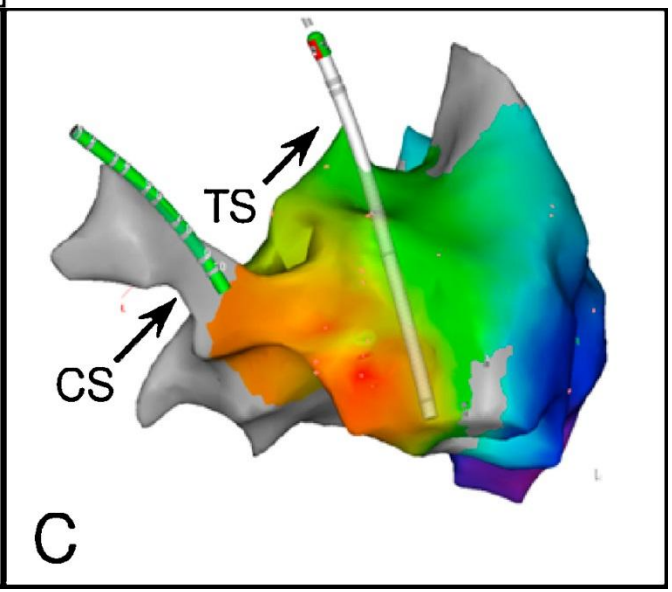
Akbulak RO. J Cardiovasc Electrophysiol 2015;26:747-53

Carto3+Smart-touch catheter+TEE +General anesthesia
For near Zero fluoroscopy during complex LA ablation



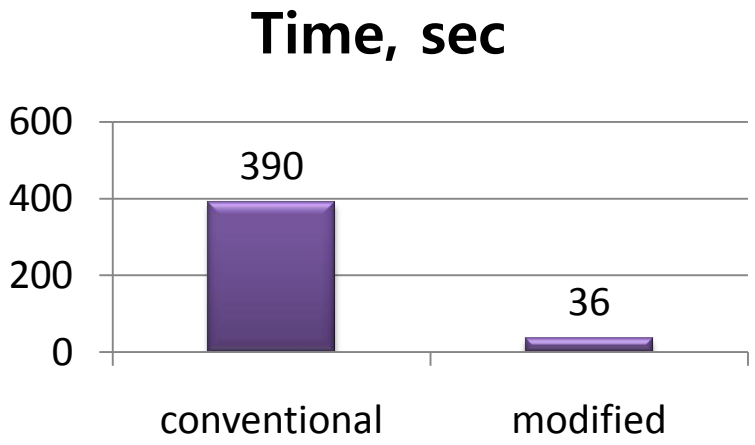


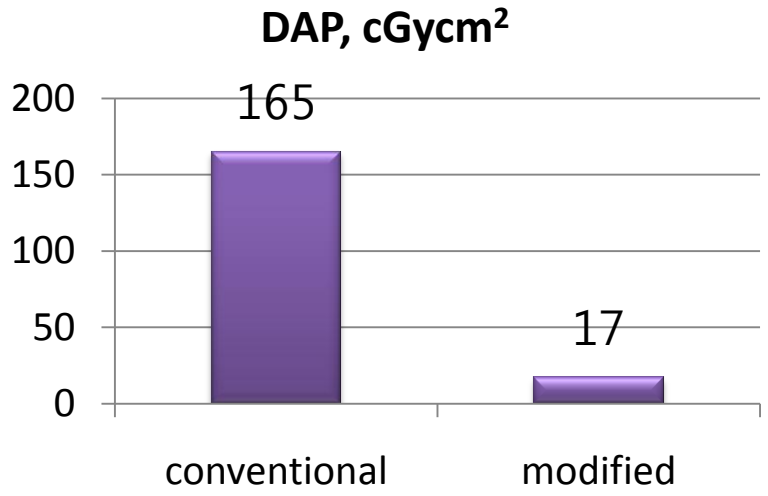




Raju H, Wright M. Heart, Lung and Circulation, 2016

Carto3+Smart-touch catheter+TEE
For near Zero fluoroscopy during complex LA ablation





N 10 vs 20
BMI 28.9(4.1) vs 29.1(5.6)

Raju H, Wright M. Heart, Lung and Circulation, 2016


EnSite™ Velocity™
Cardiac Mapping System
MediGuide™ Transmitters
Installed in fluoroscopy detector
MediGuide™ CathConnect
Connection between MediGuide Enabled™ devices and the MediGuide Connect
MediGuide Enabled™ Devices
Contain position and orientation sensor
MediGuide™ Connect
Connects bedside components to the MediGuide™ Console

The MediGuide Technology (St Jude Medical Inc.)

(i) a transmitter generating a 3D electromagnetic field;

(ii) a small single-coil sensor (<1 mm^3) assembled within an intracardiac device such as a conventional EP catheter (MediGuide Enabled Livewire™, St Jude Medical Inc.) or an ablation catheter (Safire DUO™ Ablation Catheter, MediGuide enabled, St Jude Medical Inc.and CoolPath DUO™, Ablation catheter, MediGuide enabled, St Jude Medical Inc.);

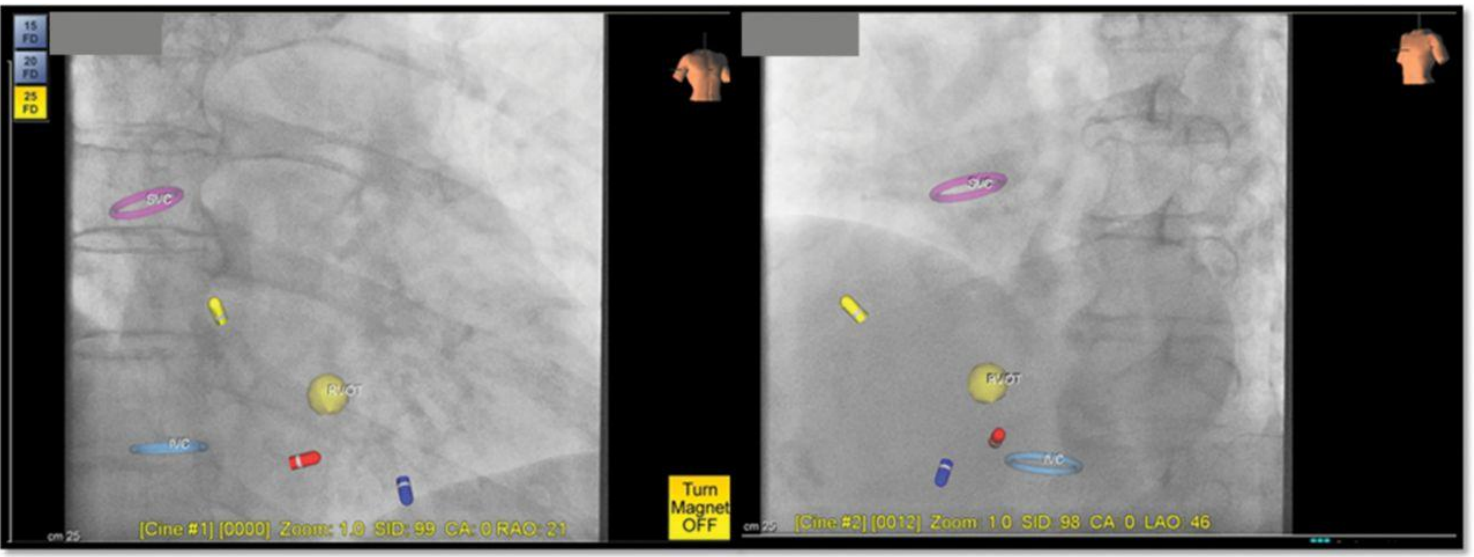
(iii) a magnetic field reference sensor attached to the patient's chest.

The transmitter is mounted on the fluoroscopy detector of a conventional X-ray imaging system aligning the fluoroscopy space with the 3D magnetic sensor field. As a result the sensor equipped EP catheters can either be seen on fluoroscopy or tracked non-fluoroscopically at the identical position by the electromagnetic sensor field.

Using pre-recorded fluoroscopy cine loops real time catheter location data obtained from the magnetic sensor field are being visualized non-fluoroscopically within the X-ray environment.

