ΚΑΡΔΙΟΛΟΓΙΚΗ ΚΛΙΝΙΚΗ Γ.Ν. ΛΕΥΚΩΣΙΑΣ ΟΚΥπΥ

Ομάδα Εργασίας Καρδιακών Αρρυθμιών, Βηματοδότησης & Ηλεκτροφυσιολογίας της ΚΕΚ

ΚΑΡΔΙΑΚΕΣ ΑΡΡΥΘΜΙΕΣ

Νέες Εξελίξεις

ΥΠΟ ΤΗΝ ΑΙΓΙΔΑ

Σάββατο 16 Σεπτεμβρίου 2023

Νέες εξελίξεις στην κατάλυση κολπικής μαρμαρυγής: Cryoablation, Pulse Field Ablation

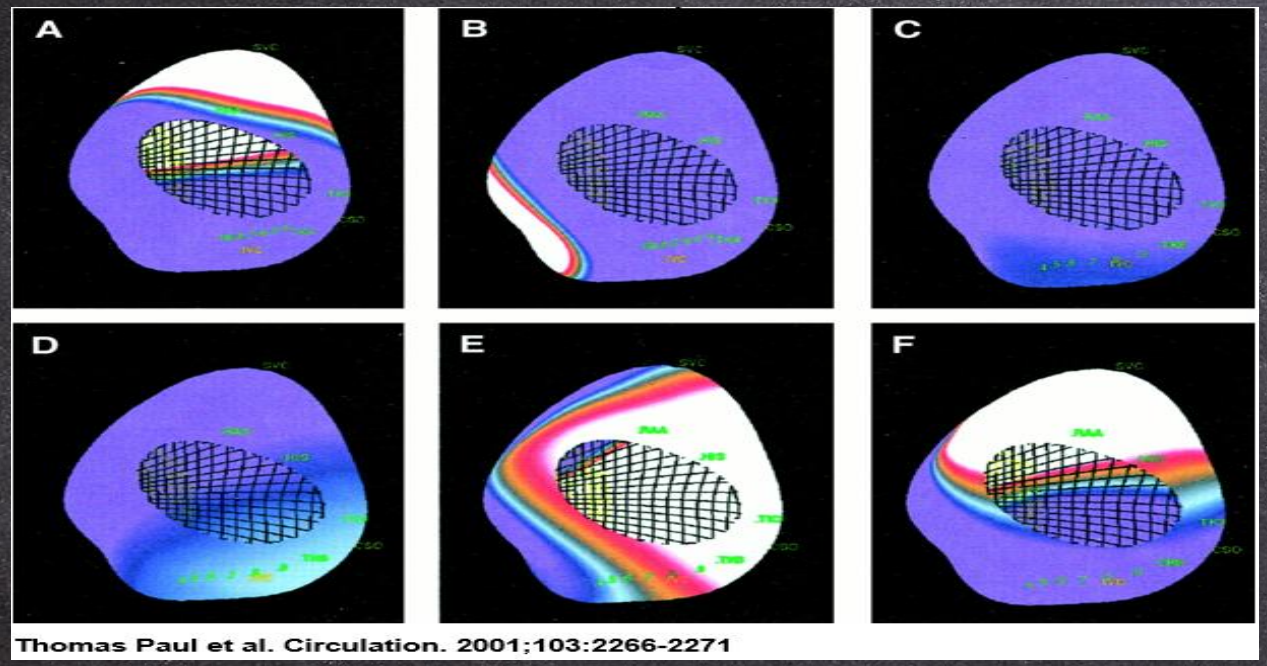
Γιώργος Ανδρικόπουλος, MD, PhD, FESC, FEHRA
Α Καρδιολογική Κλινική/Ηλεκτροφυσιολογίας Βηματοδότησης
«Ερρίκος Ντυνάν» Hospital Center, Αθήνα

Presenter Disclosure Information

The presenter has received honoraria for participation in lectures and advisory boards from the following pharmaceutical and biotechnology companies:

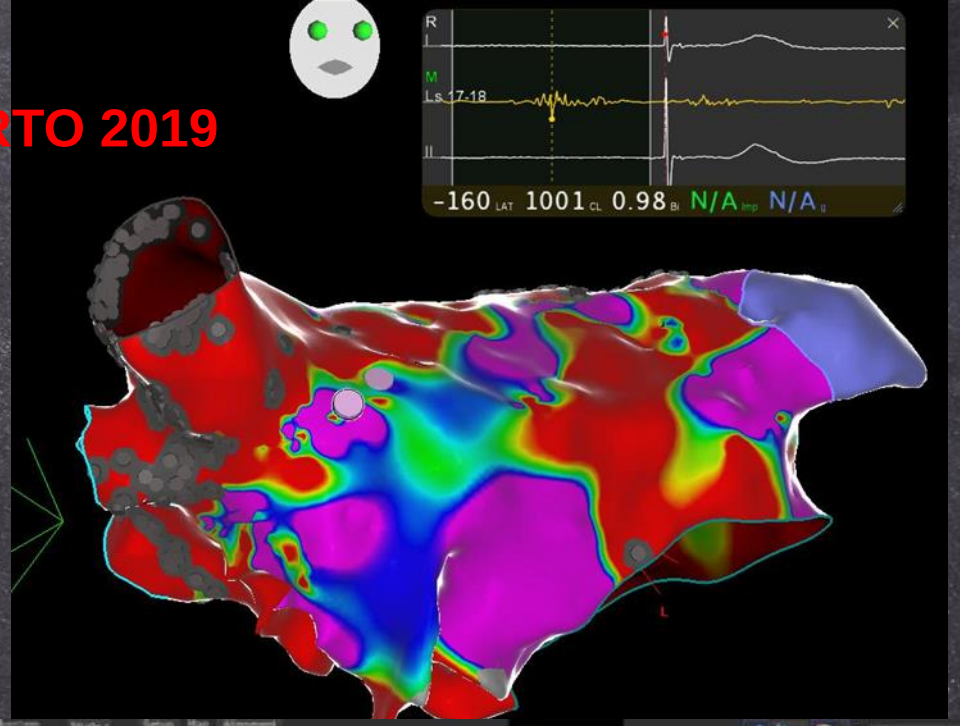
- *Abbot*
- *AstraZeneca,*
- *Bard,*
- *Bayer Healthcare,*
- *Boehringer Ingelheim,*
- *Boston Scientific,*
- *Bristol-Myers Squibb,*
- *ELPEN,*
- *Galenica,*
- *Lilly,*
- *Medtronic,*
- *Menarini,*
- *MSD,*
- *Pfizer,*
- *Sanofi,*
- *Servier,*
- *Unifarma,*
- *Vianex.*

ENSITE 1999



Thomas Paul et al. Circulation. 2001;103:2266-2271

CARTO 2019



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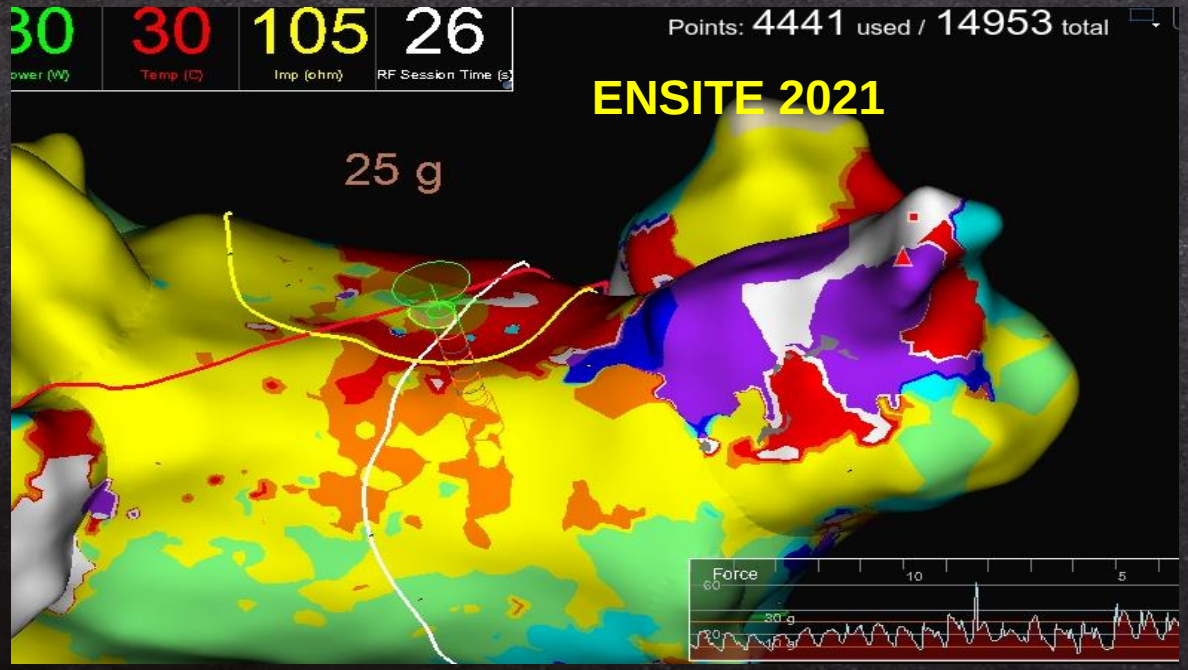
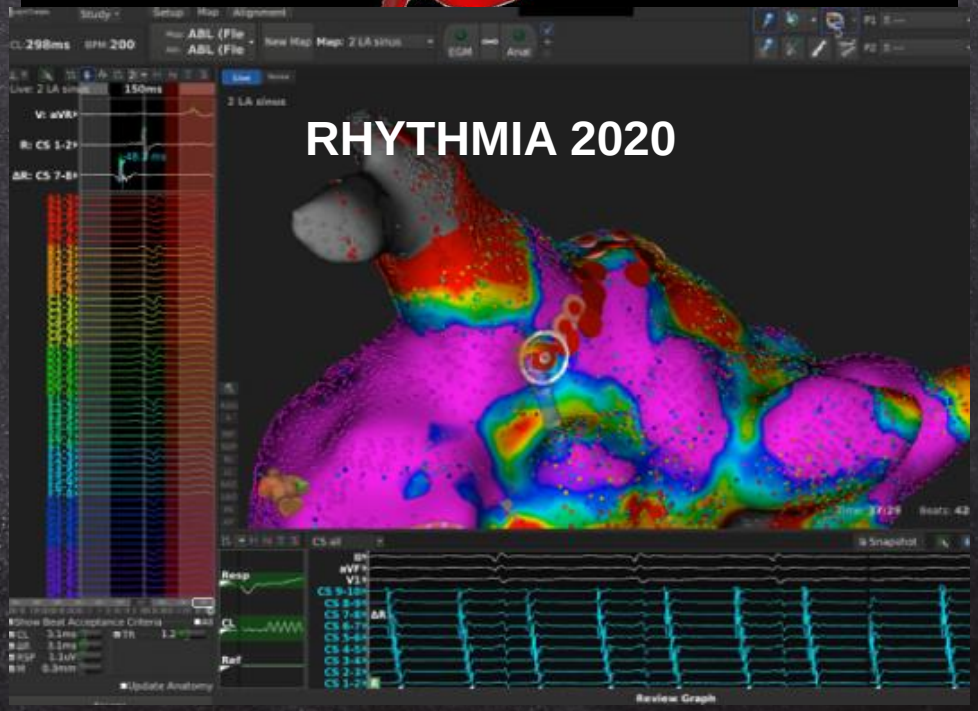


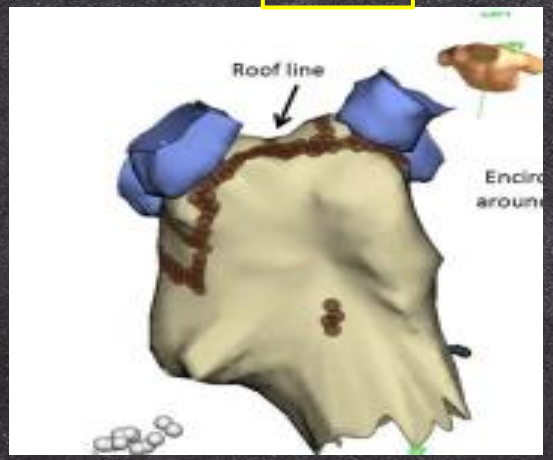
RHYTHMIA 2020



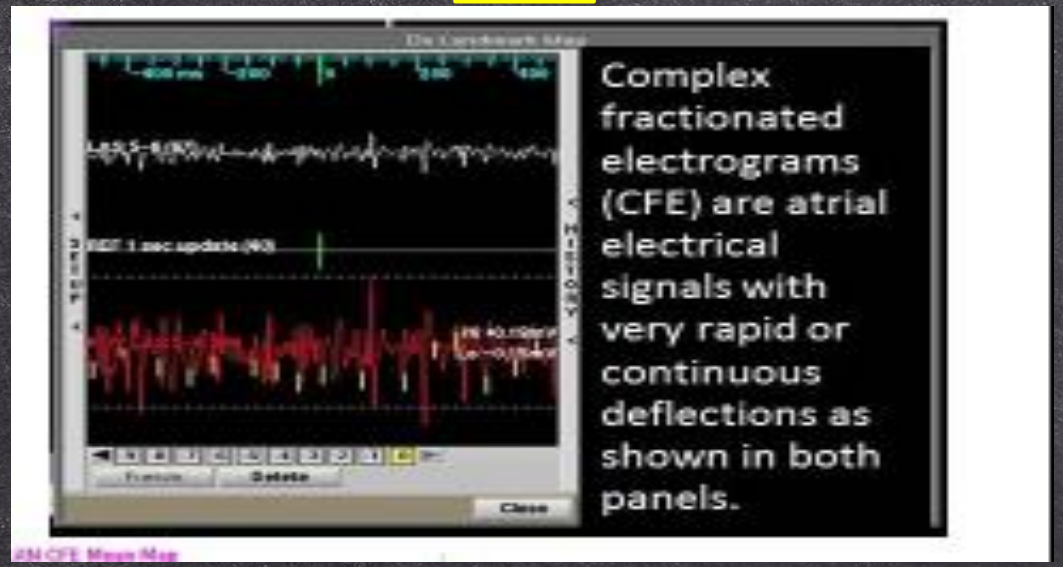
Ablation of AF

What to do beyond PVI isolation?