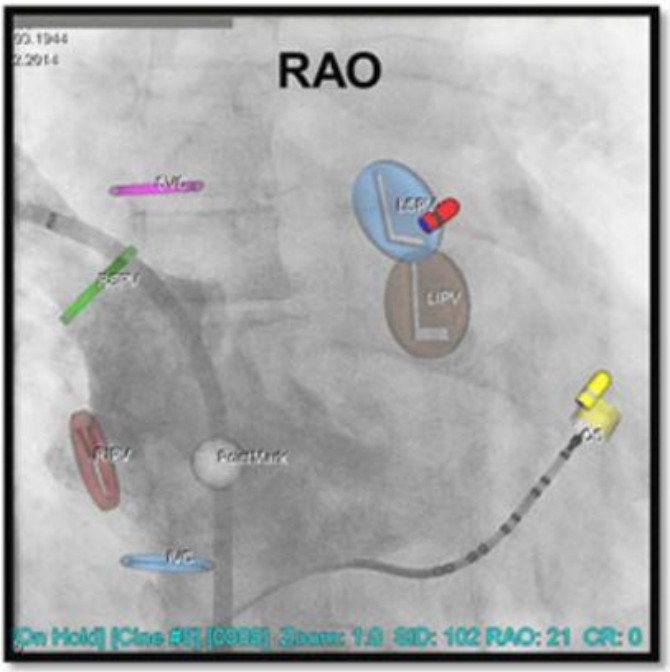
To adjust for cardiac cycle-dependent changes in catheter position the speed of the cine loop is matched to the real-time electrocardiogram signal. The magnetic field reference allows the MG Technology to accurately display the intracardiac catheter position and to compensate for respiration and patient movement. This compensation is possible since the catheter sensor localization is calculated in relation to a patient reference sensor[4] that is fixed on the sternum.

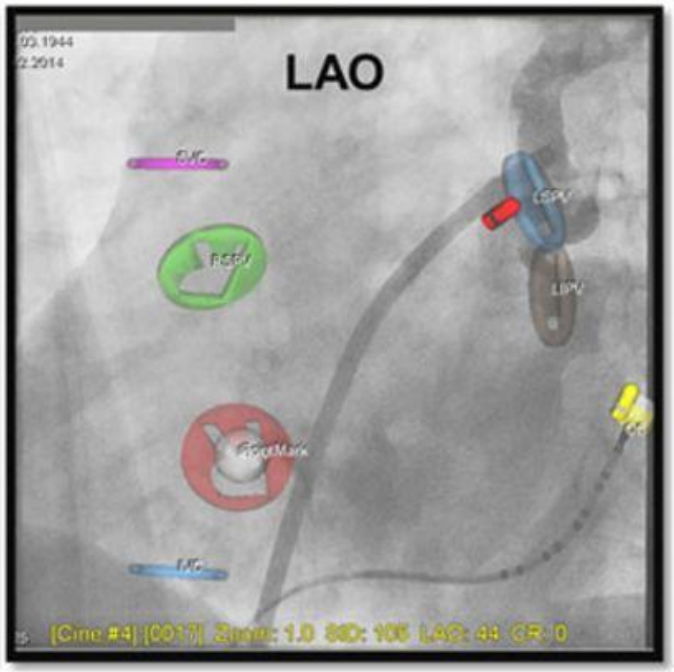
What is the procedure?

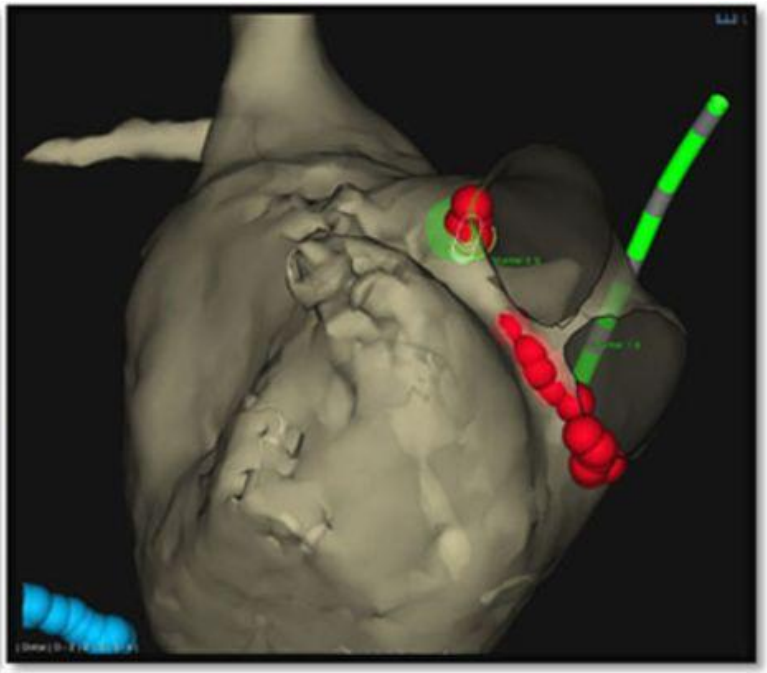


Sommer P. Europace 2013;15:

Nonfluoroscopic catheter visualization

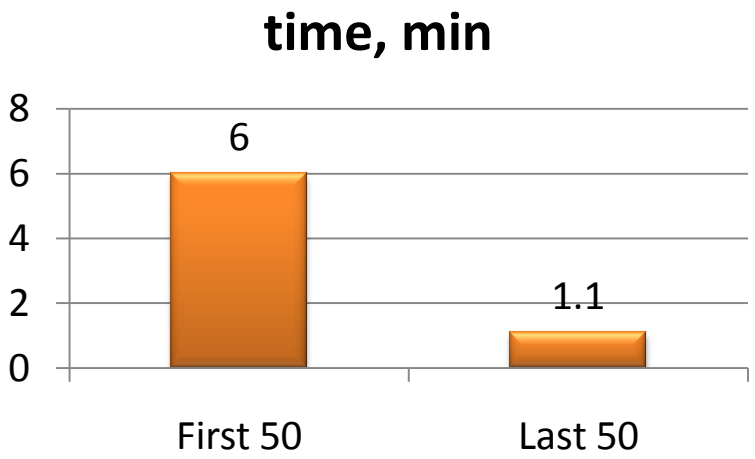


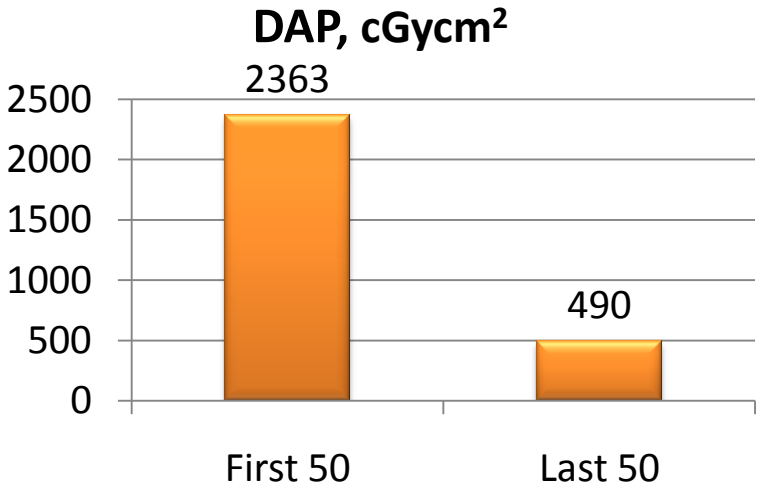




Sommer P, Circ A & E 2014;7:869-74

Nonfluoroscopic catheter visualization

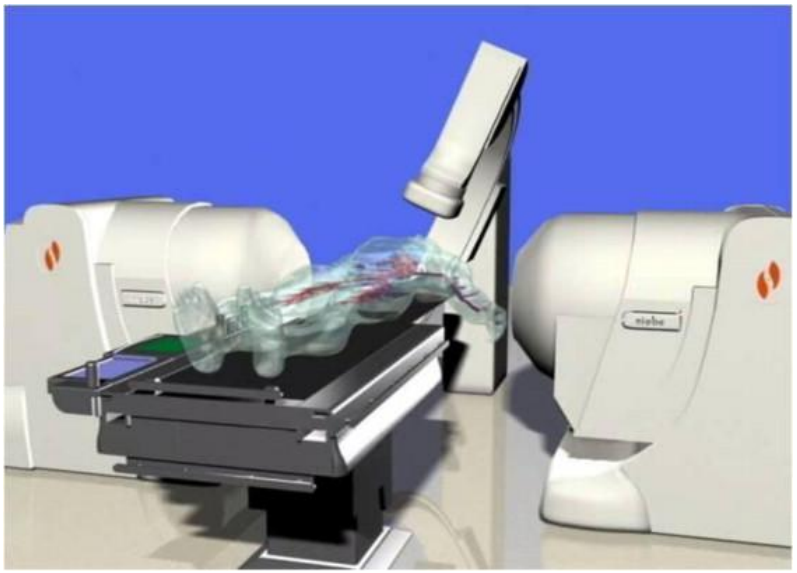


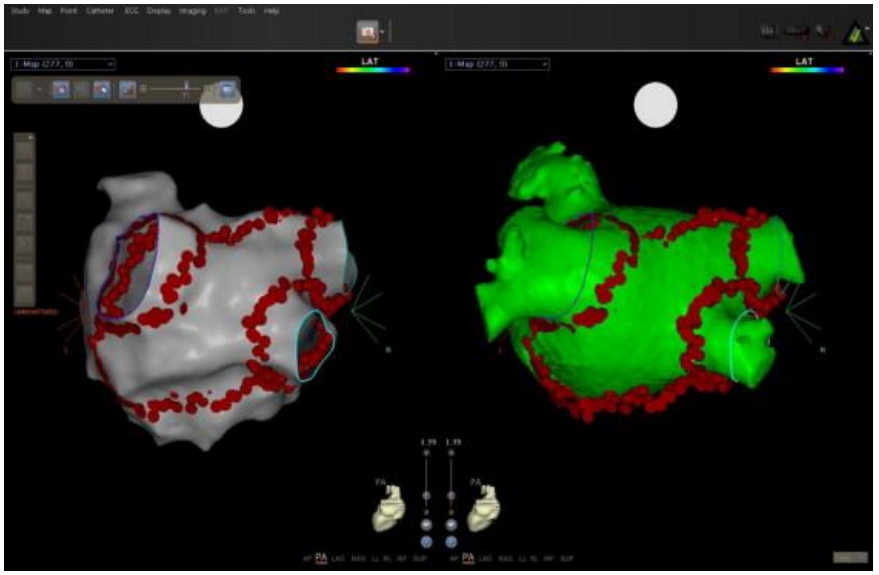


ED	13.26 mSv	6.7 mSv

Sommer P, Circ A & E 2014;7:869-74

Remote magnetic navigation (RMN)





N=81

PVI ± CA ablation± CFAE ablation

Fluoro time 13±7 min
DAP 49±36 gray/cm2=4900 cGycm2

Da Costa. Archives of cardiovascular disease 2013;106:423-32

In our lab

148 pt of SVT (Age >18)

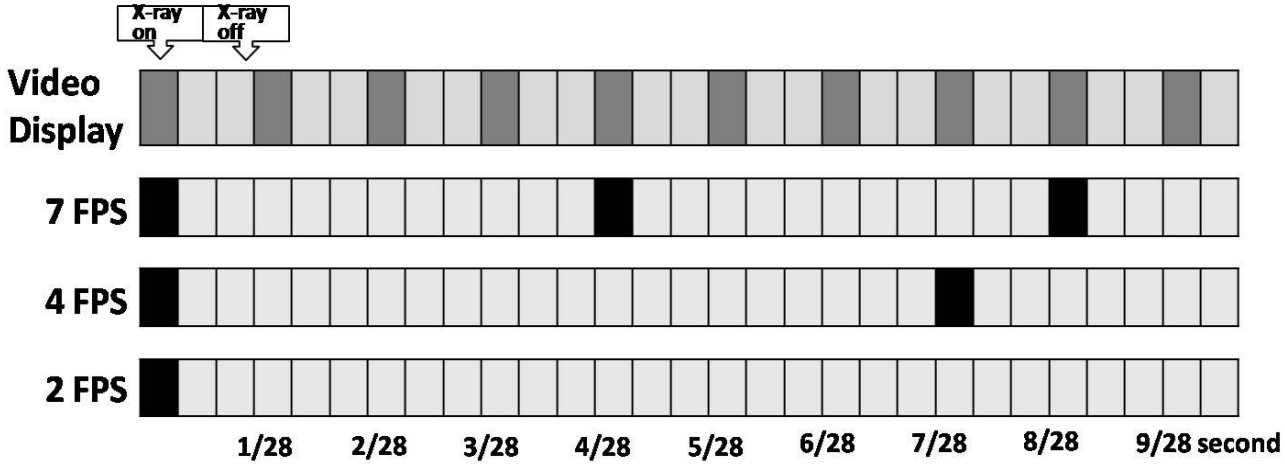
- AVNRT (69)
- WPW (35)
- Concealed bypass tract (38)
- Focal AT(6)

Digital pulse rate

Group1 (36)
7 pulses/sec

Group 2(67)
4 pulses/sec

Group 3(45)
2 pulses/sec



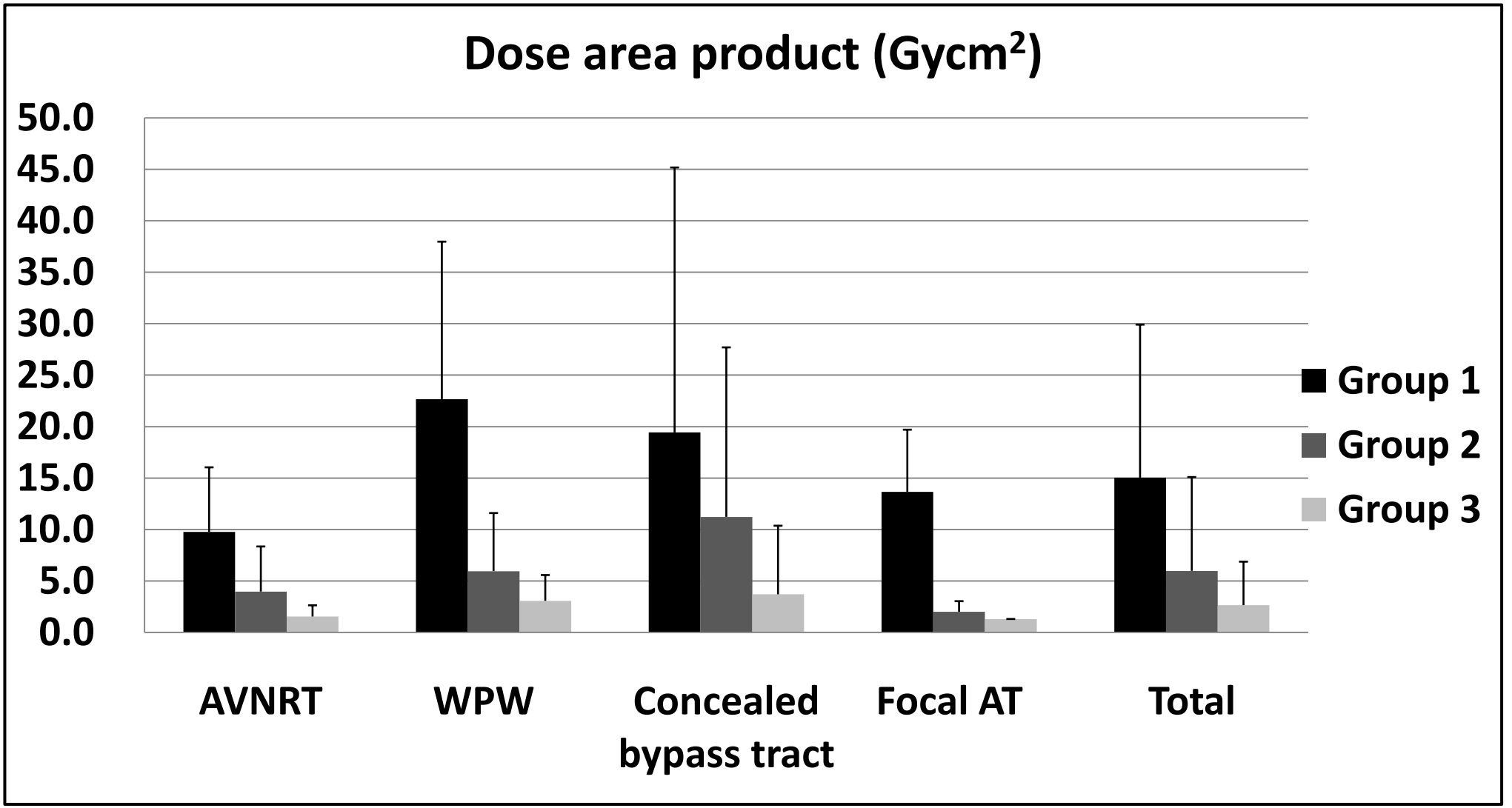
SY Lee, J Kim et al. Int J Cardiol 2014;177

Table 1. (Digital pulse rate)	Group 1 (7/sec)	Group 2 (4/sec)	Group 3 (2/sec)	p
Age	41.3 ± 16.5	44.3 ± 14.6	48.1 ± 18.3	0.168
Sex(Male)	14 (38.9%)	39 (58.2%)	23 (51.1%)	0.174
Body mass index	22.8 ± 2.6	23.1 ± 3.5	22.9 ± 2.9	0.863
Body surface area (m^2)	1.67 ± 0.15	1.73 ± 0.18	1.66 ± 0.17	0.174
Structural heart disease	2 (5.6%)	4 (6.0%)	3 (6.7%)	0.977
Types of arrhythmia				
AVNRT	16 (44.4%)	35 (52.2%)	18 (40.0%)	0.445
WPW	10 (27.8%)	15 (22.4%)	10 (22.2%)	0.946
Concealed bypass tract	8 (22.2%)	15 (22.4%)	16 (35.6%)	0.181
Focal AT	2 (3.0%)	2 (3.0%)	1 (2.2%)	0.320
Total	36 (24.3%)	67 (45.3%)	45 (30.4%)	

SY Lee, J Kim et al. Int J Cardiol 2014;177

	Group 1	Group 2	Group 3	p
Fluoroscopic duration (min)	12.6 ± 8.8	11.1 ± 11.1	8.8 ± 6.8	0.182
Dose area product ($Gycm^2$)	15.0 ± 14.9	6.0 ± 9.1	2.6 ± 4.2	<0.001
Procedural success	36 (100%)	65 (97%)	45 (100%)	0.294
Effective Dose, mSV	3.0±3.1	1.2±1.8	0.5±0.9	<0.01
Procedural Complications	0 (0%)	1 (1.5%)	0 (0%)	0.544
Table 3. Dose area product ($Gycm^2$) according to types of SVT				
AVNRT (n= 69)	9.8 ± 6.3 (n= 16)	4.0 ± 4.4 (n = 35)	1.5 ± 1.1 (n=18)	<0.001
WPW (n= 35)	22.7 ± 15.3 (n=10)	6.0 ± 5.6 (n= 15)	3.1 ± 2.5 (n=10)	<0.001
Concealed bypass tract (n=38)	19.4 ± 25.7 (n=7)	11.2 ± 16.5 (n=15)	3.7 ± 6.7 (n=16)	0.086
Focal AT (n= 6)	13.7 ± 6.0 (n= 3)	2.0 ± 1.0 (n= 2)	1.3 (n=1)	0.131

SY Lee, J Kim et al. Int J Cardiol 2014;177



SY Lee, J Kim et al. Int J Cardiol 2014;177

	4 FPS (n=57)	2 FPS (n=76)	P-value
Age	58.1 ± 10.6	57.8 ± 10.5	0.867
Male	43 (75.4)	55 (72.4)	0.691
BMI	24.8 ± 2.7	26.2 ± 3.1	0.008
Persistent AF	12 (21.1)	22 (28.9)	0.302
Past History			
CHF	7 (12.3)	4 (5.3)	0.146
Hypertension	19 (33.3)	20 (26.3)	0.379
Diabetes	5 (8.8)	6 (7.9)	0.856
Stroke	7 (12.3)	4 (5.3)	0.146
Vascular disease	6 (10.5)	3 (3.9)	0.135
CHADS2	1.1 ± 1.2	0.8 ± 1.0	0.072
CHADS2VASc	1.5 ± 1.4	1.1 ± 1.1	0.084
CHADS2VASc (≥2)	22 (38.6)	20 (26.3)	0.132
LVEF	59.4 ± 8.0	58.4 ± 7.9	0.472
LA size	40.6 ± 5.6	42.9 ± 7.0	0.033

JH Lee, MS Kim, J Kim, unpublished data

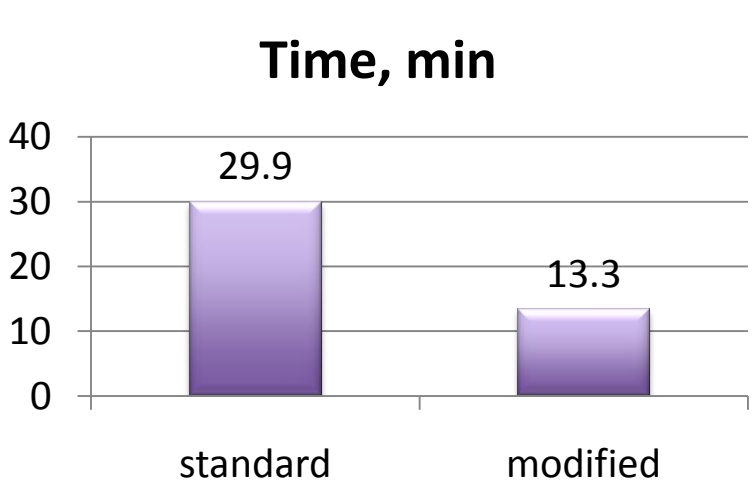
	4 FPS (n=57)	2 FPS (n=76)	P-value
4 PVI success	57 (100.0)	76 (100)	NA
4 PVI + additional ablation	48 (84.2)	68 (89.5)	0.368
CTI ablation	43 (75.4)	56 (73.7)	0.818
LA linear ablation	26 (45.6)	51 (67.1)	0.013
CFAE ablation	4 (7.0)	3 (3.9)	0.461
Procedural time, min	273.0 (245.0–312.0)	229.0 (185.0–279.5)	<0.001
Fluoroscopy time, min	23.4 (17.5–32.6)	15.1 (10.7–20.1)	<0.001
DAP, $cGycm^2$	562.0 (341.7–1412.5)	392.0 (289.7–591.4)	0.006
ED estimate, mSv	1.1 (0.6–2.4)	0.8 (0.6–1.9)	0.004

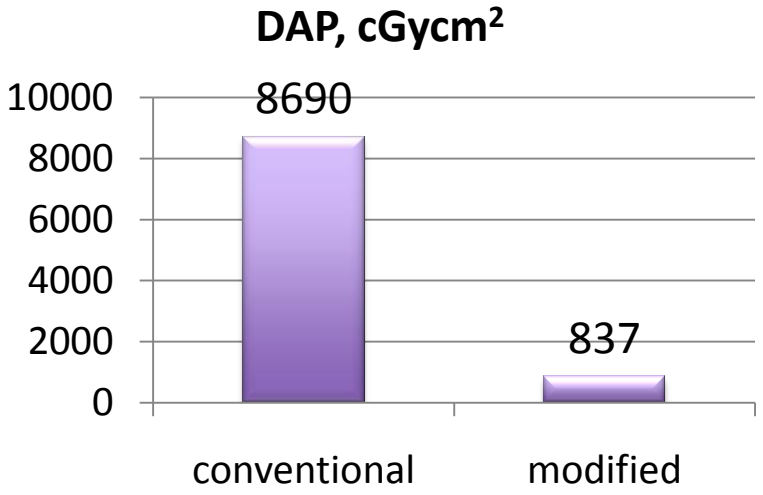
JH Lee, MS Kim, J Kim, unpublished data

	4 FPS, n=57	2 FPS, n=76	P value
4PVI	13	16	
Fluoroscopy time, min	18.3 (11.9, 20.3)	13.7 (10.2, 17.9)	0.171
DAP, cGycm^2	476.5 (225.2,944.5)	391.5 (317.9, 644.0)	0.642
ED estimate, mSv	0.9 (0.3, 1.6)	0.8 (0.6, 1.2)	0.965
4PVI + CTI	25	26	
Fluoroscopy time, min	25.4 (17.5, 33.1)	13.4 (10.1, 18.6)	<0.001
DAP, cGycm^2	479.7 (271.2, 1480.0)	324.0 (230.2 529.6)	0.07
ED estimate, mSv	1.0 (0.6, 3.2)	0.6 (5.0, 1.1)	0.042
4PVI + line	19	34	
Fluoroscopy time, min	31.9 (21.8, 44.4)	15.8 (12.5, 22.8)	<0.001
DAP, cGycm^2	1026.0 (497.5, 1511.0)	435.0 (313.5, 594.3)	0.002
ED estimate, mSv	2.0 (1.1. 2.8)	0.8 (0.6, 1.1)	<0.001