LINES

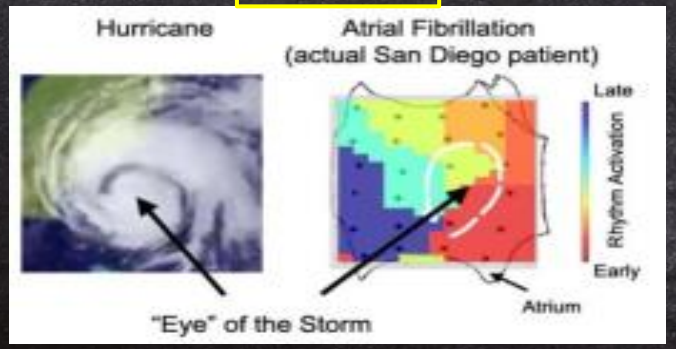


CAFE

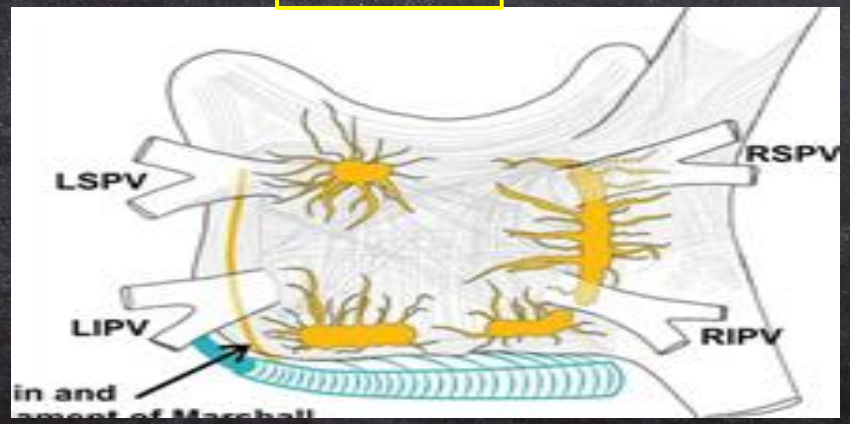


Non-PV triggers

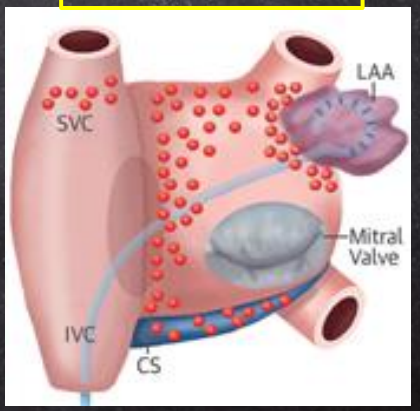
ROTORS



GANGLIA

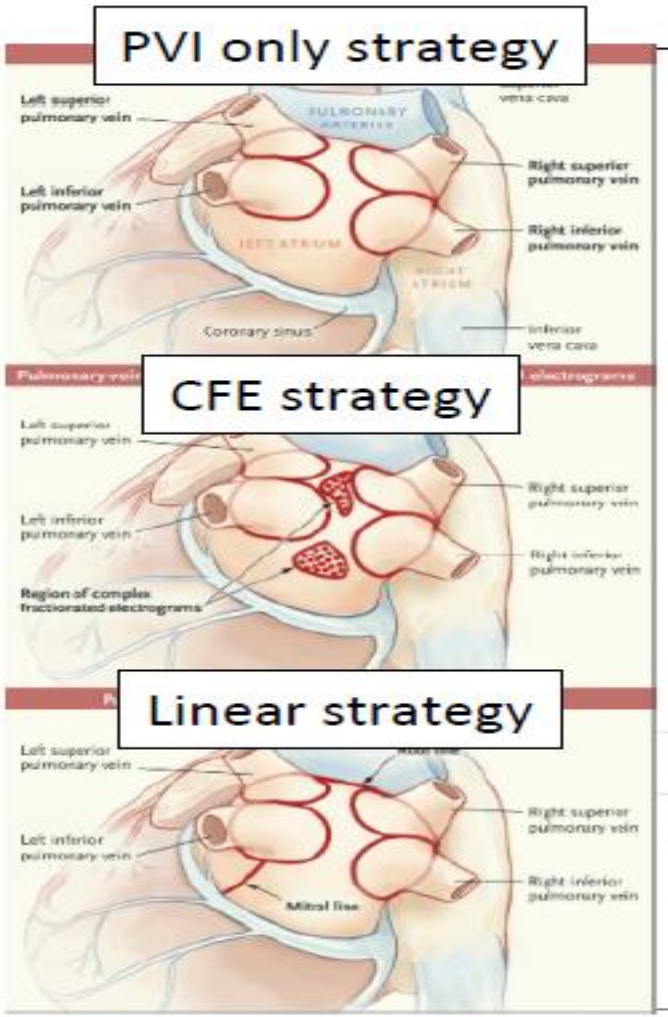


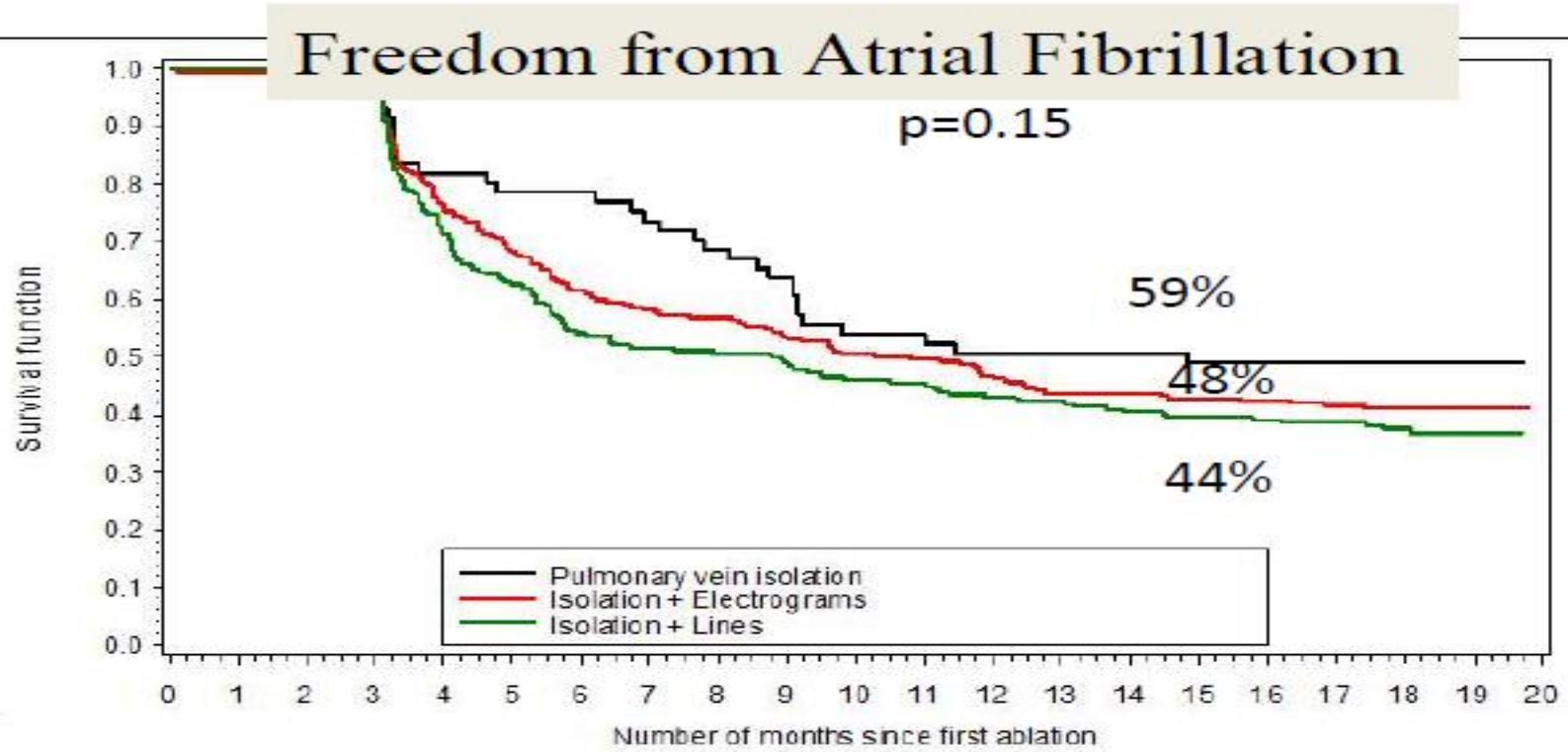
LAA isolation



Catheter Ablation for Persistent AF

The STAR AF 2 - Randomized Trial (n=589)





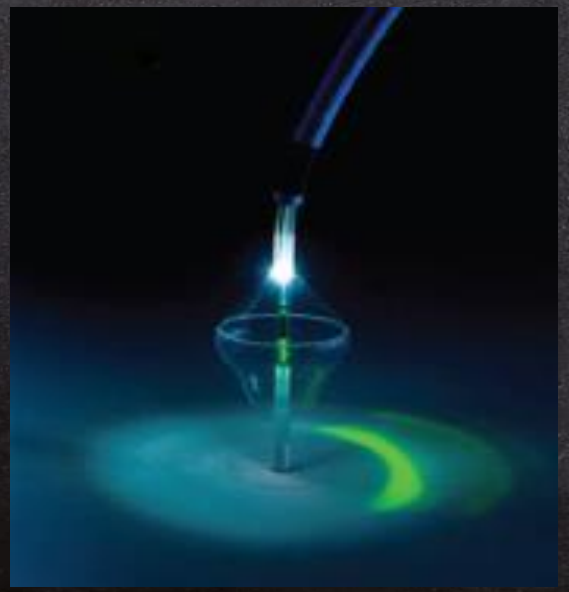
No. at Risk

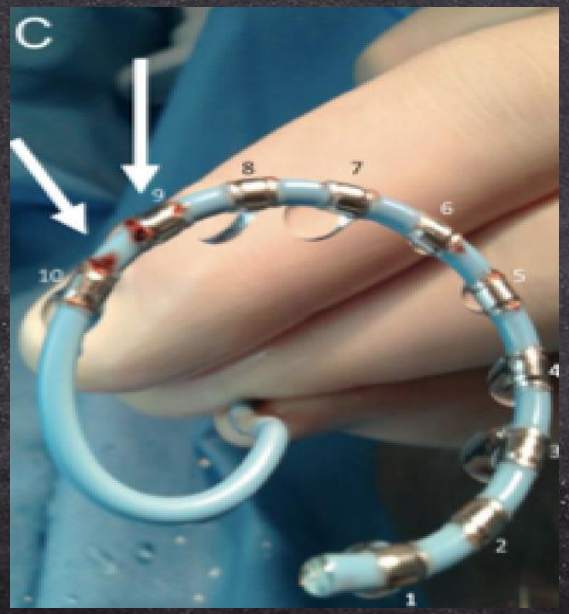
Pulmonary vein isolation	61	60	50	41	36	23
Isolation + Electrograms	244	242	161	137	124	72
Isolation + Lines	244	240	152	133	115	57

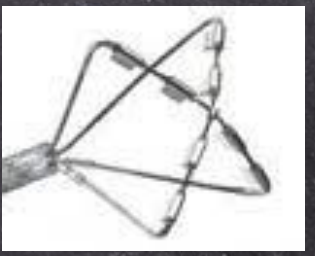
Verma A, et a. N Engl J Med 2015; 372:1812-1822

One for ALL and … all for one purpose?

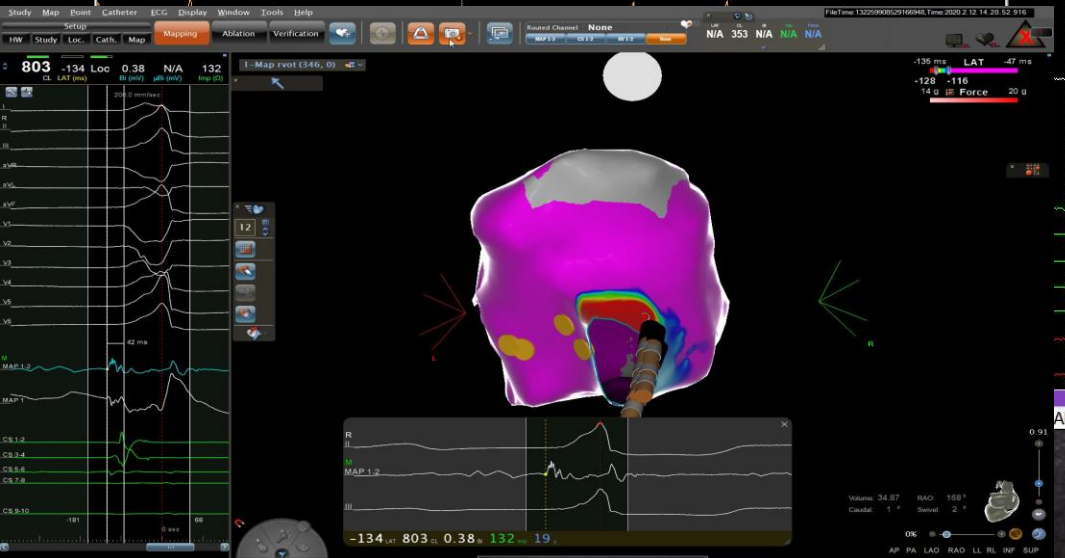
Laser balloon





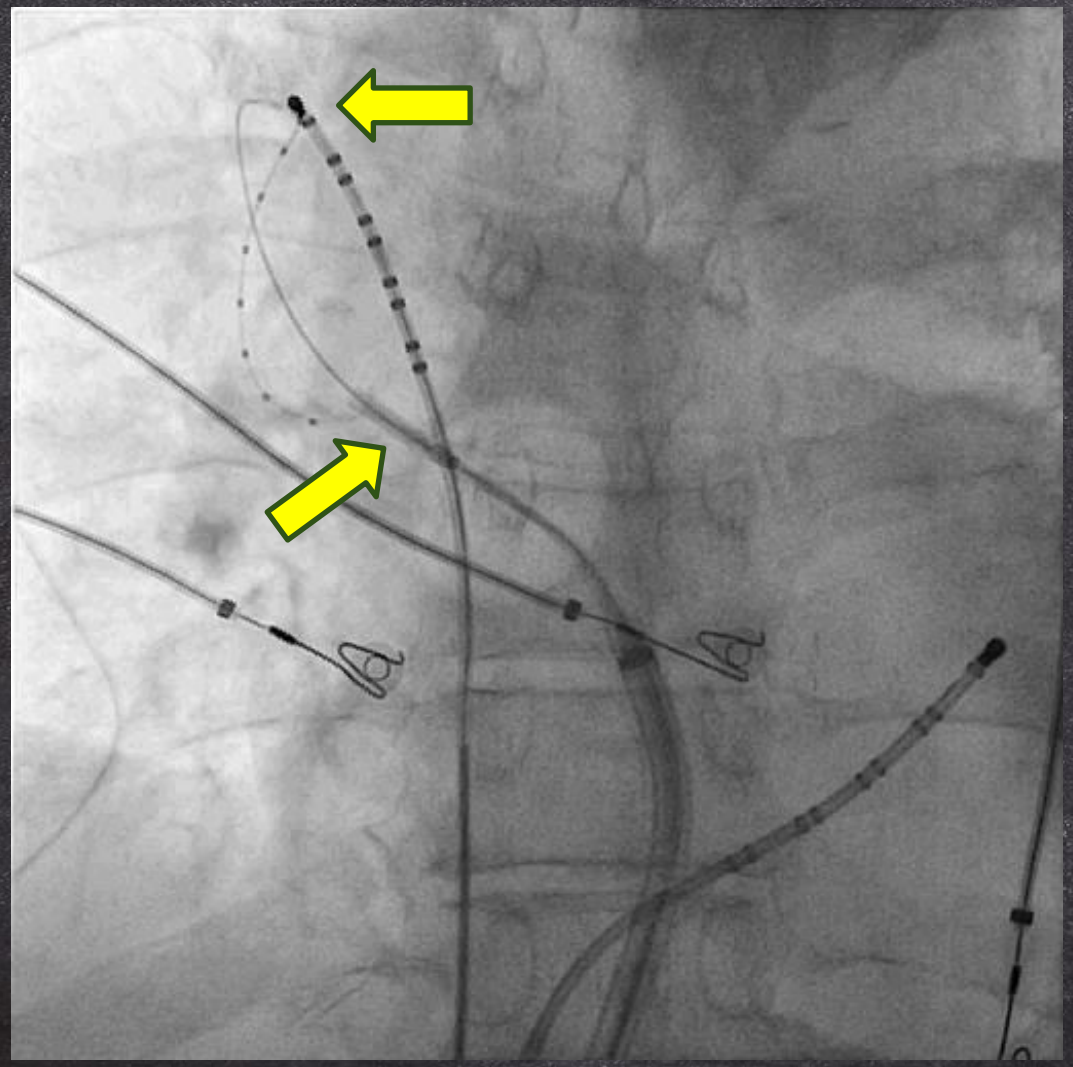


Cryoablation in a young female patient with parahisian PVCs (>30.000/24h)