JH Lee, MS Kim, J Kim, unpublished data

Standard vs modified fluoroscopy for AF ablation



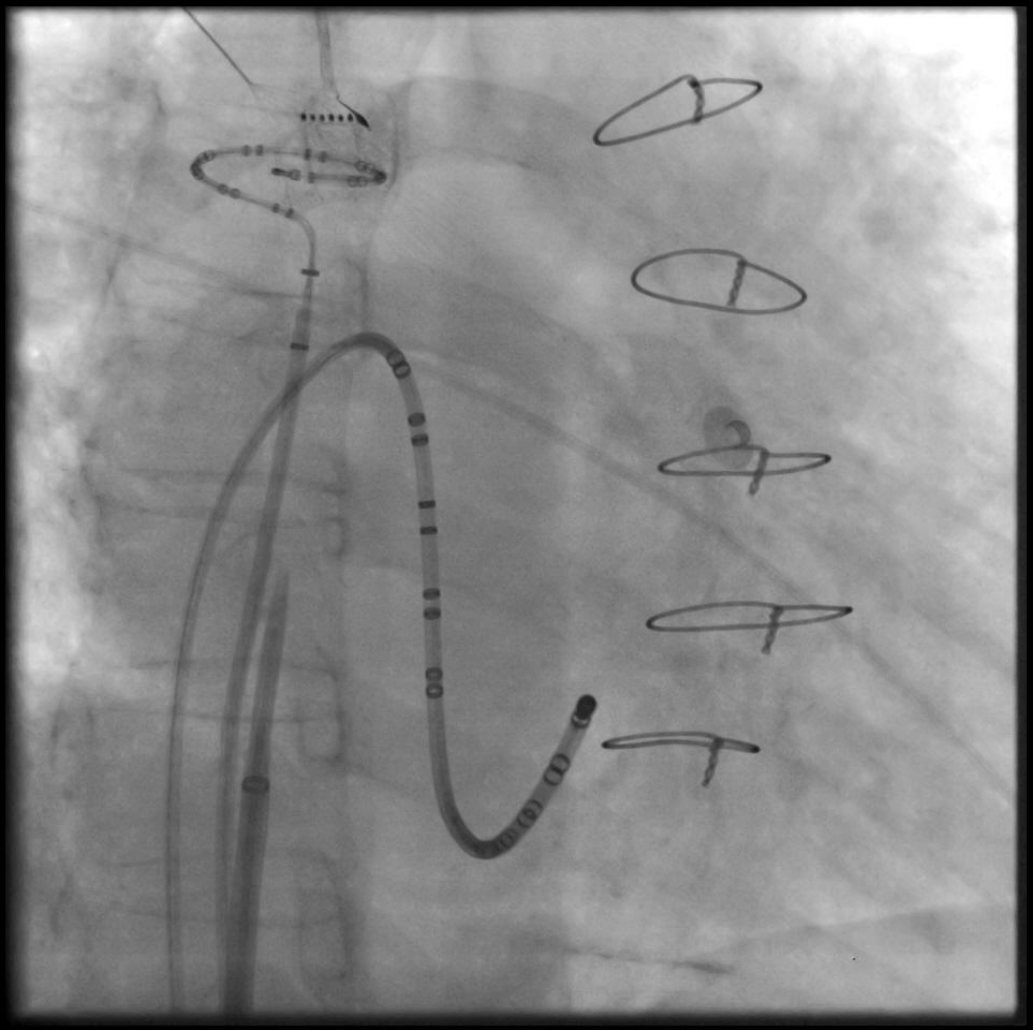


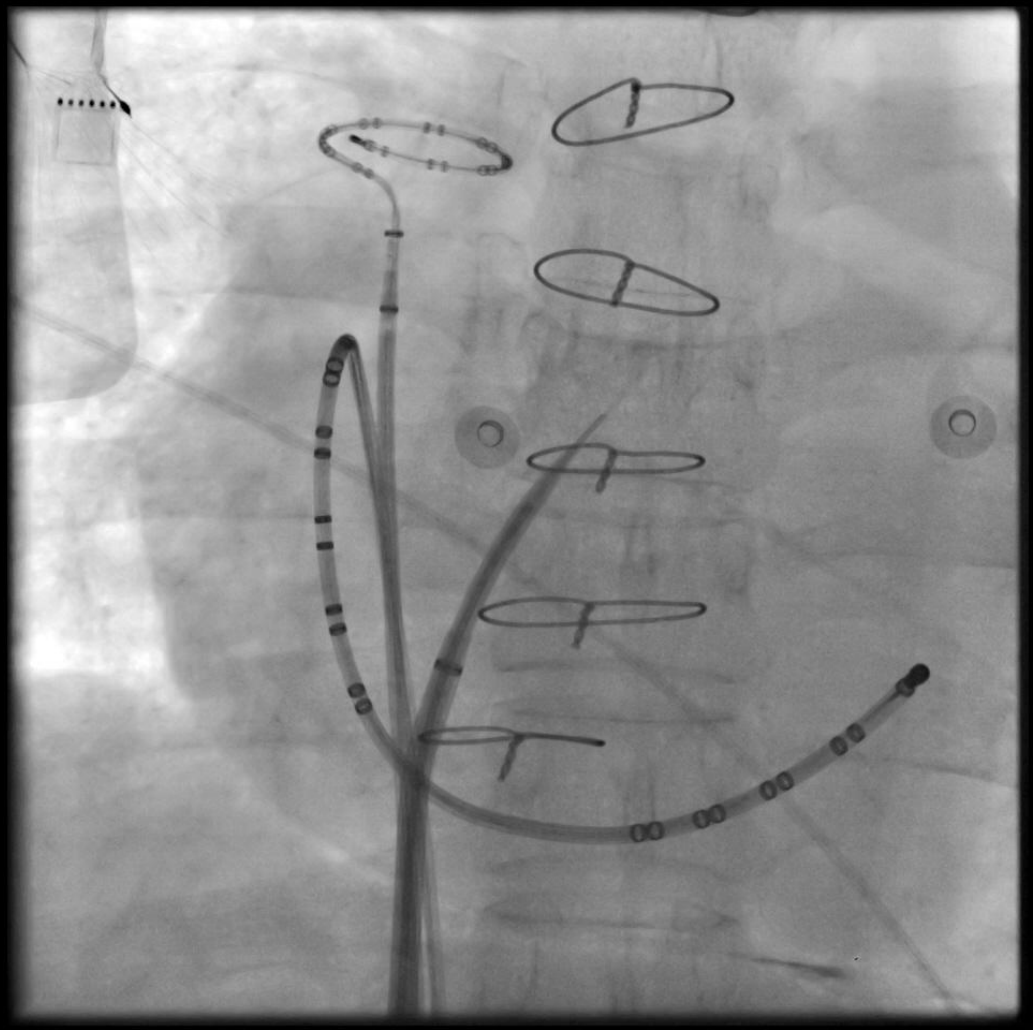
4 pulses per second
maximal collimation to the LA

Schneider R, Herz, 2015;40:883-91

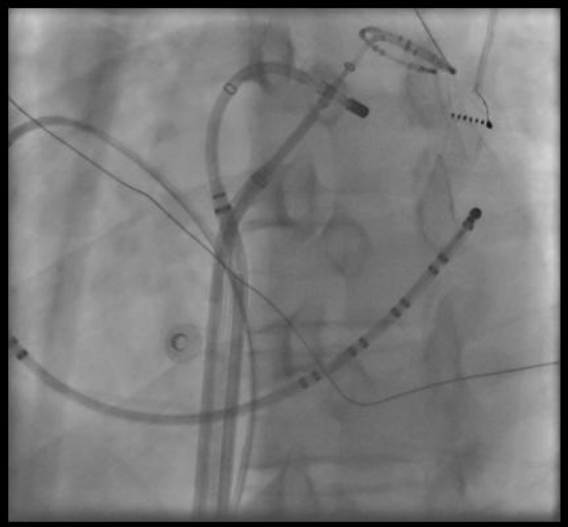
Why I use fluoroscopy in AF ablation?

1. Posterior puncture is only possible with use of fluoroscopy.

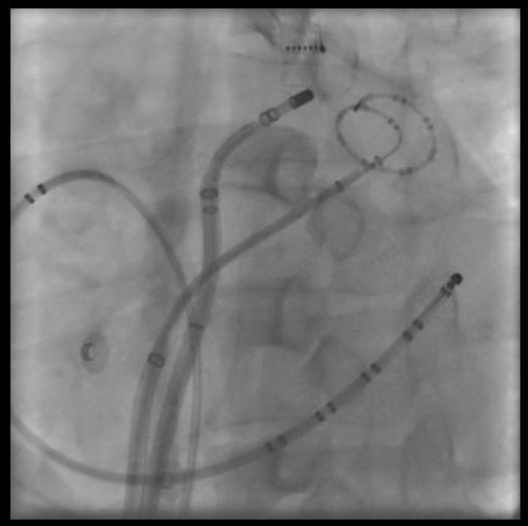




2. Catheter-sheath combination increase contact force and stability



LSPV anterior wall

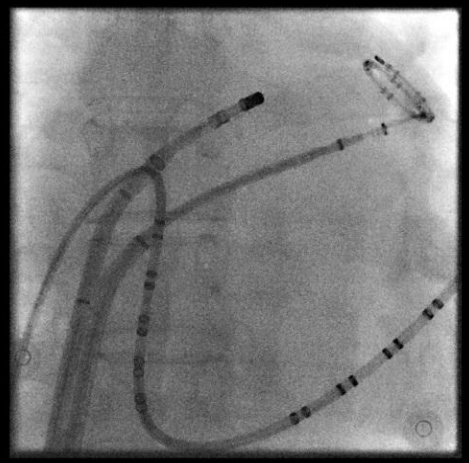
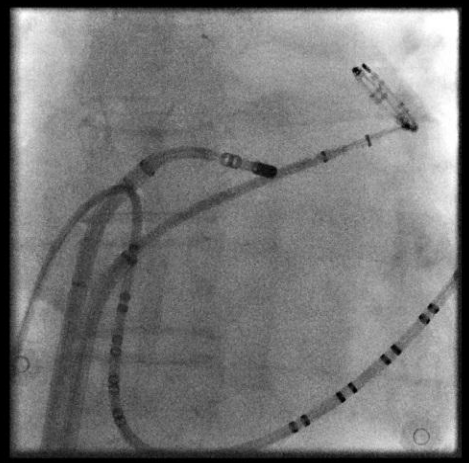
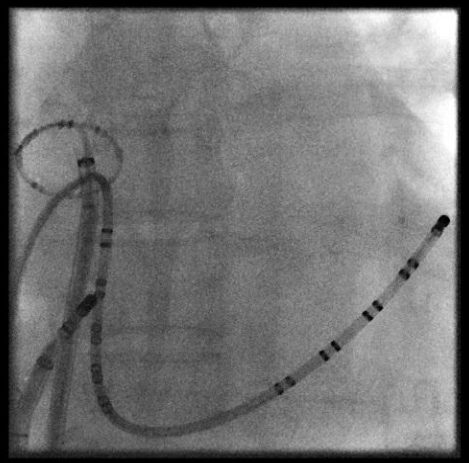
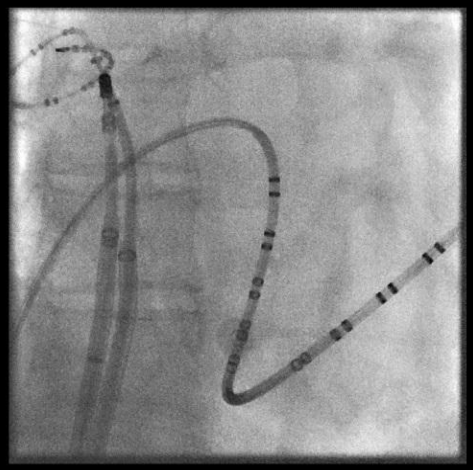
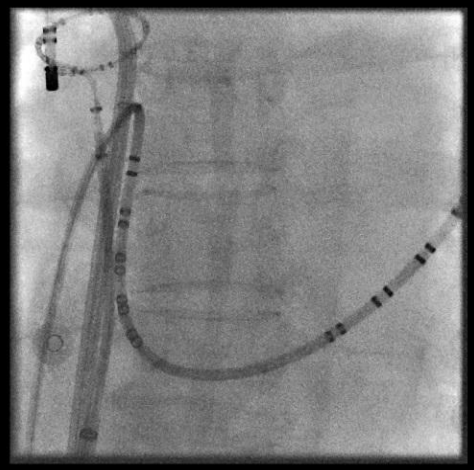