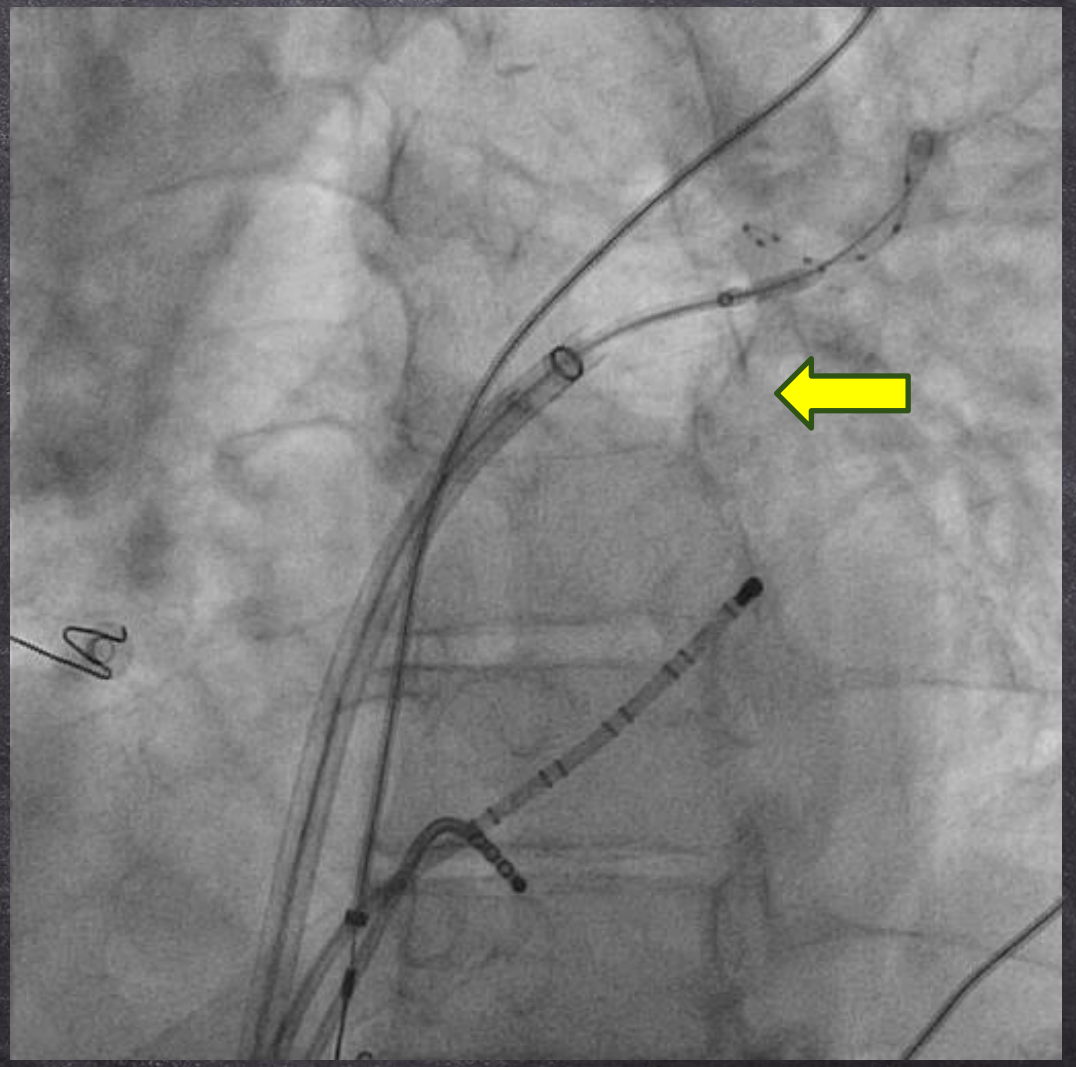


Αρχείο Γ. Ανδρικόπουλου, 2020

Απομόνωση πνευμονικών φλεβών με Cryoballoon



Δεξιά άνω πνευμονική φλέβα



Αριστερή άνω πνευμονική φλέβα

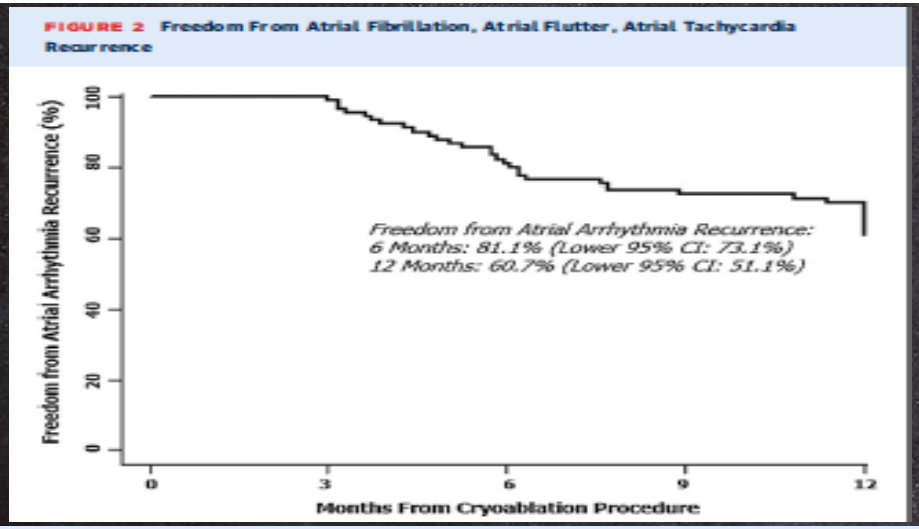
Αρχείο Γ. Ανδρικόπουλου, 2014

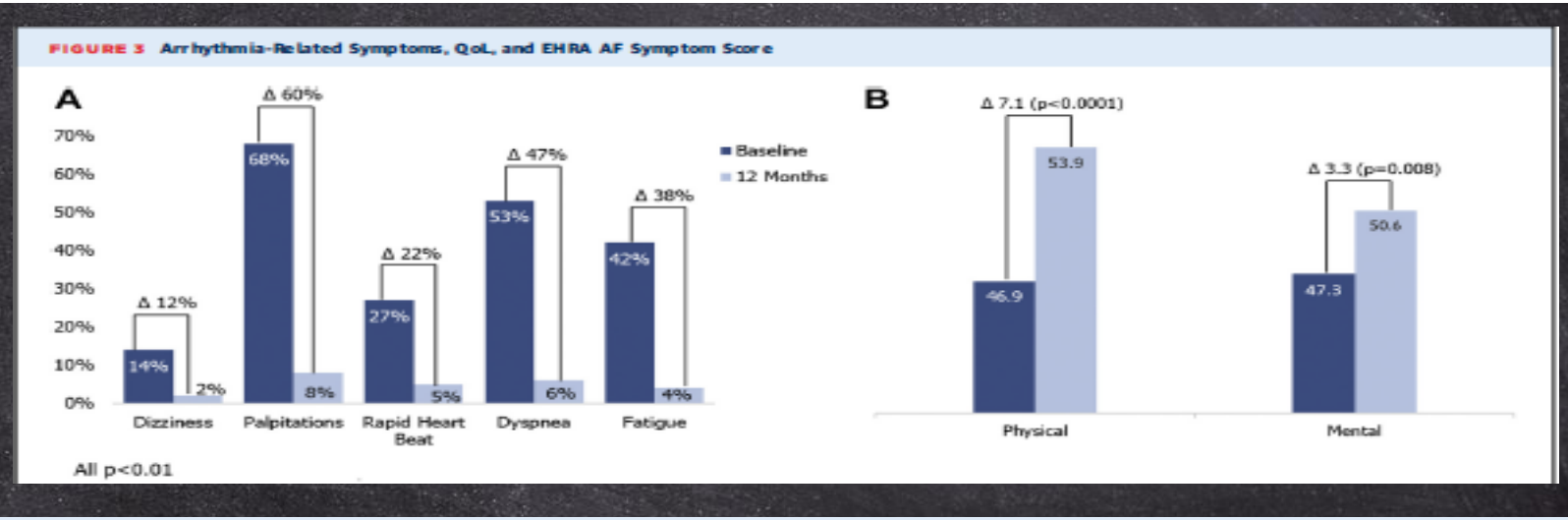
Single-Procedure Outcomes and Quality-of-Life Improvement 12 Months Post-Cryoballoon Ablation in Persistent Atrial Fibrillation

Results From the Multicenter CRYO4PERSISTENT AF Trial

Serge Boveda, MD,[a] Andreas Metzner, MD,[b] Dinh Q. Nguyen, MD,[c] K.R. Julian Chun, MD,[d] Konrad Goehl, MD,[e] George Noelker, MD,[f] Jean-Claude Deharo, MD,[g] George Andrikopoulos, MD,[h] Tillman Dahme, MD,[i] Nicolas Lellouche, MD,[j] Pascal Defaye, MD[k]

(JACC Electrophysiology in press 2018)

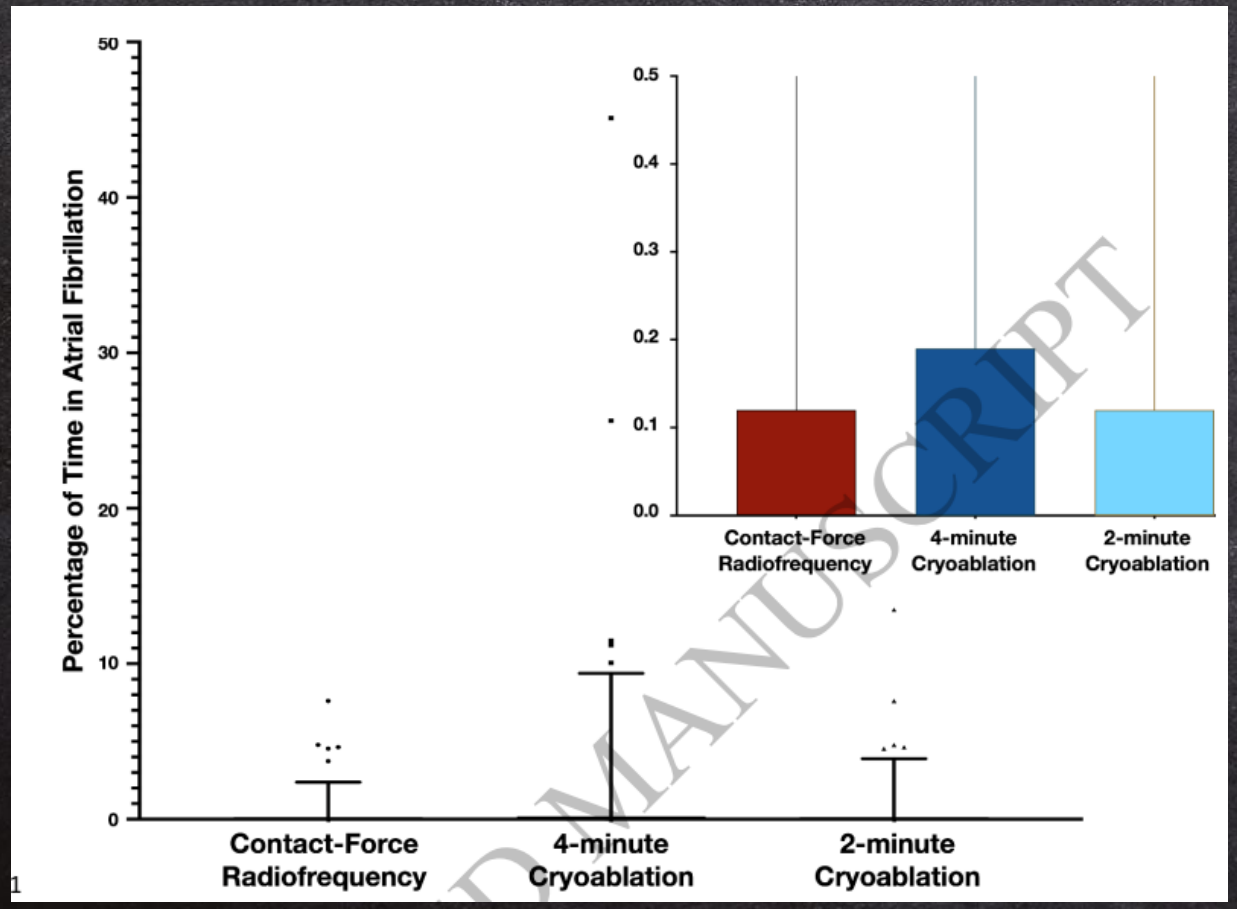


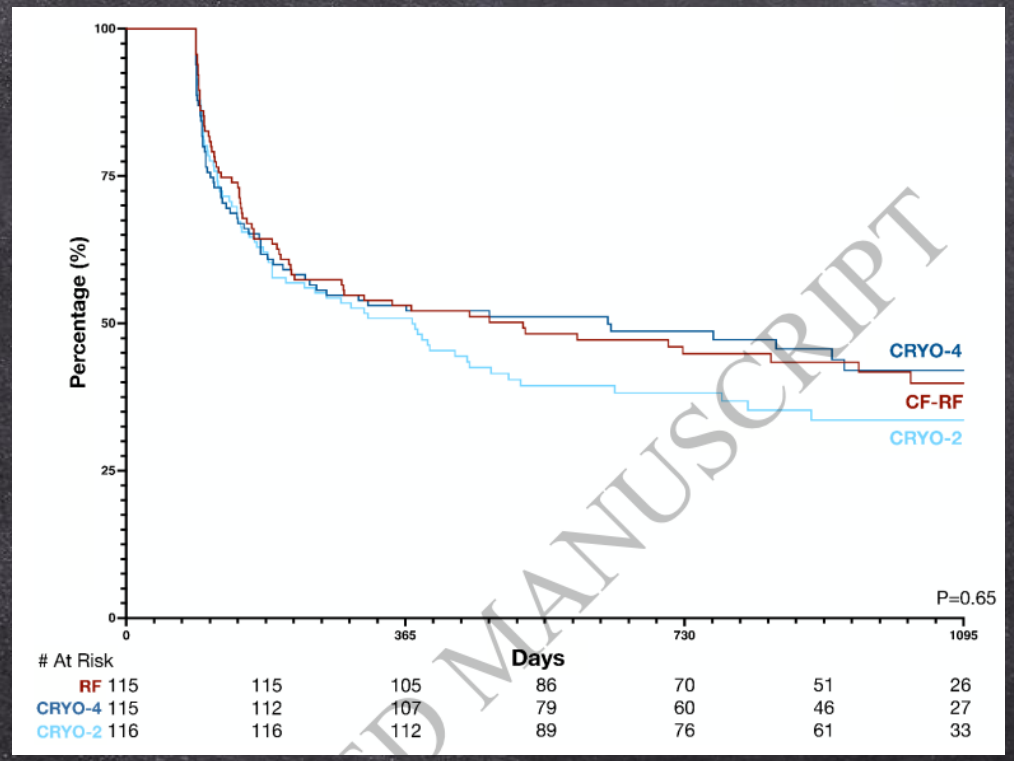


CONCLUSIONS Cryoballoon ablation for treatment of PerAF demonstrated 61% single-procedure success at 12 months post-ablation in addition to significant reduction in arrhythmia-related symptoms and improved quality of life. (Cryoballoon Ablation for Early Persistent Atrial Fibrillation [Cryo4 Persistent AF]; NCT02213731). (J Am Coll Cardiol EP 2018;■:■–■)

Atrial fibrillation progression after cryoablation versus radiofrequency ablation: the CIRCA-DOSE trial

346 patients with drug-refractory paroxysmal AF were enrolled and randomized to contact-force guided radiofrequency ablation (CF-RF ablation, n = 115), 4-minute cryoballoon ablation (CRYO-4, n = 115), or 2-minute cryoballoon ablation (CRYO-2, n = 116). Implantable cardiac monitors placed at study entry were used for follow-up.





Andrade J., et al. Atrial fibrillation progression after cryoablation versus radiofrequency ablation: the CIRCA-DOSE trial. Eur Heart J 2023 Aug 25;ehad572.

Atrial fibrillation progression after cryoablation versus radiofrequency ablation: the CIRCA-DOSE trial

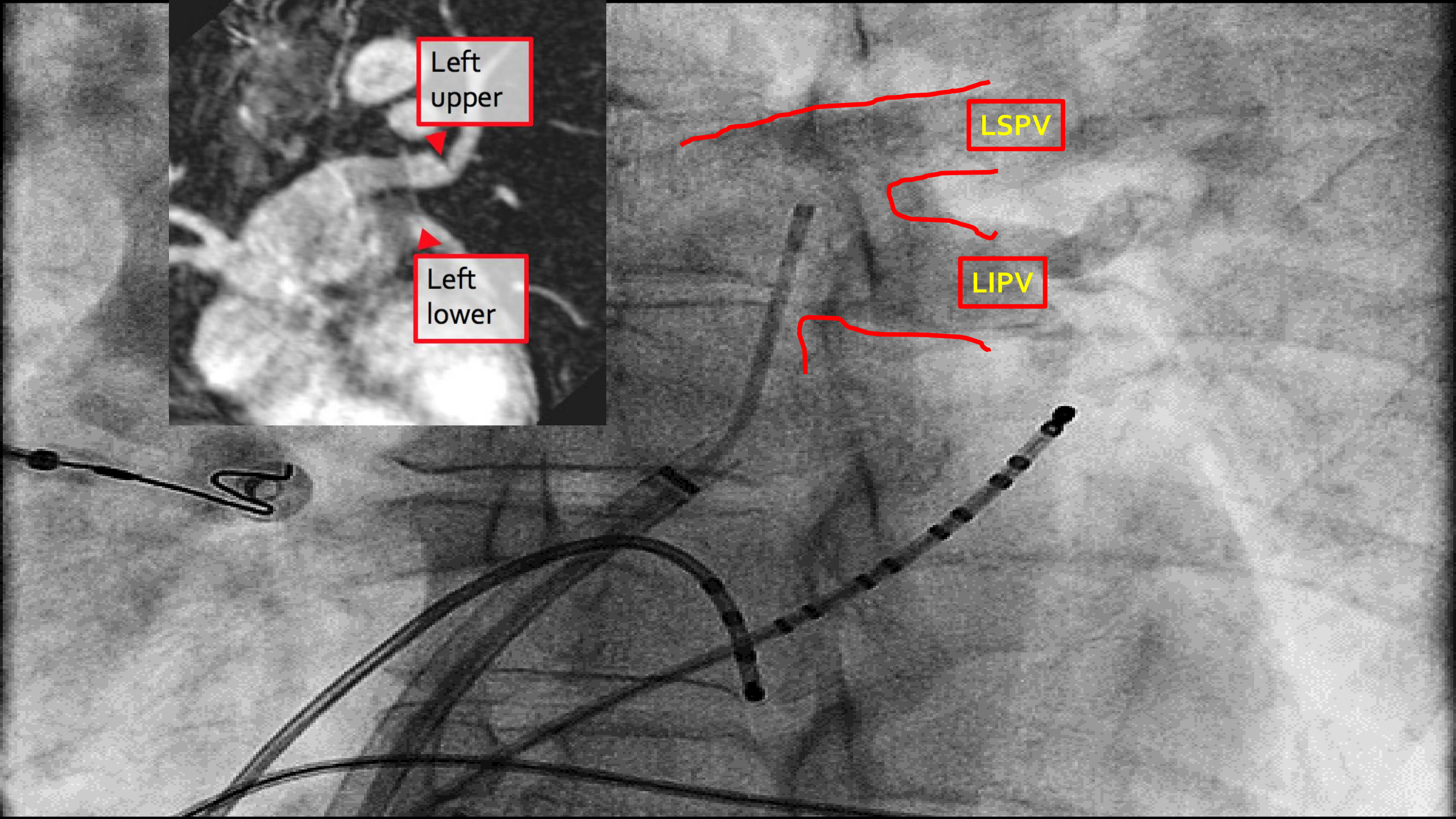
346 patients with drug-refractory paroxysmal AF were enrolled and randomized to contact-force guided radiofrequency ablation (CF-RF ablation, n = 115), 4-minute cryoballoon ablation (CRYO-4, n = 115), or 2-minute cryoballoon ablation (CRYO-2, n = 116). Implantable cardiac monitors placed at study entry were used for follow-up.

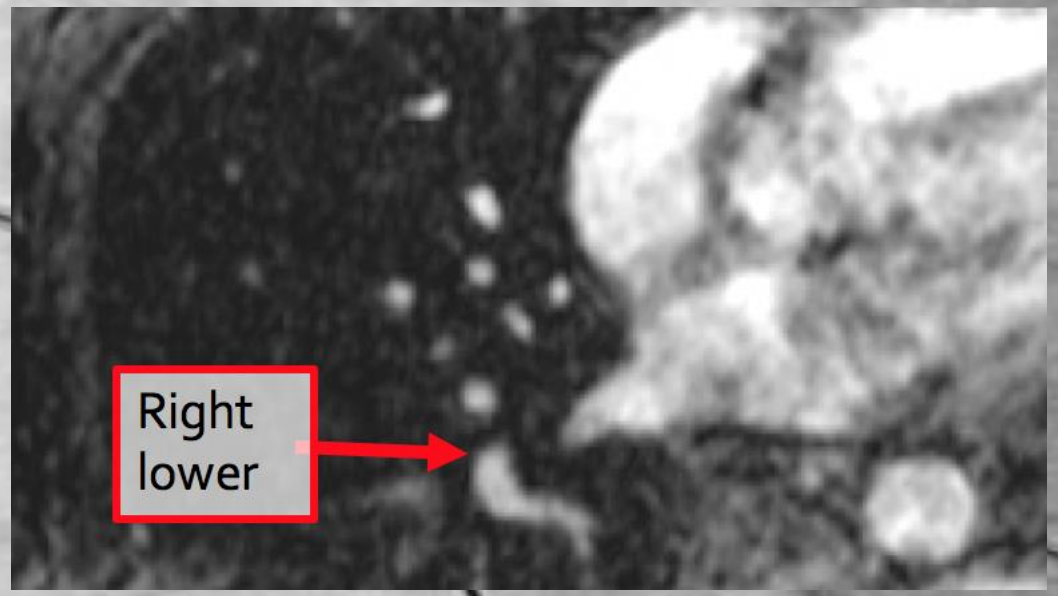
Clinical Perspectives:

1. **What is new?**
   a. Progression from paroxysmal to persistent atrial fibrillation was observed less frequently after pulmonary vein isolation using radiofrequency energy compared to cryoballoon ablation.
   b. Significant differences in the rate of atrial fibrillation progression were observed between ablation technologies despite similar rates of atrial fibrillation recurrence, and similar substantial reductions in atrial fibrillation burden.
   c. In those who progressed to persistent atrial fibrillation prior to ablation, catheter ablation enabled "regression" to paroxysmal forms of the arrhythmia.

2. **What are the clinical implications?**
   a. Pulmonary vein isolation using radiofrequency energy is more effective than cryoballoon ablation in preventing "progression" to persistent atrial fibrillation and enabling regression to paroxysmal atrial fibrillation.
   b. Given the differences observed herein, it cannot be assumed that all ablation technologies and modalities are equally efficacious in modifying disease progression.
   c. The disconnect between binary recurrence, burden reduction, and atrial fibrillation progression suggests that the latter should be considered as an independent endpoint of clinical trials.

Andrade J., et al. Atrial fibrillation progression after cryoablation versus radiofrequency ablation: the CIRCA-DOSE trial. Eur Heart J 2023 Aug 25;ehad572.


Left
upper
Left
lower
LSPV
LIPV



CRYOABLATION CONS

1. Uncommon anatomy
2. Complications from esophagus possible
3. Phrenic nerve palsy
4. Painful
5. Reconnection

RIPV

3D Printed atria before AF ablation (The 3-D GALA study)

3D printing for ablation planning in patients undergoing atrial fibrillation ablation: Preliminary results of the pilot randomized 3D GALA trial.