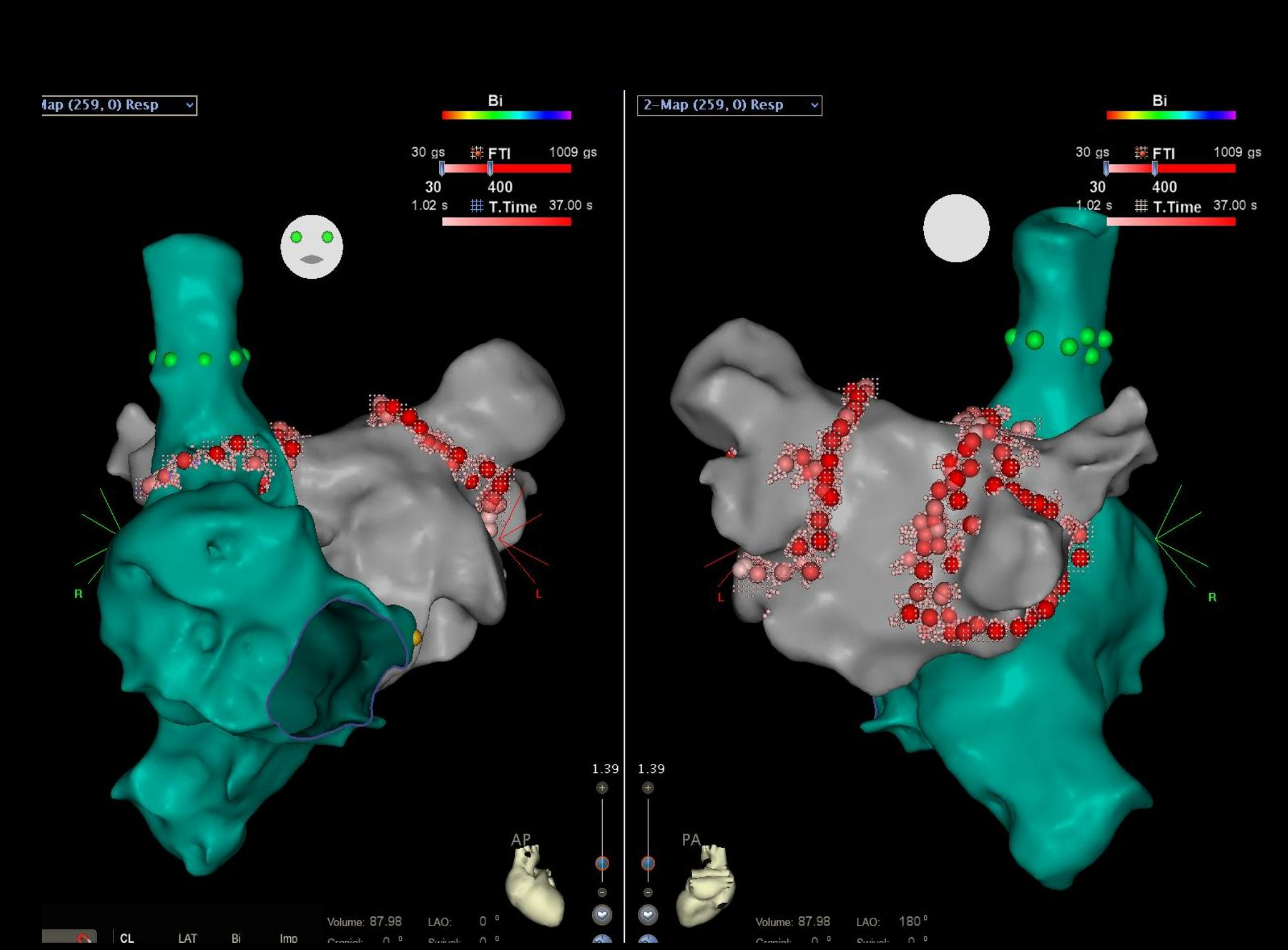
LSPV roof

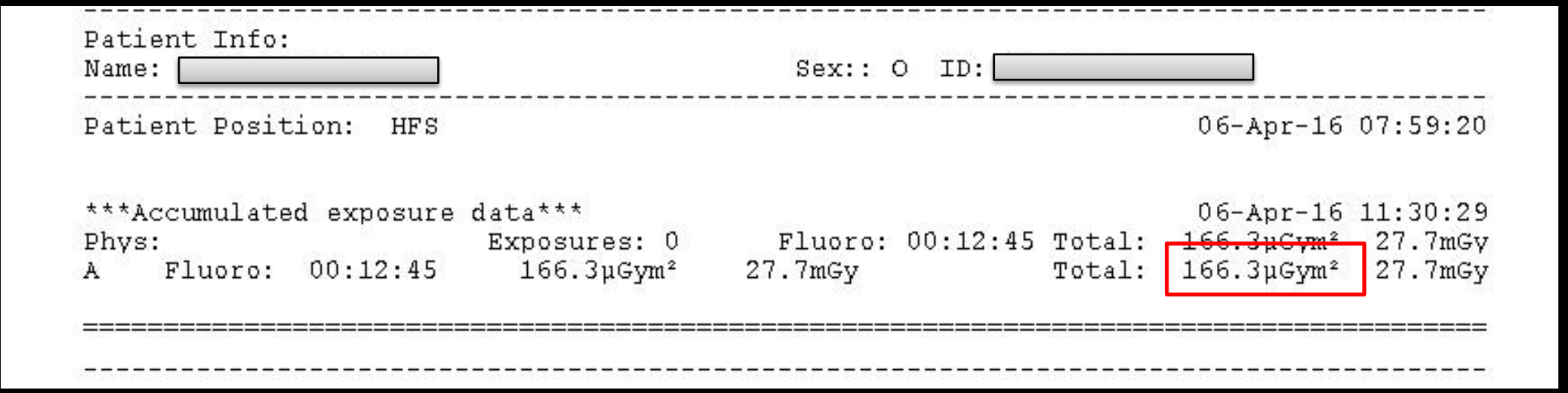
RSPV top

3. Rapid detection of cardiac tamponade is possible!

56/F, PsAF, LA 44 mm, BMI=25.64


Map (259, 0) Resp
Bi
30 gs
FTI
1009 gs
30
400
1.02 s
T.Time
37.00 s
R
L
1.39
AP
Volume: 87.98
LAO: 0 °
CL
LAT
Bi
Imp
2-Map (259, 0) Resp
Bi
30 gs
FTI
1009 gs
30
400
1.02 s
T.Time
37.00 s
L
R
1.39
PA
Volume: 87.98
LAO: 180 °


Patient Info:
Name: [redacted] Sex:: O ID: [redacted]
Patient Position: HFS 06-Apr-16 07:59:20
Accumulated exposure data 06-Apr-16 11:30:29
Phys: Exposures: 0 Fluoro: 00:12:45 Total: 166.3µGym² 27.7mGy
A Fluoro: 00:12:45 166.3µGym² 27.7mGy Total: 166.3µGym² 27.7mGy

uGym2 * 0.01=Gycm2

1.663 Gycm2

DAP * 0.180 (overweight)= ED

0.299 mSv

05-Apr-2016 13:32

Ward:
Physician: D131741
Operator: HJY

Total mAs 2686 Total DLP 155 mGycm

	Scan	KV	mAs / ref.	CTDIvol* mGy	DLP mGycm	TI s	cSL mm
Patient Position F-SP							
Topogram	1	120	35 mA	0.14 L	6	4.4	0.6
Pre 5mm	2	100	30	1.23 L	29	0.5	0.6
PreMonitoring Contrast	3	120	20	1.01 L	1	0.28	10.0
Monitoring	4	120	20	7.08 L	7	0.28	10.0
DS_30%~40%	11D	80	84 / 250	7.17 L	112	0.28	0.6

Medium	Type	Iodine Conc. mg/ml	Volume ml	Flow ml/s	CM Ratio
Contrast		0	0	0.0	100%
Saline			0	0.0	

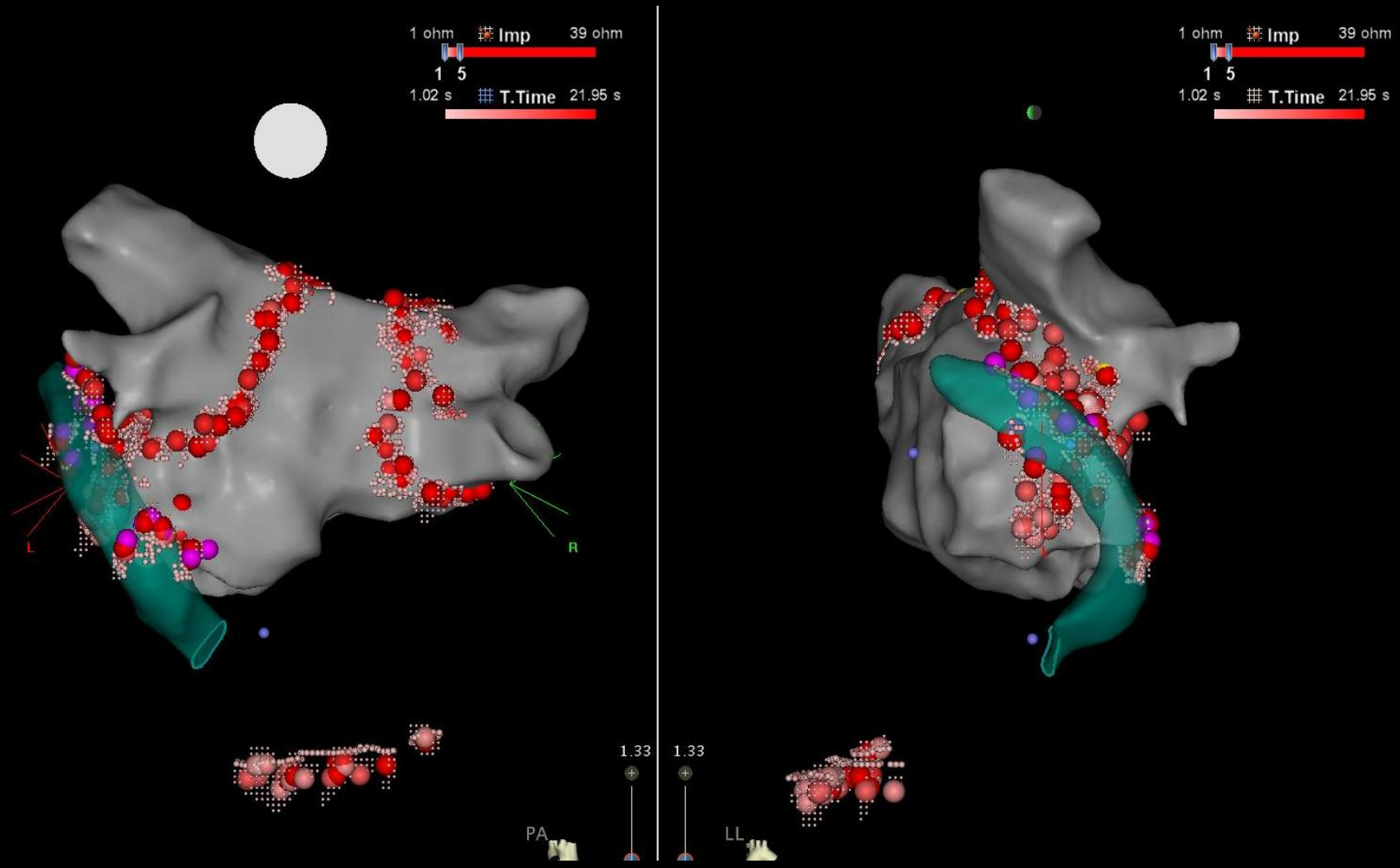
DLP*0.014=ED

Total ED=2.469

2.17 mSV

*: L = 32cm, S = 16cm

59/F BM=22 PsAF Spontaneous perimitral flutter



Fluroscopic time=12.02 min
DAP=103.9

ED=0.22 mSv

DLP=318 mGycm
CT ED=4.45 mSV

- If DAP is less than 500 uGym^2,

then, ED will be less than 1 mSv.

- If DLP of CT is less than 250 mGycm,

Then, ED will be less than 3.5 mSv.