Terentes-Printzios D, Xydis P, Gourgouli I, Tampakis K, Pastromas S, Sikiotis A, Antonopoulos A, **Andrikopoulos G**, Tsioufis K, Vlachopoulos C.

Hellenic J Cardiol. 2023 May-Jun;71:64-66. doi: 10.1016/j.hjc.2022.12.004. Epub 2022 Dec 9.

Contents lists available at ScienceDirect

Hellenic Journal of Cardiology

journal homepage: http://www.journals.elsevier.com/hellenic-journal-of-cardiology/

Correspondence

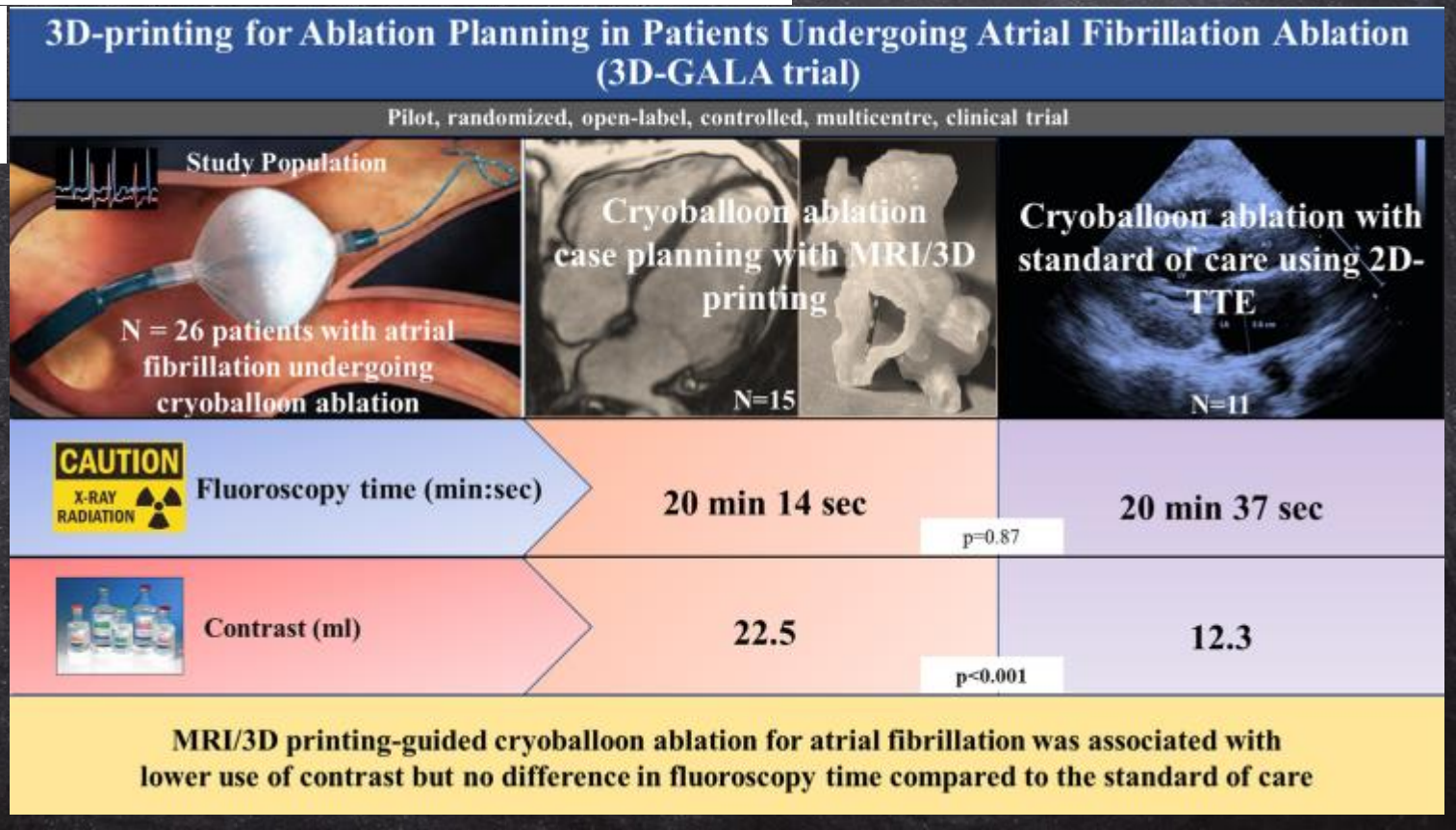
3D printing for ablation planning in patients undergoing atrial fibrillation ablation: Preliminary results of the pilot randomized 3D GALA trial

Terentes-Printzios D, Xydis P, Gourgouli I, Tampakis K, Pastromas S, Sikiotis A, Antonopoulos A, **Andrikopoulos G**, Tsioufis K, Vlachopoulos C.

Hellenic J Cardiol. 2022 Dec 9:S1109-9666(22)00178-6. doi: 10.1016/j.hjc.2022.12.004. Online ahead of

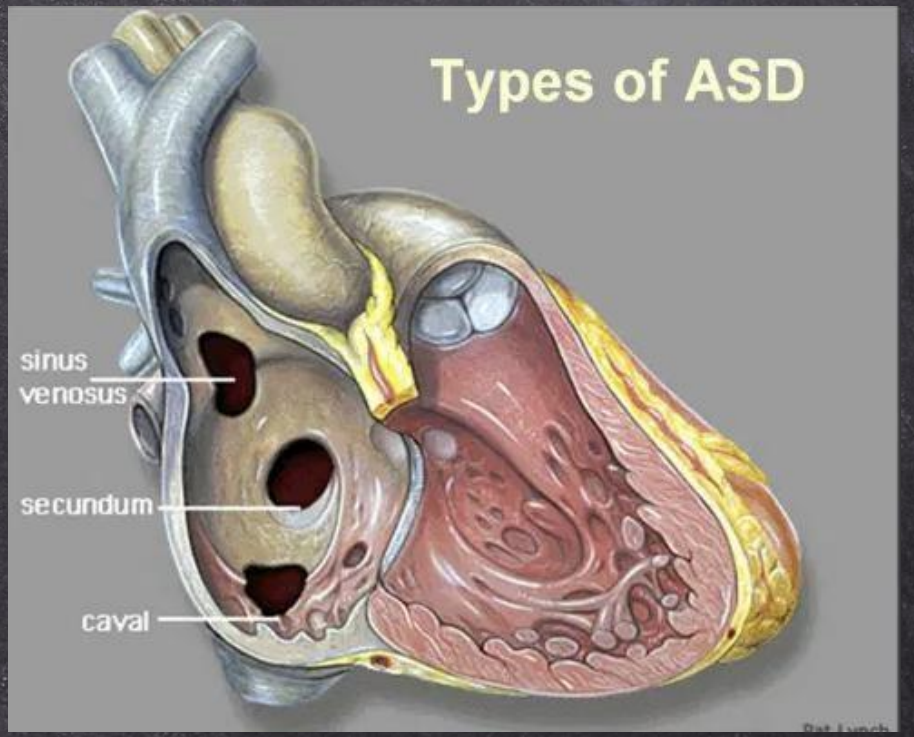
Table 1
Baseline characteristics and procedural results and variables reflecting relative procedural efficiency between case planning with combined MRI/3D printing versus standard of care using 2D-TTE.

Variables	No preprocedural imaging n = 11	MRI+3D model n = 15	*p* value
Age (years)	61.4 (13.3)	58.2 (13.4)	0.56
Gender, male	7 (64)	11 (73)	0.60
Weight (kg)	77.5 (13.4)	86.2 (12.4)	0.10
Height (cm)	172.6 (9.8)	176.7 (8.6)	0.28
Obesity, n (%)	4 (36)	4 (27)	0.60
Diabetes, n (%)	4 (36)	3 (20)	0.37
Hypertension, n (%)	5 (45)	6 (40)	0.78
Smoking, n (%)	6 (55)	2 (13)	**0.024**
History of CAD, n (%)	4 (36)	1 (7)	0.06
Persistent AF, n (%)	2 (18)	3 (20)	0.91
LVEF (%)	56.3 (4.9)	55.6 (11.1)	0.85
Left atrium size (mm)	38.6 (4.0)	40.6 (4.1)	0.23
Presence of MR, n	3 (27)	3 (20)	0.66
Presence of TR, n	2 (18)	1 (7)	0.36
Primary and secondary procedural outcomes			
Fluoroscopy time (min/sec)	20:14 (05:58)	20:37 (05:07)	0.87
Contrast (ml)	22.5 (6.5)	12.3 (4.7)	**<0.001**
Air Kerma (mGy)	495.1 (142.8)	483.4 (198.9)	0.87
Cryoballoon applications, n	4.7 (0.8)	5 (0.7)	0.36



Ασθενής 36 ετών με παροξυσμική κολπική μαρμαρυγή υποβάλλεται σε MRI στο πλαίσιο προετοιμασίας επέμβασης κατάλυσης κολπικής μαρμαρυγής

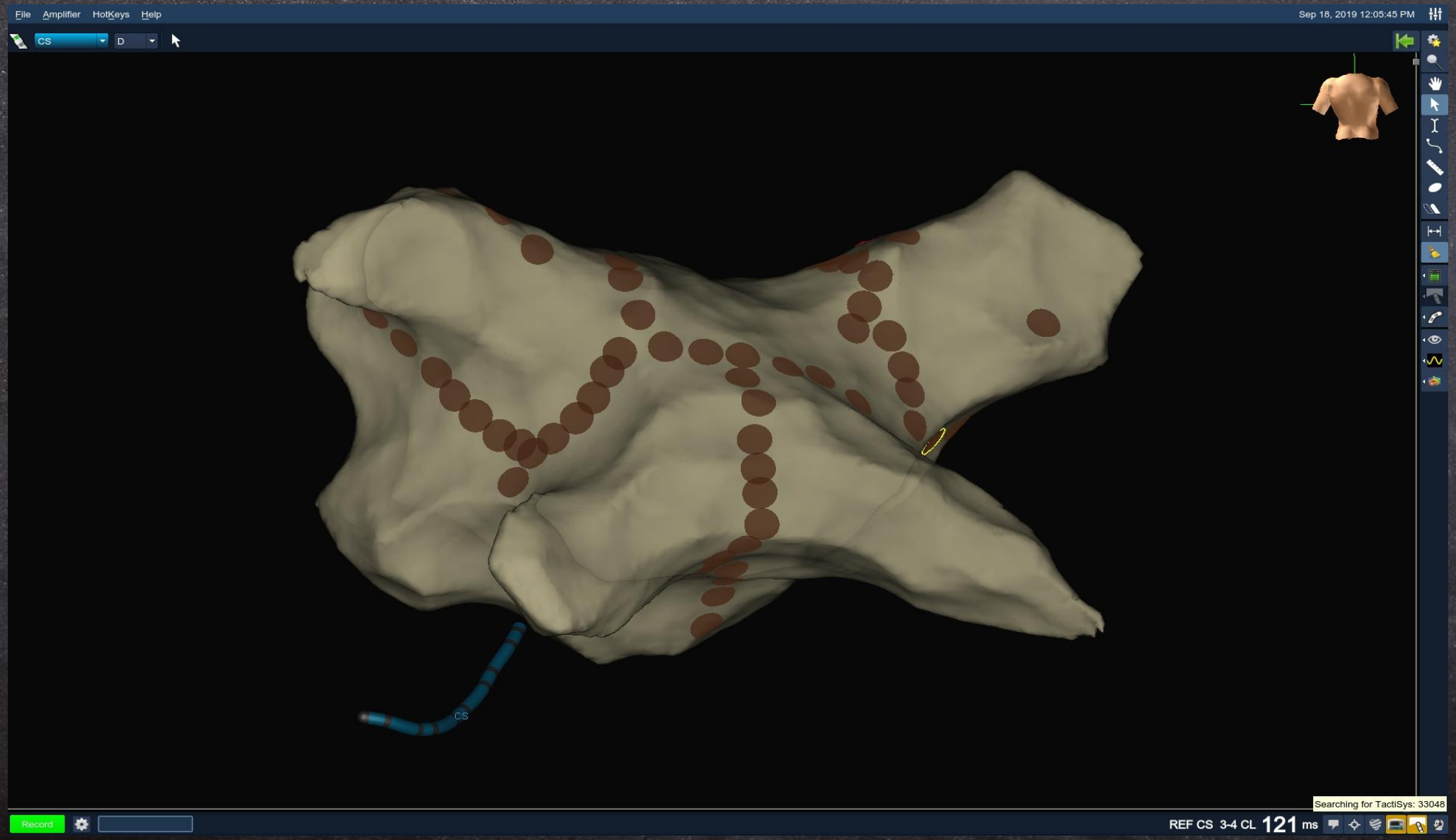
Cardiac MRI multiplanar reconstruction
Arrow: right upper pulmonary vein draining into superior vena cava



Andrikopoulos G. Henry Dunant Hospital Center, May 2020

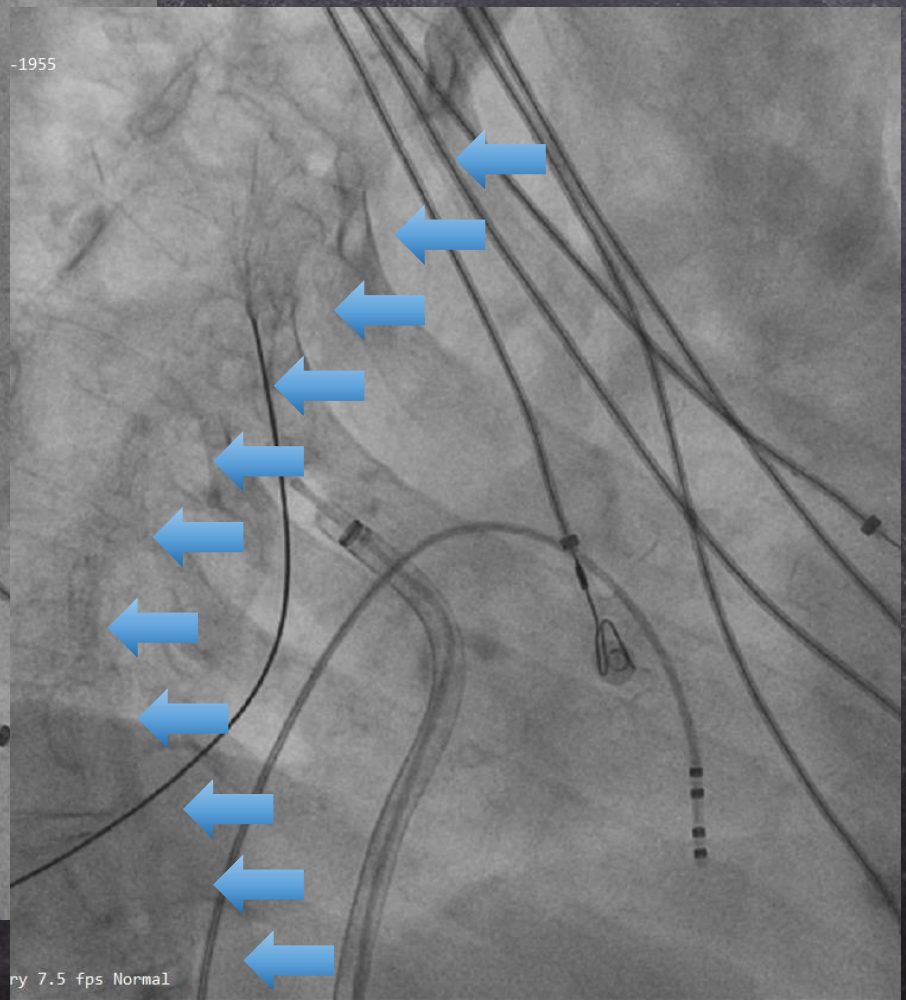
2. ΑΣΘΕΝΗΣ ΜΕ ΙΔΙΑΙΤΕΡΗ ΑΝΑΤΟΜΙΑ

Α. Δυνατότητα αλλαγής πλάνου – Ασθενής προγραμματισμένος για Cryoablation



Andrikopoulos G. Henry Dunant Hospital Center, September 2019

Η τεχνολογία ΔΕΝ υποκαθιστά την κλινική σωφροσύνη



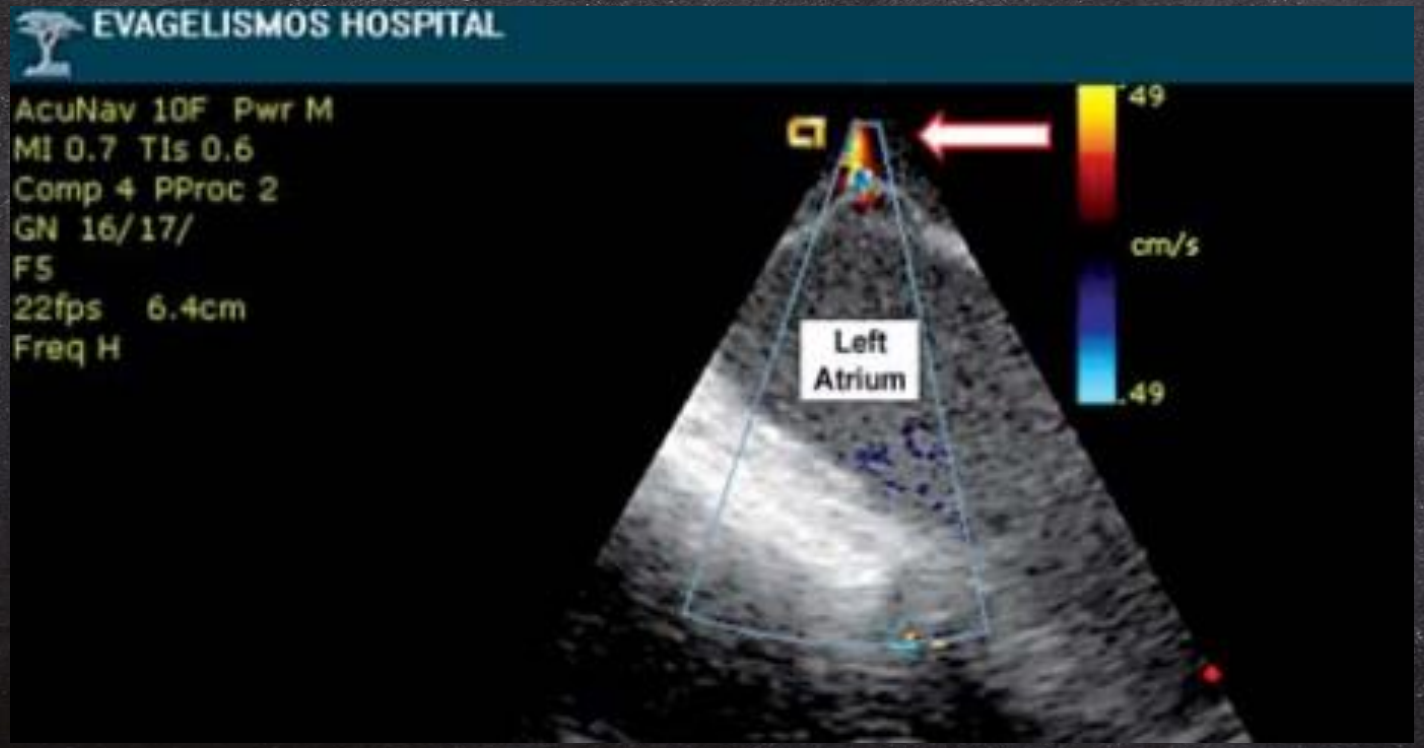
Hellenic J Cardiol 2008; 49: 437-440

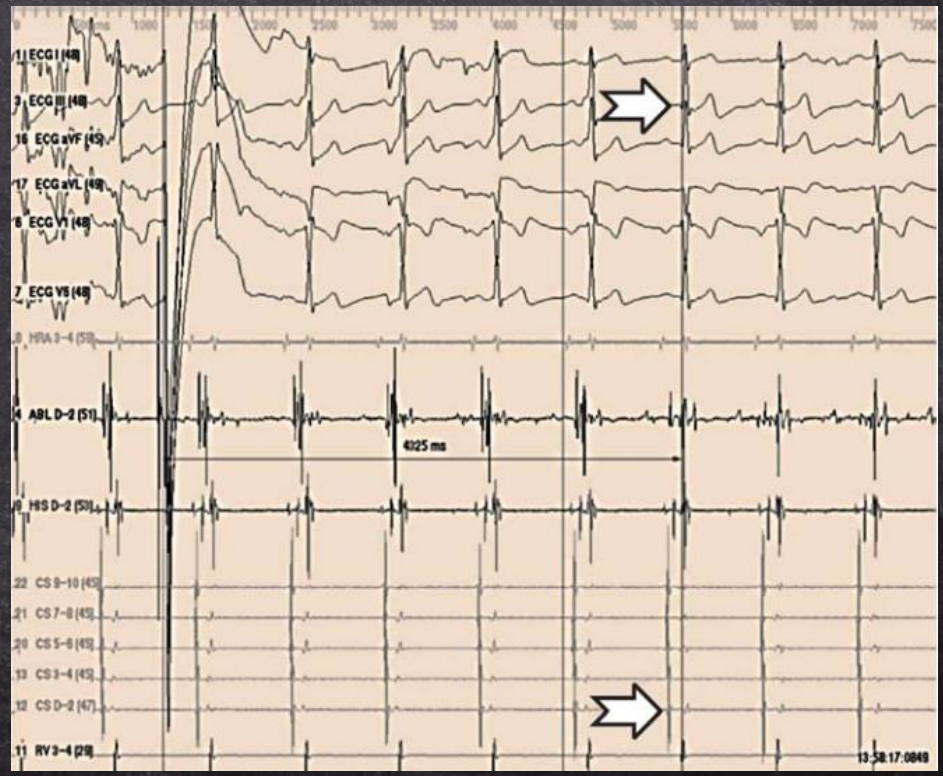
Case Report

Intracardiac Echocardiography-Facilitated Ablation of a Left-Lateral Bypass Tract in a Patient with Atrial Septal Aneurysm

George K. Andrikopoulos, Stylianos Tzeis, Dimitrios Tsilakis, Athanasios Kranidis, Antonios S. Manolis

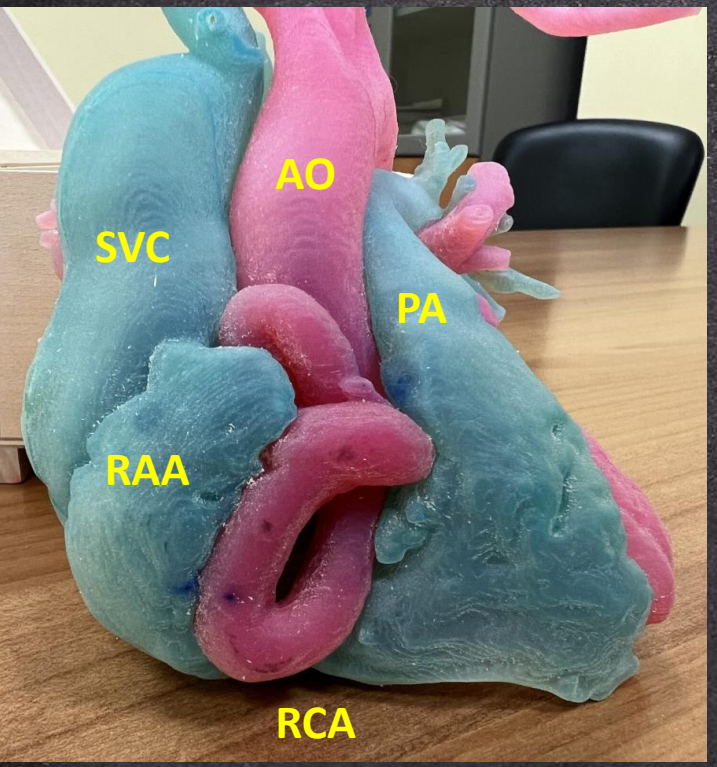
First Cardiac Department, Evaggelismos Hospital, Athens, Greece



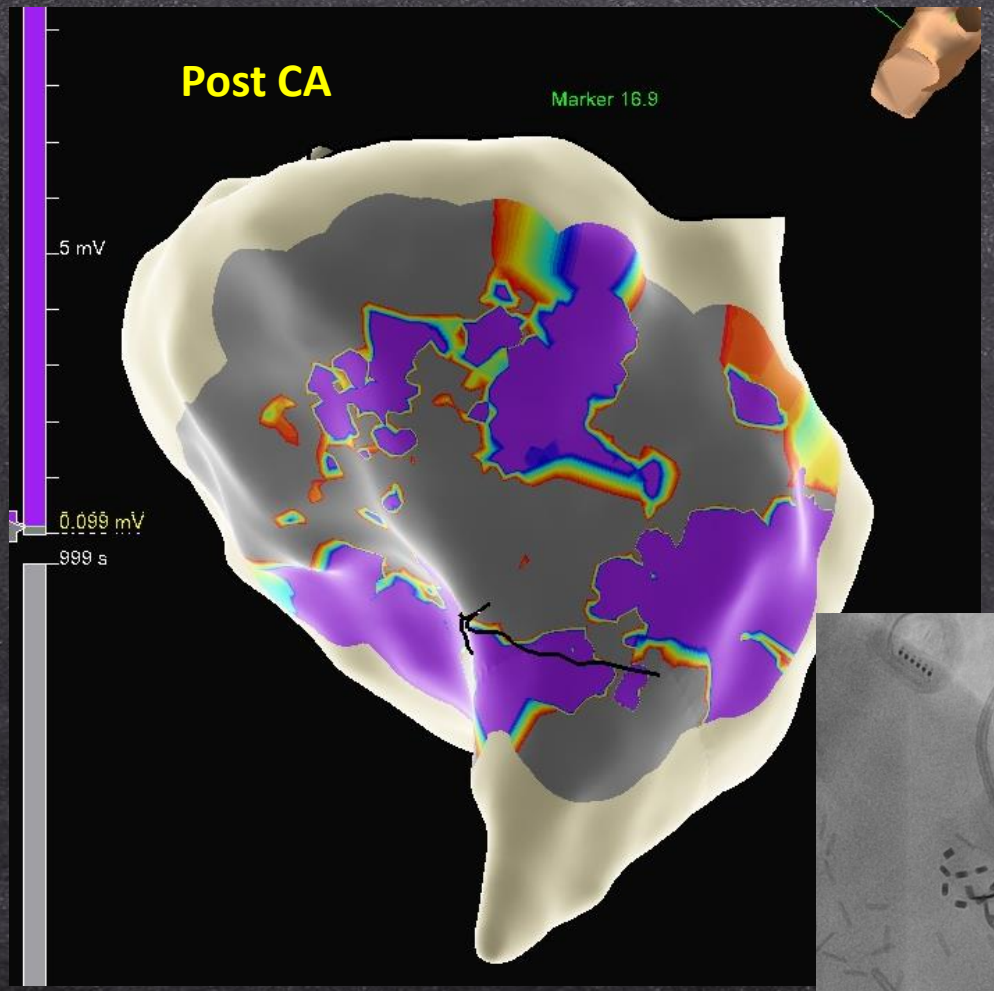


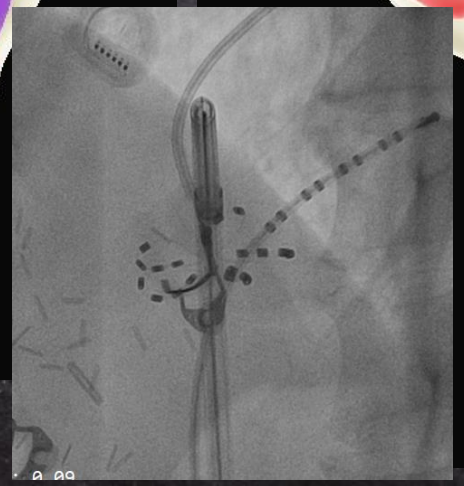
Fluoroscopy guided PF CTI ablation in a patient with peculiar anatomy

(CTI bidirectional block NOT feasible with irrigated catheter and electroanatomic mapping)



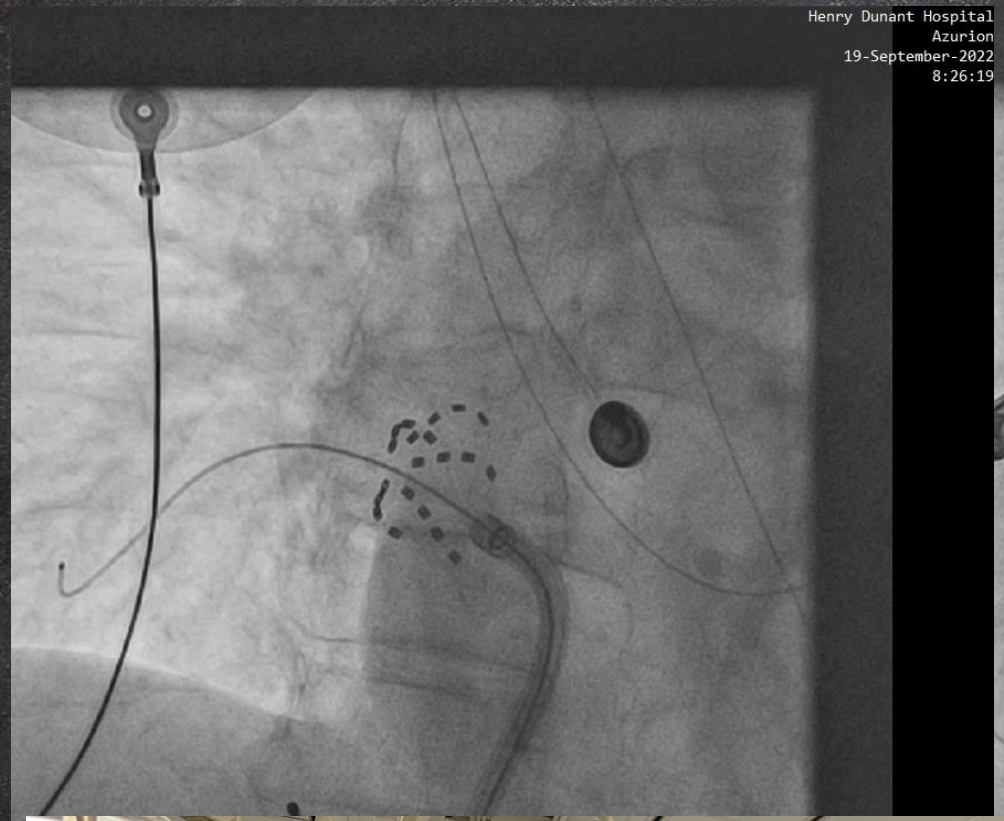
Η σημασία της δυνατότητας αξιοποίησης διαφορετικών τεχνολογιών (και πολλών πόρων)