50/M, PAF BMI=26.65, LA=36 mm

```
***Accumulated exposure data***                                  04-Apr-16 16:16:40
Phys:                      Exposures: 0      Fluoro: 00:15:25 Total:   203.3µGym²   31.4mGy
A    Fluoro:  00:15:25      203.3µGym²     31.4mGy               Total:   203.3µGym²   31.4mGy

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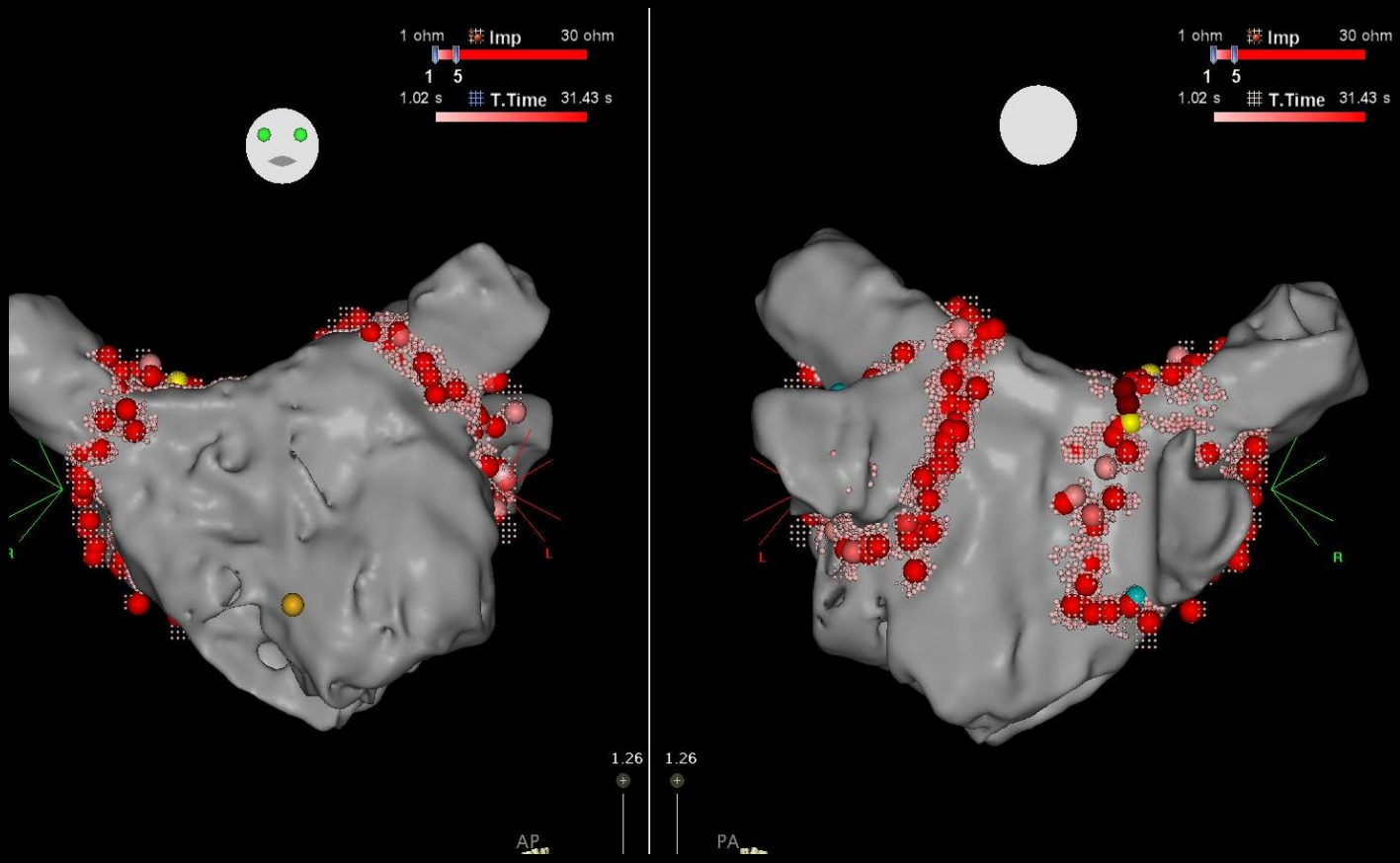
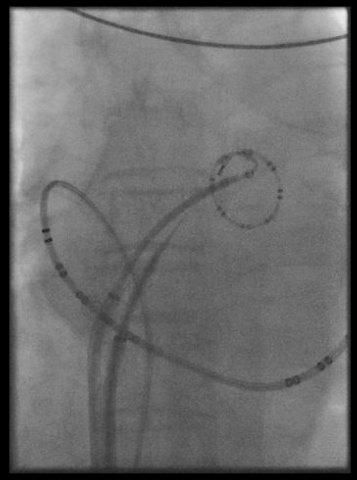
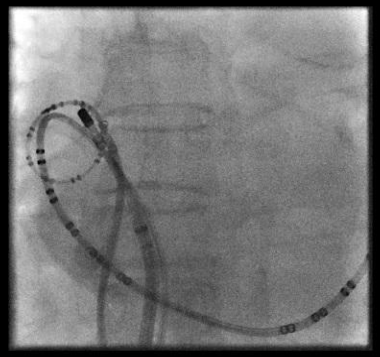


2.03 *0.180=
0.3654 mSv

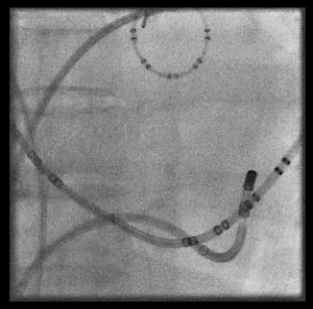
76/F, mild mitral stenosis, paroxysmal atrial fibrillation, H/o PVI + roof line ablation



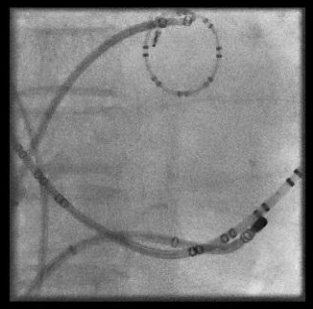
Transseptal
catheterization



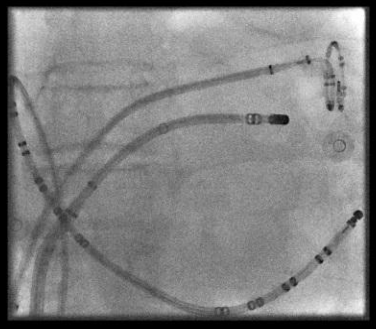
RSPV
isolation



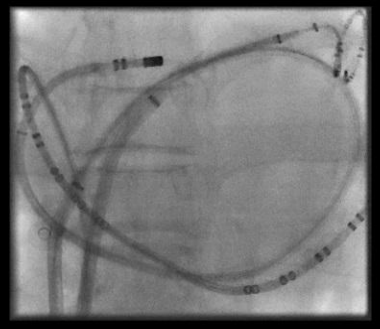
CS
ablation



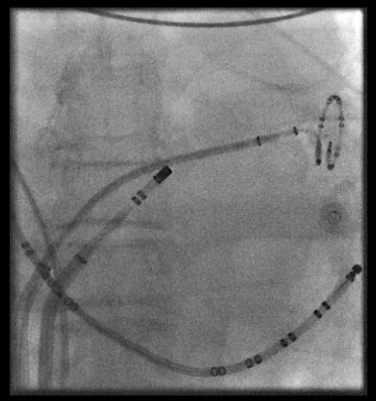
CS
ablation



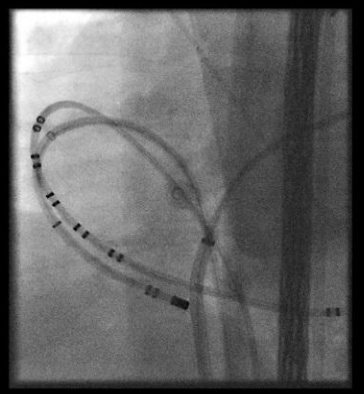
LPV
Carina ablaiton



R. Roof gap
ablation



LA ant wall
ablation



CTI
ablation

Accumulated exposure data 12-Apr-16 11:55:47

Phys:		Exposures: 0	Fluoro: 00:13:22	Total:	508.6µGym²	92.4mGy
A Fluoro:	00:13:22	508.6µGym²	92.4mGy	Total:	508.6µGym²	92.4mGy

==========

Summary (1)

- Intracardiac echocardiography
- General anesthesia
- Transesophageal echocardiography
- Carto UNIVU
- MEDIGUIDE

Summary (2)

- Simplify procedure
- Least number of diagnostic catheters
- Low pulse rate digital fluoroscopy
- No cineangiography
- No CT angiography
- No rotational angiography

Conclusion

- Advanced technologies help to reduce radiation exposure to patients and operators.
- Simple modifications of procedures (views, collimation and pulse rates) are simple methods to reduce radiation dose without additional cost.