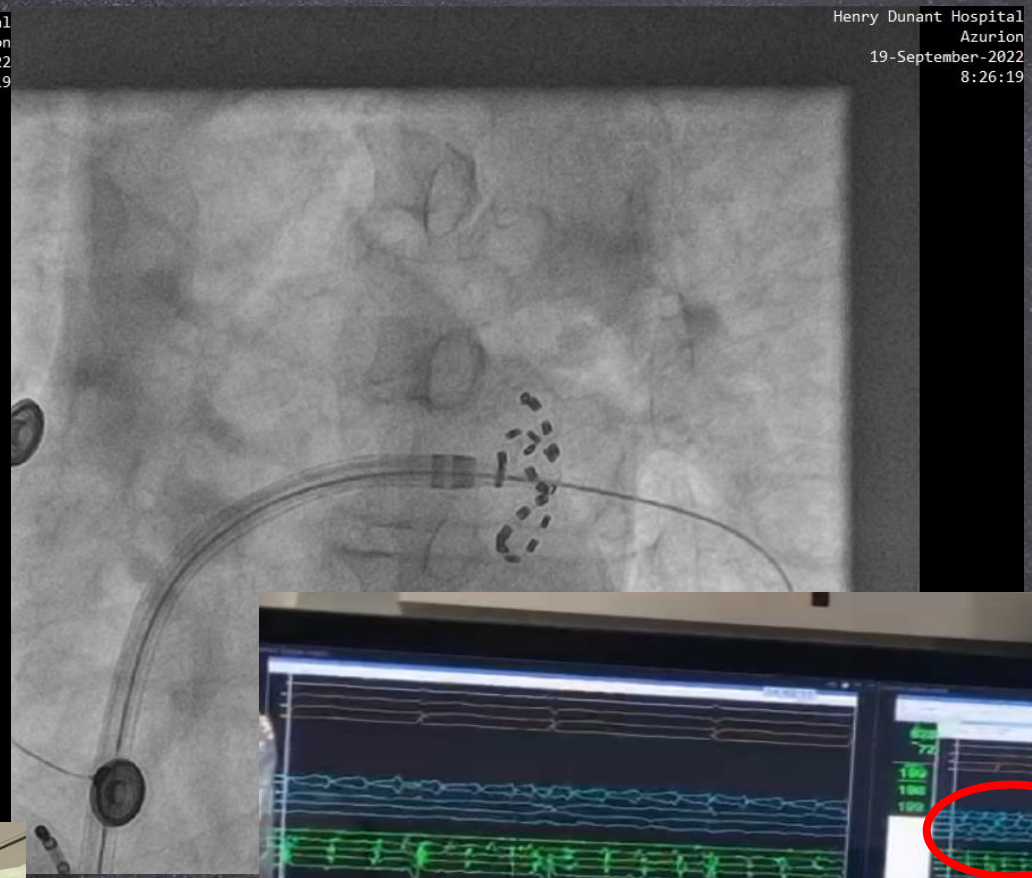


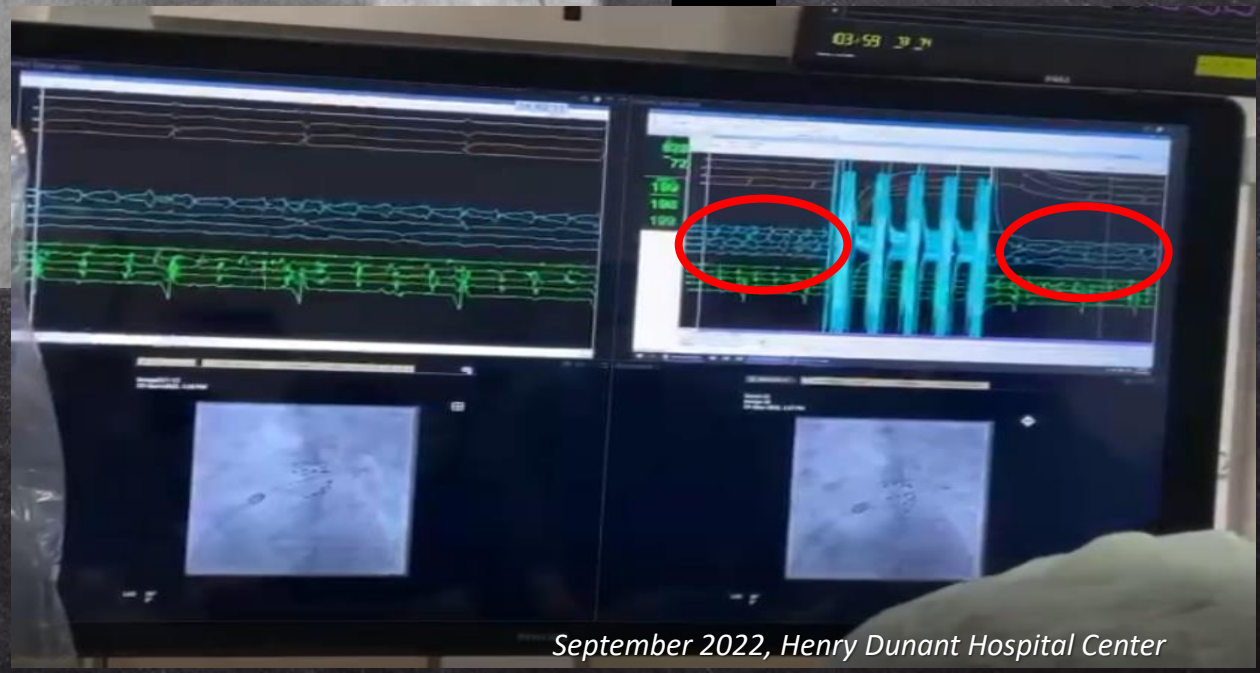


Ερρίκος Ντυνάν Hospital Center, Ιανουάριος 2023

PFA for AF ablation





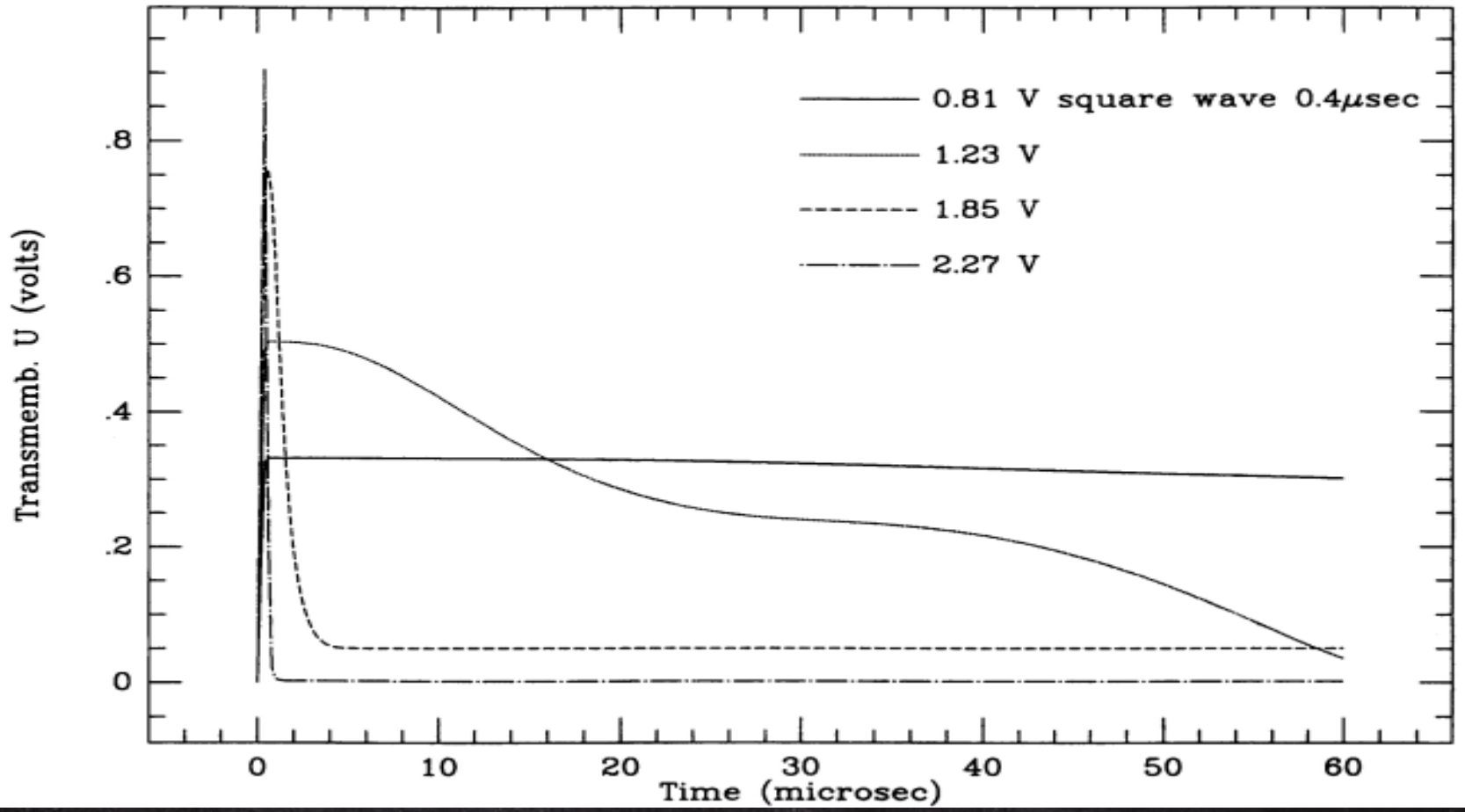


September 2022, Henry Dunant Hospital Center

Theory of Electroporation of Planar Bilayer Membranes: Predictions of the Aqueous Area, Change in Capacitance, and Pore-Pore Separation

Scott A. Freeman,* Michele A. Wang,* and James C. Weaver‡
*Department of Physics and ‡Harvard-M.I.T. Division of Health Sciences and Technology, Massachusetts Institute of Technology, Cambridge, Massachussetts 02139 USA

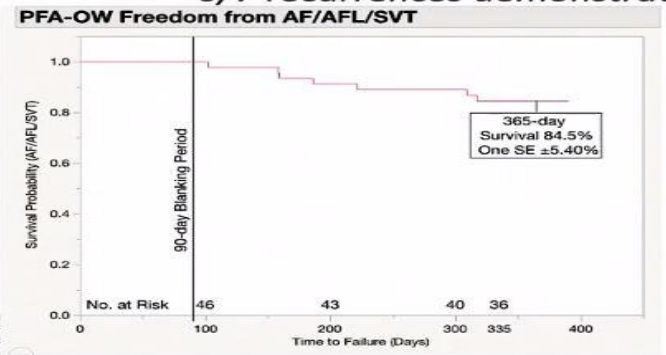
FIGURE 2 Predicted square pulse behavior of the transmembrane voltage, $U(t)$, due to a single 0.4-μs pulse of the indicated amplitudes. As found previously, four distinguishable outcomes are possible: (1) simple charging of the membrane capacitance (smallest pulse; here 0.81 V), (2) rupture of the membrane (larger pulse; here 1.23 V), (3) incomplete reversible electrical breakdown (still larger pulse; here 1.85 V), (4) reversible electrical breakdown (REB) (largest pulse; here 2.27 V). The electrical behavior predicted by a recent transient aqueous pore model (Barnett and Weaver, 1991) agrees reasonably, but not exactly, with experimental observations of these outcomes (Benz et al., 1979).

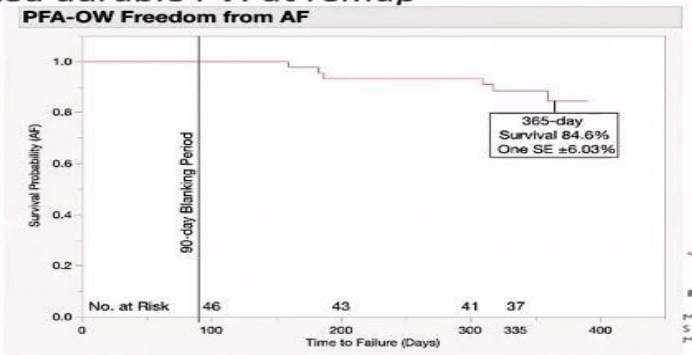


PVI in PAF pts

1-Year Clinical Recurrence

- **97 pts reached 1 year of follow-up**
- Optiwave cohort
  - *86% per-week (TTM) and 98% per-monitor (Holter) compliance*
  - *85±5% freedom from atrial arrhythmia*
  - *6/7 recurrences demonstrated durable PVI at remap*





PVI in PAF pts

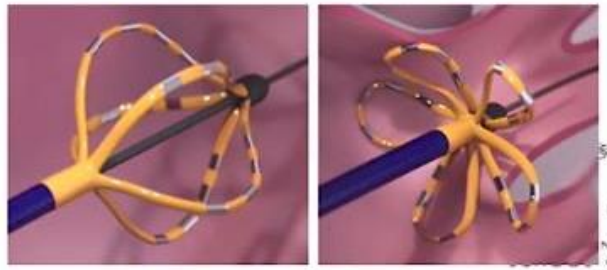
Remap Results

EHRA 2021
As presented by Vivek Reddy

110 pts returned for prospective remaps at 93±30 days

Cohort	n	Durable PVI (% PVs)	Durable PVI (% pts)
Monophasic	11	45%	18%
Biphasic (Early/Other)	55	84%	58%
Optiwave (Optimized Biphasic)	**44**	**96%**	**84%**

- 4 paired applications / PV @ 1.8-2.0kV
  - 2 pairs in “Flower”
  - 2 pairs in ”Basket”



Farapulse gains CE mark for its pulsed field ablation system

29th January 2021 · 1630

FARAPULSE

Farapulse announced that it has received the CE mark for its pulsed field ablation (PFA) system for the treatment of paroxysmal atrial fibrillation (AF). The approval will allow the company to commercialise the cardiac PFA system and permits marketing of the system across the European Union and other CE mark geographies.

Farapulse said in a press release that it will partner with a select number of physicians prior to a broader rollout of the device.

"Farapulse PFA has garnered a high level of interest at scientific symposia in the past several years, making it abundantly clear that the medical community is primed to adopt our technology into routine use. The clinical results and unparalleled volume of data chronicled through investigator-authored abstracts and manuscripts have been exceedingly well received," said Allan Zingeler, president and CEO of Farapulse. "Europe's modern and progressive electrophysiology market represents a unique opportunity for Farapulse to showcase our PFA system's powerful yet incredibly safe ability to lead in the treatment of AF."

Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE

Pulsed Field Ablation Versus Radiofrequency Ablation

Esophageal Injury in a Novel Porcine Model

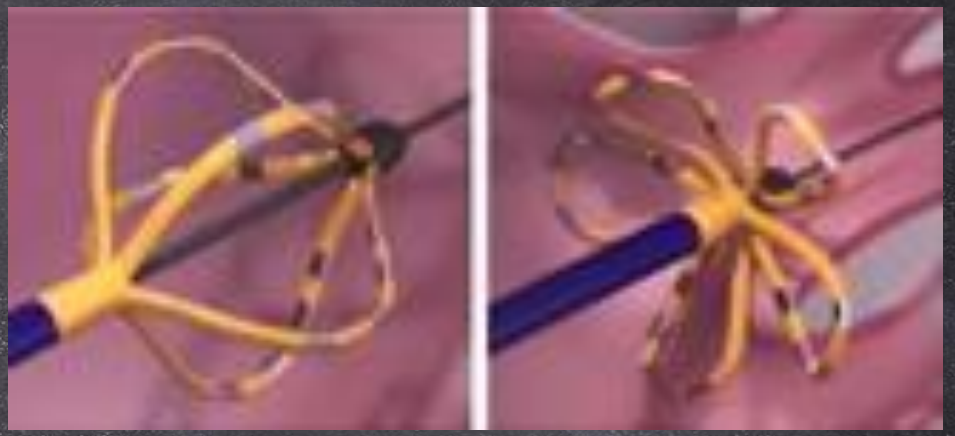
Jacob S. Koruth, MD; Kenji Kuroki, MD; Iwanari Kawamura, MD; Richard Brose, MS; Raju Viswanathan, PhD; Eric D. Buck, MS; Elina Donskoy, MD, PhD; Petr Neuzil, MD, PhD; Srinivas R. Dukkipati, MD; Vivek Y. Reddy, MD

BACKGROUND: Pulsed field ablation (PFA) can be myocardium selective, potentially sparing the esophagus during left atrial ablation. In an in vivo porcine esophageal injury model, we compared the effects of newer biphasic PFA with radiofrequency ablation (RFA).

METHODS: In 10 animals, under general anesthesia, the lower esophagus was deflected toward the inferior vena cava using an esophageal deviation balloon, and ablation was performed from within the inferior vena cava at areas of esophageal contact. Four discrete esophageal sites were targeted in each animal: 6 animals received 8 PFA applications/site (2 kV, multispline catheter), and 4 animals received 6 clusters of irrigated RFA applications (30 W×30 seconds, 3.5 mm catheter). All animals were survived to 25 days, sacrificed, and the esophagus submitted for pathological examination, including 10 discrete histological sections/esophagus.

RESULTS: The animals weight increased by 13.7±6.2% and 6.8±6.3% (P=0.343) in the PFA and RFA cohorts, respectively. No PFA animals (0 of 6, 0%) developed abnormal in-life observations, but 1 of 4 RFA animals (25%) developed fever and dyspnea. On necropsy, no PFA animals (0 of 6, 0%) demonstrated esophageal lesions. In contrast, esophageal injury occurred in all RFA animals (4 of 4, 100%; P=0.005): a mean of 1.5 mucosal lesions/animal (length, −21.8±8.9 mm; width, −4.9±1.4 mm) were observed, including one esophago-pulmonary fistula and deep esophageal ulcers in the other animals. Histological examination demonstrated tissue necrosis surrounded by acute and chronic inflammation and fibrosis. The necrotic RFA lesions involved multiple esophageal tissue layers with evidence of arteriolar medial thickening and fibrosis of periesophageal nerves. Abscess formation and full-thickness esophageal wall disruptions were seen in areas of perforation/fistula.

CONCLUSIONS: In this novel porcine model of esophageal injury, biphasic PFA induced no chronic histopathologic esophageal changes, while RFA demonstrated a spectrum of esophageal lesions including fistula and deep esophageal ulcers and abscesses.



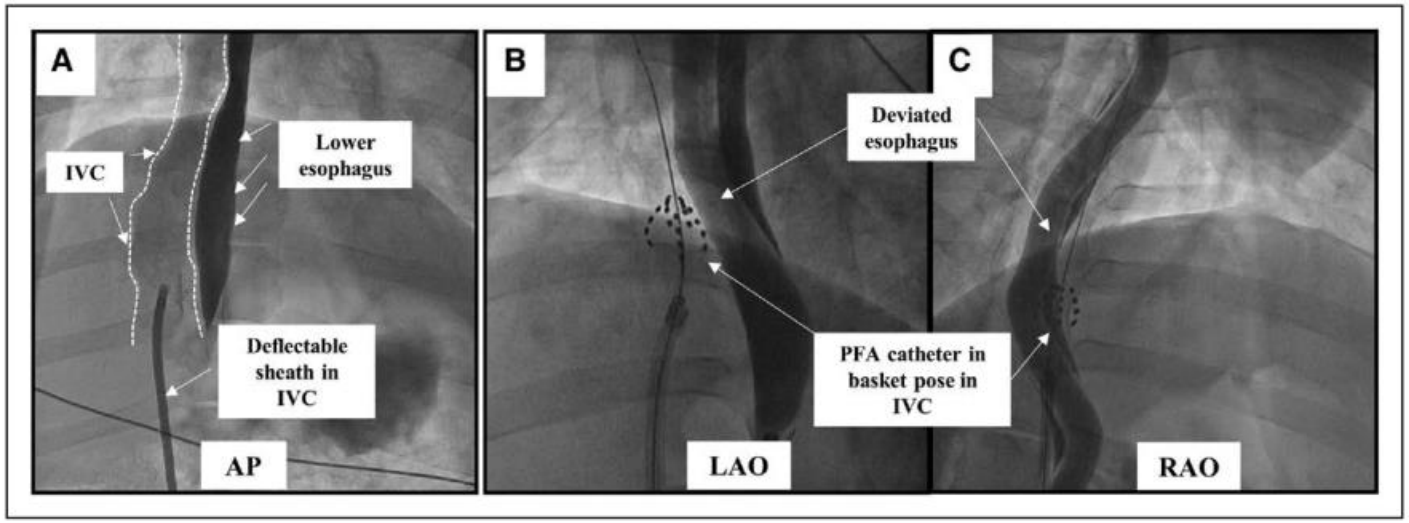


Figure 2. Fluoroscopic view of the esophageal injury mode: pulsed field ablation (PFA) cohort.
A, Contrast angiography was performed using a long deflectable sheath placed in the inferior vena cava (IVC; outlined). In the anteroposterior (AP) view, the IVC is seen rightward of the contrast filled esophagus. **B** and **C**, Left and right anterior oblique (LAO and RAO) projections demonstrate the PFA catheter in basket pose forcefully pushed against the deviated esophagus. The PFA catheter is shown here ablating 2 different esophageal locations.

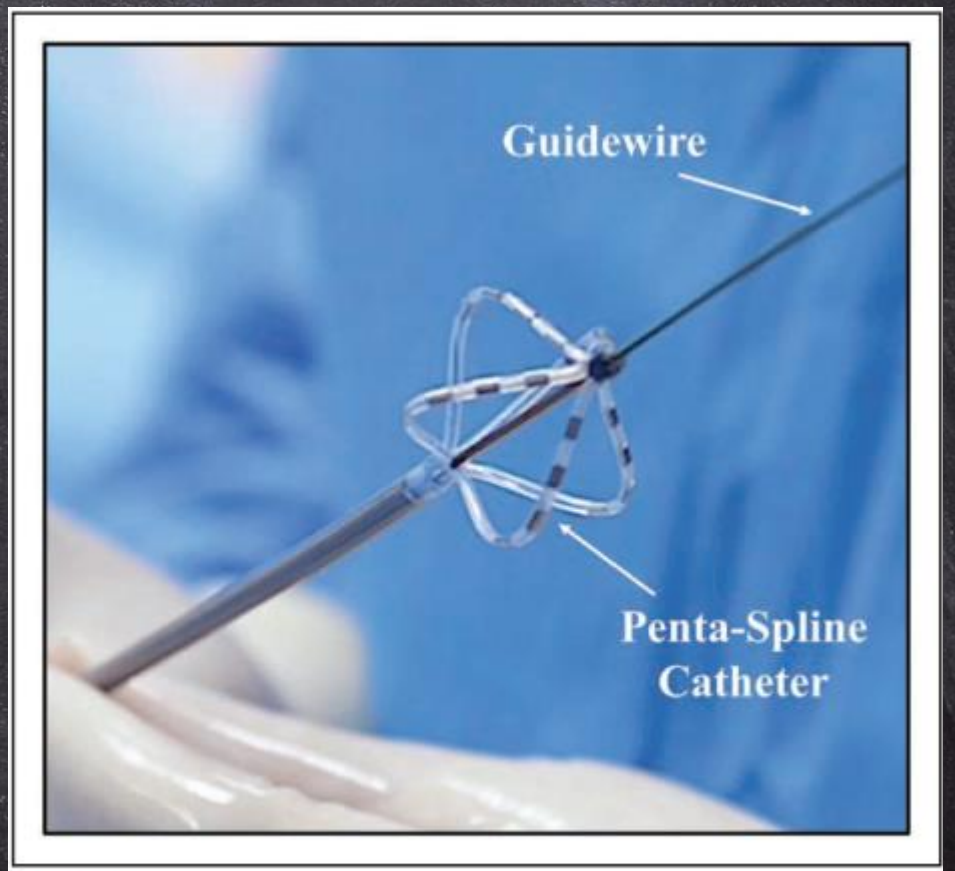


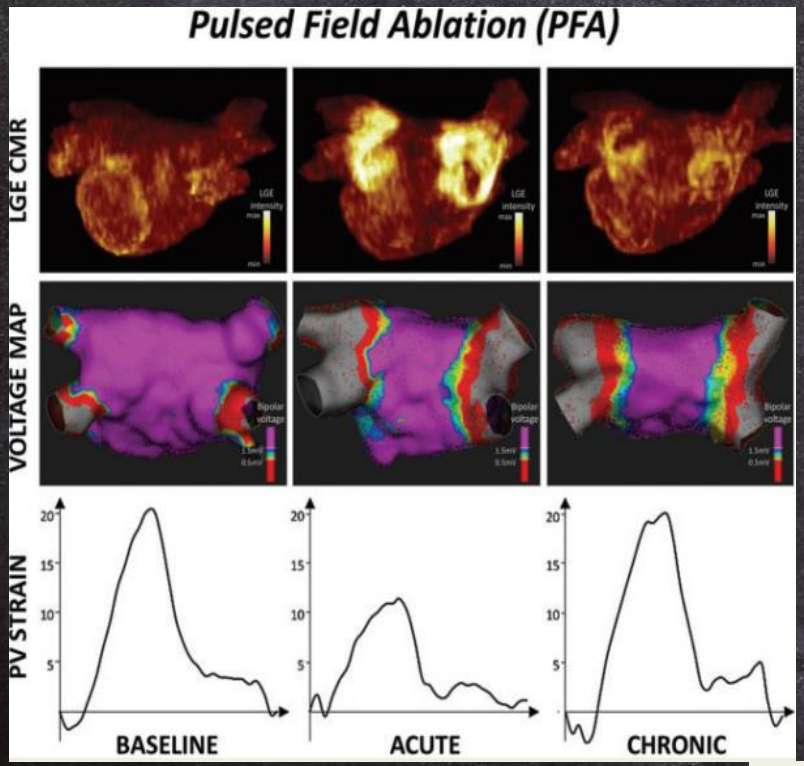
Figure 1. Pulsed field ablation (PFA) catheter: pentaspline over-the-wire PFA catheter in basket pose.

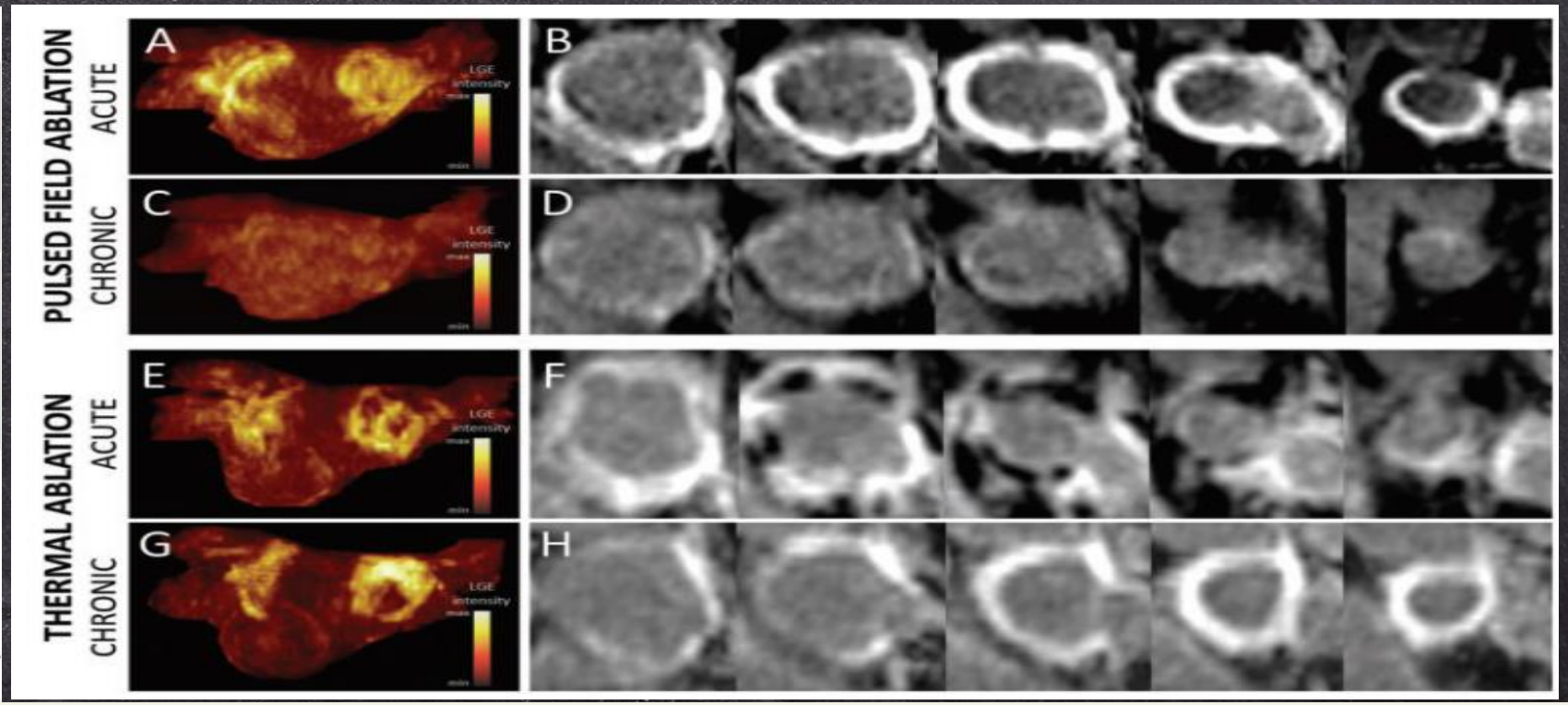
ESC
European Society of Cardiology

Pulsed field ablation prevents chronic atrial fibrotic changes and restrictive mechanics after catheter ablation for atrial fibrillation

Methods and results

Cardiac magnetic resonance was performed pre-ablation, acutely (<3 h), and 3 months post-ablation in 41 patients with paroxysmal atrial fibrillation (AF) undergoing pulmonary vein (PV) isolation with PFA ($n = 18$) or thermal ablation ($n = 23$, 16 radiofrequency ablations, 7 cryoablations). Late gadolinium enhancement (LGE), T2-weighted, and cine images were analysed. In the acute stage, LGE volume was 60% larger after PFA vs. thermal ablation



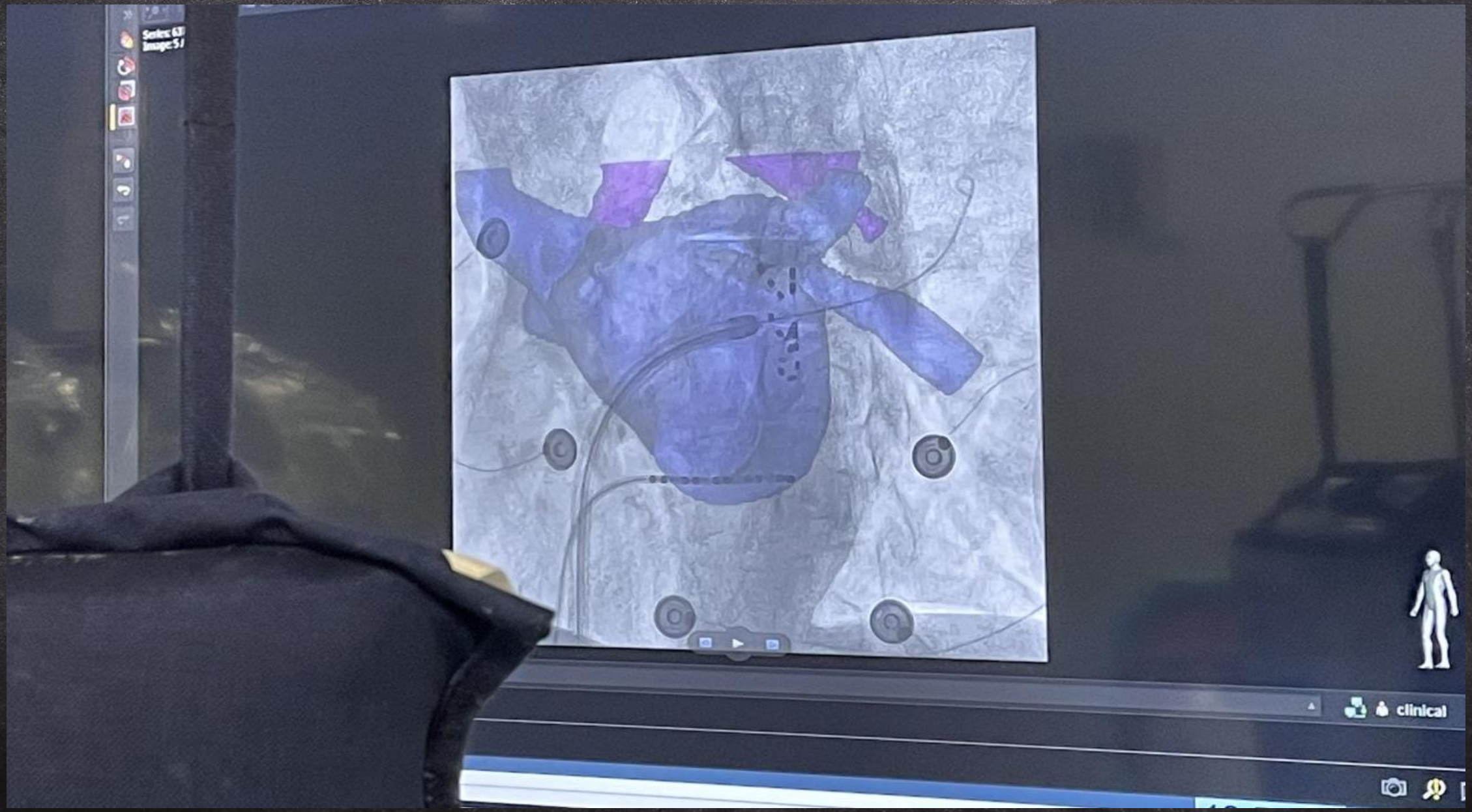


Conclusion

Pulsed field ablation induces large acute LGE without microvascular damage or intramural haemorrhage. Most LGE lesions disappear in the chronic stage, suggesting a specific reparative process involving less chronic fibrosis. This process may contribute to a preserved tissue compliance and LA reservoir and booster pump functions.

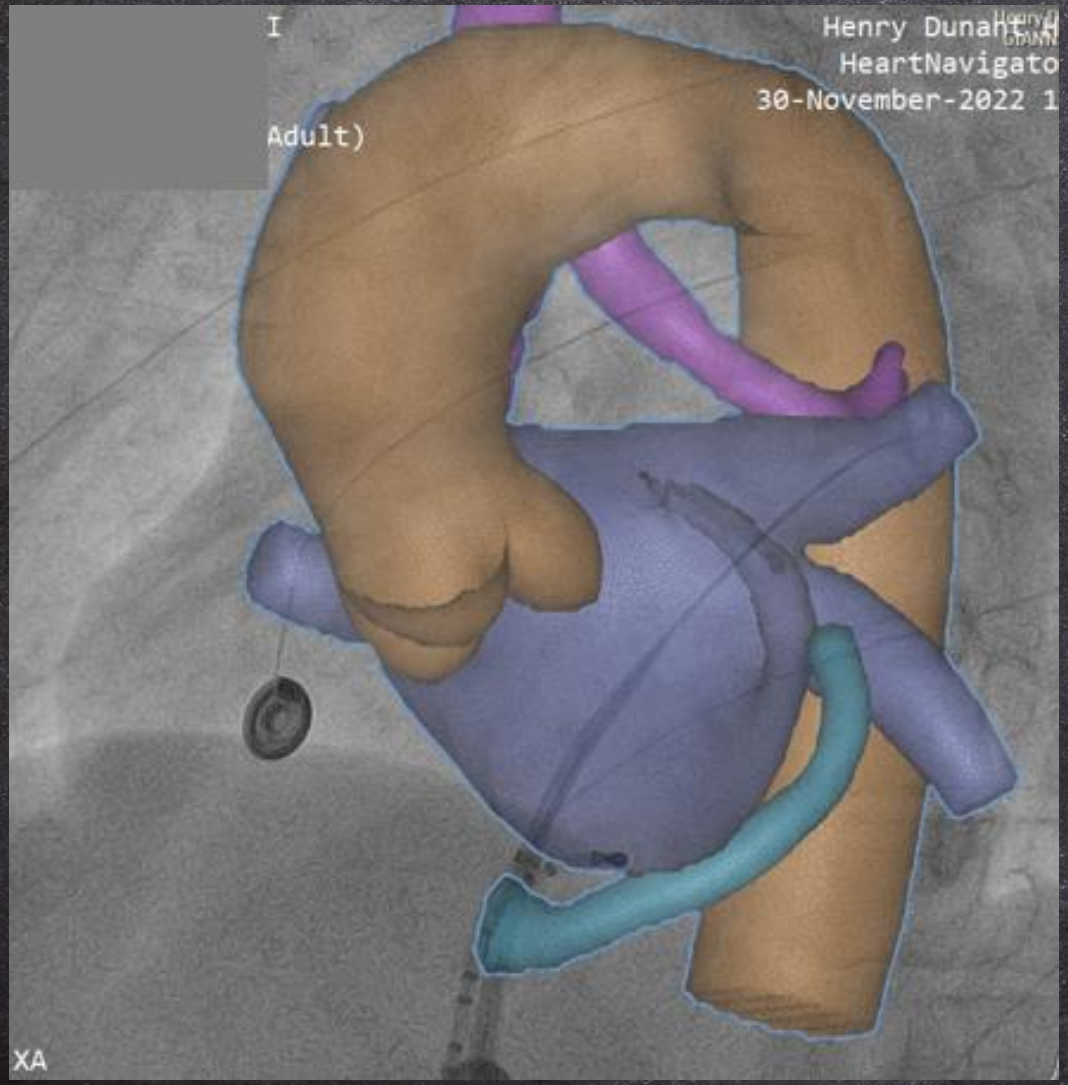
Nakatani Y et al. Europace 2021(23):1767-1776

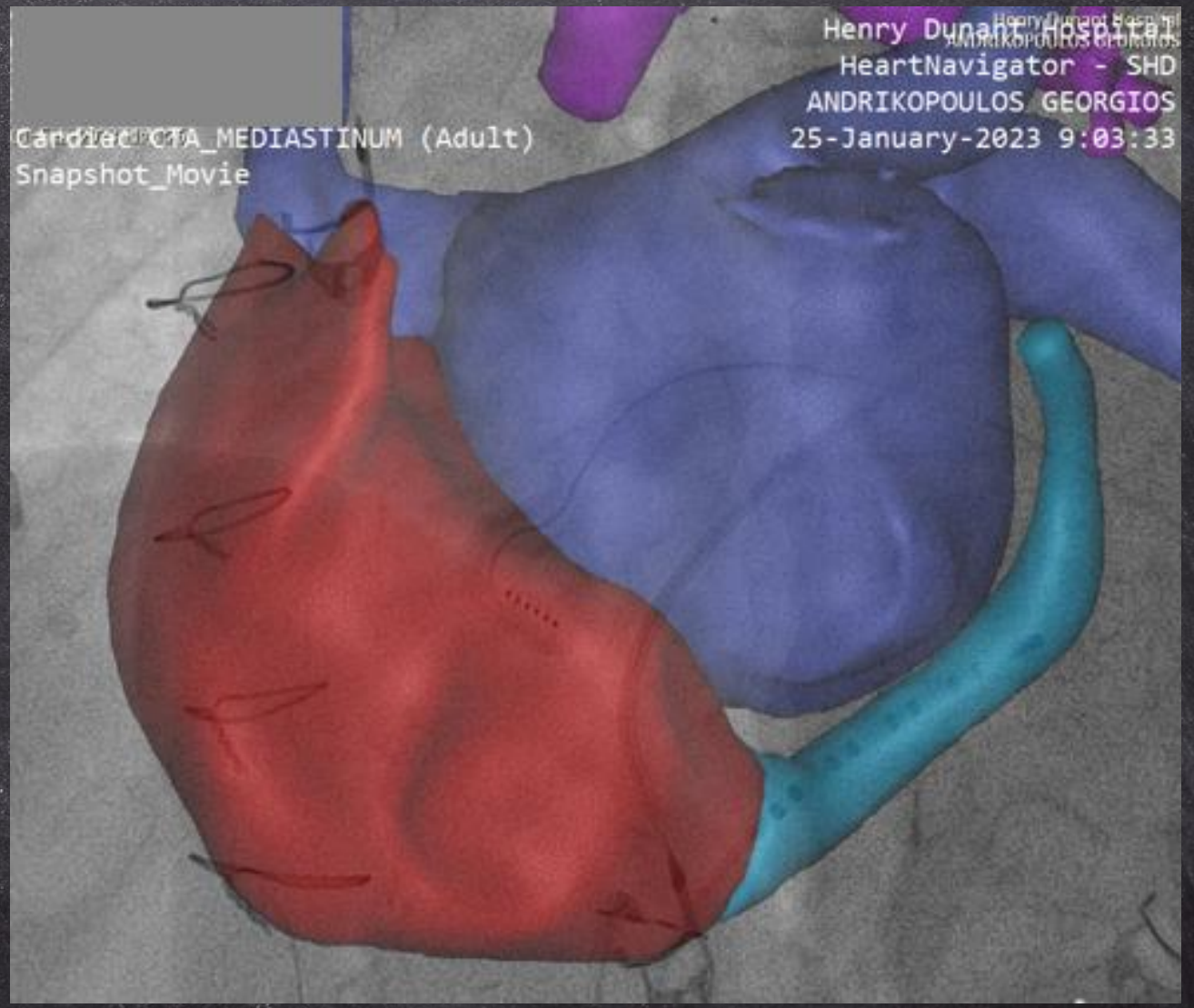
CT imaging integrated into Fluoroscopy during PFA ablation



Αρχείο Γ.Ανδρικόπουλου, Oct2022

CT imaging integrated into Fluoroscopy





Andrikopoulos G. Henry Dunant Hospital Center, Jan 2023

ESC European Society of Cardiology

Europace (2022) 24, 1256–1266
https://doi.org/10.1093/europace/euac050

CLINICAL RESEARCH
Ablation for atrial fibrillation

Multi-national survey on the methods, efficacy, and safety on the post-approval clinical use of pulsed field ablation (MANIFEST-PF)

Emmanuel Ekanem [1], Vivek Y. Reddy [1,2], Boris Schmidt [3], Tobias Reichlin [4], Kars Neven [5,6], Andreas Metzner [7], Jim Hansen [8], Yuri Blaauw [9], Philippe Maury [10,11], Thomas Arentz [12], Philipp Sommer [13], Ante Anic [14], Frederic Anselme [15], Serge Boveda [16,17], Tom Deneke [18], Stephan Willems [19], Pepijn van der Voort [20], Roland Tilz [21,22,23], Moritoshi Funasako [2,24], Daniel Scherr [25], Reza Wakili [26], Daniel Steven [27], Josef Kautzner [28], Johan Vijgen [29], Pierre Jais [6], Jan Petru [2], Julian Chun [3], Laurent Roten [4], Anna Füting [5,30], Andreas Rillig [7], Bart A. Mulder [9], Arne Johannessen [8], Anne Rollin [10], Heiko Lehrmann [12], Christian Sohns [13], Zrinka Jurisic [14], Arnaud Savoure [15], Stephanes Combes [16,17], Karin Nentwich [18], Melanie Gunawardene [19], Alexandre Ouss [20], Bettina Kirstein [21,22,23], Martin Manninger [25], Jan-Eric Bohnen [26], Arian Sultan [27], Petr Peichl [28], Pieter Koopman [29], Nicolas Derval [6], Mohit K. Turagam [1], and Petr Neuzil [2]* (for the MANIFEST-PF Cooperative)

[1]Icahn School of Medicine at Mount Sinai, New York, NY, USA; [2]Cardiology Department, Na Homolce Hospital, Homolka Hospital, Roentgenova 37/2, 15030 Praha 5 Prague, Czech Republic; [3]MVZ CCB Frankfurt und Main-Taunus GbR, Frankfurt, Germany; [4]Inselspital—Bern University Hospital, University of Bern, Bern, Switzerland; [5]Department of Electrophysiology, Alfried Krupp Hospital, Essen, Germany; [6]IHU LIRYC, CHU Bordeaux, University of Bordeaux, Bordeaux, France; [7]University Heart and Vascular Center, University of Hamburg, Hamburg, Germany; [8]Copenhagen University Hospital, Copenhagen, Denmark; [9]Universitair Medish Groningen, Groningen, The Netherlands; [10]Department of Cardiology, University Hospital Rangueil, Toulouse, France; [11]I2MC, INSERM UMR 1297, Toulouse, France; [12]Universitätsklinikum Freiburg, Breisgau, Germany; [13]Clinic for Electrophysiology, Herz- und Diabeteszentrum NRW, Ruhr-University Bochum, Bad Oeynhausen, Germany; [14]Department for Cardiovascular Diseases, University Hospital Center Split, Split, Croatia; [15]Department of Cardiology, Rouen Hospital, Rouen, France; [16]Heart Rhythm Department, Clinique Pasteur, Toulouse, France; [17]Universitair Ziekenhuis VUB, Brussels, Belgium; [18]Heart Center Bad Neustadt, Rhoen-Clinic Campus Bad Neustadt, Bad Neustadt an der Saale, Germany; [19]Asklepios Hospital St Georg, Hamburg, Germany; [20]Department of Cardiology, Catharina Ziekenhuis Eindhoven, Eindhoven, The Netherlands; [21]Department of Rhythmology, University Heart Center, Lubeck, Germany; [22]German Center for Cardiovascular Research (DZHK), Partner Site Hamburg/Kiel/Lübeck, Lübeck, Germany; [23]LANS Cardio, Hamburg, Germany; [24]Neuron Medical, Brno, Czech Republic; [25]Medical University of Graz, Graz, Austria; [26]Department of Cardiology and Vascular Medicine, West German Heart and Vascular Center Essen, University Duisburg-Essen, Duisburg, Germany; [27]Universitätsklinikum Köln AöR, Köln, Germany; [28]IKEM—Institute for Clinical and Experimental Medicine, Prague, Czech Republic; [29]Department of Cardiology, Jessa Hospitals, Hasselt, Belgium; and [30]Department of Medicine, Witten/Herdecke University, Witten, Germany

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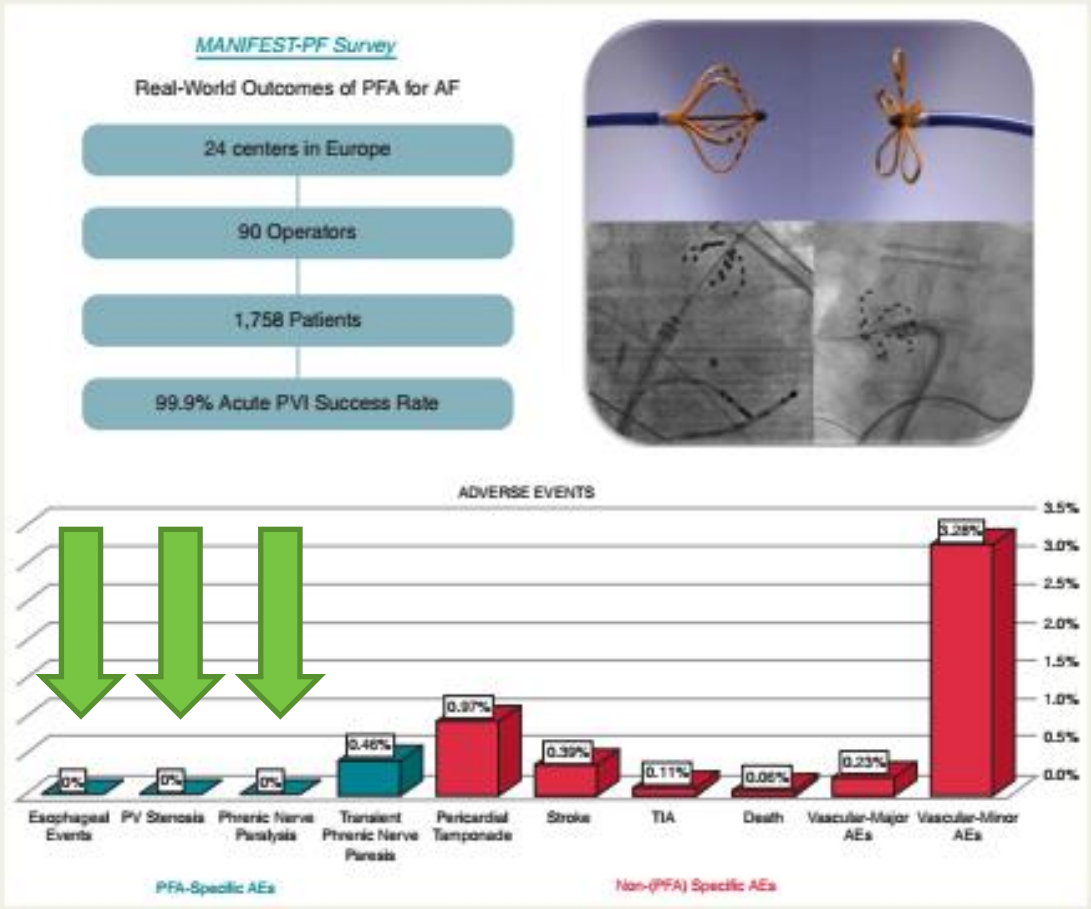
Methods and results This retrospective survey included all 24 clinical centres using the pentaspline PFA catheter after regulatory approval. Institution-level data were obtained on patient characteristics, procedure parameters, acute efficacy, and adverse events. With an average of 73 patients treated per centre (range 7–291), full cohort included 1758 patients: mean age 61.6 years (range 19–92), female 34%, first-time ablation 94%, paroxysmal/persistent AF 58/35%. Most procedures employed deep sedation without intubation (82.1%), and 15.1% were discharged same day. Pulmonary vein isolation (PVI) was successful in 99.9% (range 98.9–100%). Procedure time was 65 min (38–215). There were no oesophageal complications or phrenic nerve injuries persisting past hospital discharge. Major complications (1.6%) were pericardial tamponade (0.97%) and stroke (0.4%); one stroke resulted in death (0.06%). Minor complications (3.9%) were primarily vascular (3.3%), but also included transient phrenic nerve paresis (0.46%), and TIA (0.11%). Rare complications included coronary artery spasm, haemoptysis, and dry cough persistent for 6 weeks (0.06% each).

Conclusion In a large cohort of unselected patients, PFA was efficacious for PVI, and expressed a safety profile consistent with preferential tissue ablation. However, the frequency of 'generic' catheter complications (tamponade, stroke) underscores the need for improvement.

Graphical Abstract



Multi-national survey on the methods, efficacy, and safety on the post-approval clinical use of pulsed field ablation (MANIFEST-PF)

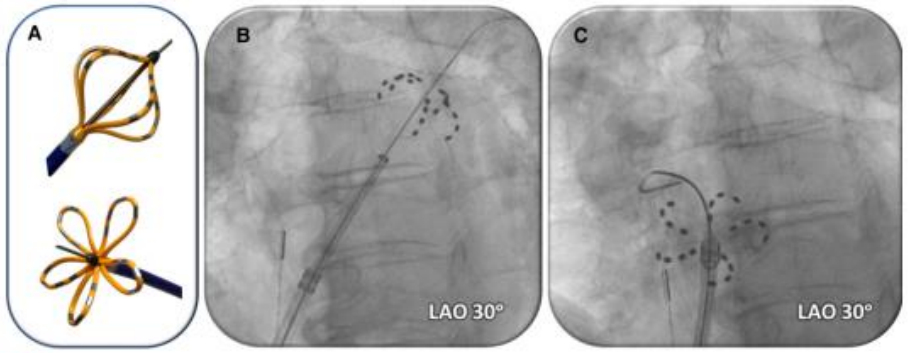


Figure 1 PFA catheter. (A) Pentaspline PFA catheter in basket (top) and flower (bottom) configurations. (B and C) Fluoroscopic images of pentaspline PFA catheter over a guidewire in the left superior (B) or right superior (C) pulmonary veins.

Table 3 Procedural parameters

Procedural parameters	Percentages (%)
General anaesthesia/intubation (%)	17.8%
Deep sedation/no intubation (%)	82.1%
No. of transeptal punctures, n (%)	1 (100%)
PVI success rate (%), mean (min–max)	99.9% (98.9–10[illegible])
Procedure time (min), mean (min–max)	65 (38–215)
Fluoroscopy time (min), mean (min–max)	13.7 (4.5–33)
Same day discharge (%)	15.8%

Table 5 Adverse events

	N (%)
Major complications	29 (1.6%)
Oesophageal fistula	0
Oesophageal dysmotility	0
Pulmonary vein stenosis	0
Pericardial tamponade	17 (0.97)
Percutaneous treatment	13 (0.74)
Surgical treatment	4 (0.23)
Stroke	7 (0.39)[a]
Phrenic nerve injury (persistent)	0
Vascular complications requiring surgery	4 (0.23)
Coronary artery spasm	1 (0.06)
Death	1 (0.06)[a]
Minor complications	68 (3.86%)
TIA	2 (0.11)
Phrenic nerve injury (transient)	
Transient effect	8 (0.46)
Sustained effect[b]	0
Vascular	
Hematoma	43 (2.44)
Pseudoaneurysm	4 (0.22)
AV fistula	3 (0.17)
Other	6 (0.34)
Other complications	2 (0.11)

[a]One patient who sustained a stroke subsequently died.
[b]Defined as persisting beyond hospital discharge.

Table 1 Clinical s

Clinical Site Char	
Practice type	
Academic (%)	70.8
Semi-academic (%)	8.3
Private (%)	20.8
No. of operators, mean (min–max)	3.8 (2–11)
Years in practice, mean (min–max)	13.2 (5.3–22.5)
Annual no. of AF ablations, mean (min–max)	704 (300–2200)
No. of PFA cases in past year, mean (min–max)	73.3 (7–291)
Date of first PFA case, month/year (earliest–latest)	7/2021 (3/2021–12/2021)

PFA, pulsed field ablation

Table 4 Procedural characteristics

Procedural characteristics	Never	Sometimes	Frequently	Always
Pre-procedural imaging				
TEE (%)	25	37.5	12.5	25
CT (%)	25	29.2	12.5	33.3
MRI (%)	70.8	25	4.2	0
Intra-procedural imaging				
TEE (%)	58.3	33.3	0	8.3
ICE (%)	69.6	8.7	0	21.7
Fluoroscopy (%)	0	4.3	4.3	91.3
Follow-up imaging				
TEE (%)	73.9	21.7	4.3	0
CT (%)	86.9	13.1	0	0
MRI (%)	73.9	26.1	0	0
Electroanatomical mapping				
Paroxysmal AF (%)	41.6	16.6	8.3	33.3
Persistent AF (%)	29.2	8.3	20.8	41.7
Long standing persistent AF (%)	37.5	4.2	8.3	41.7
Additional lesion sets				
Roof line (%)	50	25	12.5	12.5
Lateral mitral isthmus line (%)	62.6	33.2	4.2	0
Left atrial posterior wall (%)	25	45.8	16.7	12.5
Anterior line (%)	75	25	0	0
SVC isolation (%)	95.8	4.2	0	0
CFAE (%)	95.8	4.2	0	0
LAA isolation (%)	93.8	6.2	0	0
Non-PV trigger (%)	79.2	20.8	0	0

Ekanem et al. Europace 2022

Pulsed-field ablation-based pulmonary vein isolation: acute safety, efficacy and short-term follow-up in a multi-center real world scenario

138 patients undergoing a first PVI (67 ± 12 years, 66% male, 62% persistent AF)were treated

Results: A total of 138 patients undergoing a first PVI (67 ± 12 years, 66% male, 62% persistent AF) were treated. PVI was achieved in all patients by deploying 4563 applications in 546 PVs (8.4 ± 1.0/PV). Disappearance of PV signals after the first application was demonstrated in 544/546 PVs (99.6%). More than eight PFA applications were performed in 29/546 PVs (6%) following adapted catheter positioning or due to reconnection as assessed during remapping. Mean procedure time was 78 ± 22 min including pre- and post PVI high-density voltage mapping. PFA catheter LA dwell-time was 23 ± 9 min. Total fluoroscopy time and dose area product were 16 ± 7 min and 505 [275;747] cGy*cm^2. One pericardial tamponade (0.7%), one transient ST-elevation (0.7%) and three groin complications (2.2%) occurred. 1-year follow-up showed freedom of arrhythmia in 90% in patients with paroxysmal AF (n = 47) and 60% in patients with persistent AF (n = 82, p = 0.015).

Conclusions: PFA-based PVI is acutely highly effective and associated with a beneficial safety and low recurrence rate.

Lemoine MD, et al. Clin Res Cardiol 2022 Sep 22. doi: 10.1007/s00392-022-02091-2

J Interv Card Electrophysiol. 2023 Feb 8. doi: 10.1007/s10840-023-01495-y. Online ahead of print.

Pulsed field ablation in real-world atrial fibrillation patients: clinical recurrence, operator learning curve and re-do procedural findings

Martin H Ruwald [1], Arne Johannessen [2], Morten Lock Hansen [2], Martin Haugdal [2], Rene Worck [2], Jim Hansen [2]

121 consecutive AF who underwent PFA ablation and high-density mapping

Results: PVI was achieved with PFA-only in 119 (98%) of the cases. During the implementation phase the mean procedure and fluoroscopy time was reduced from 85 ± 34 to 72 ± 18 min (p = 0.044) and 22 ± 9 to 16 ± 4 (p = 0.034). We observed one phrenic nerve palsy with only partial remission at follow-up. Other adverse events were numerically comparable to standard PVI procedures. Over a mean follow-up of 308 ± 87 days, a total of 22/121 (18.2%) cases experienced clinically significant recurrence or initiation of anti-arrhythmic drugs with Kaplan-Meier event-free estimate at 365 days of 80% (88% for paroxysmal versus 69% for persistent). In five of eight re-do procedures, gaps were primarily located at the right pulmonary veins.

Conclusions: PFA was a highly efficient method to achieve PVI with reductions in procedure time and fluoroscopy over the implementation period. The procedural data and clinical recurrence rates from initial trials were confirmed in real-life non-selected AF patients. More data is needed to establish lesion durability and limitations of PFA.

Pulsed Field Ablation for the Treatment of Atrial Fibrillation: PULSED AF Pivotal Trial

Prospective, global, multicenter, nonrandomized, paired single-arm study in which patients with paroxysmal (n=150) or persistent (n=150) symptomatic atrial fibrillation (AF) refractory to class I or III antiarrhythmic drugs

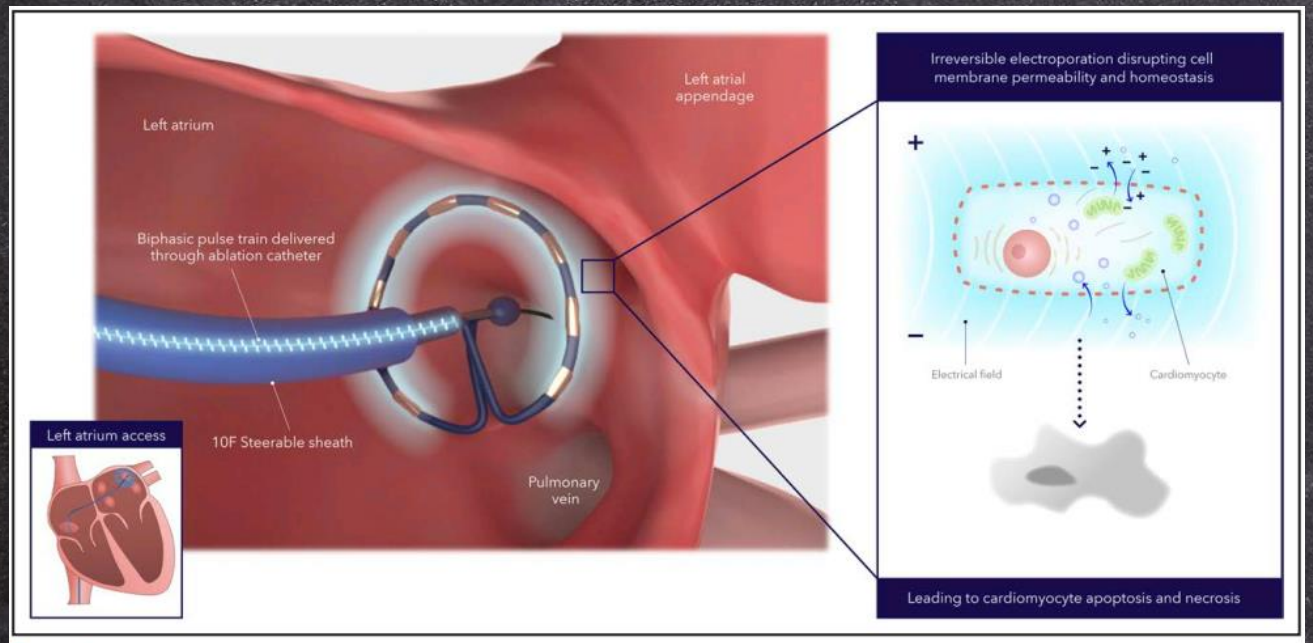
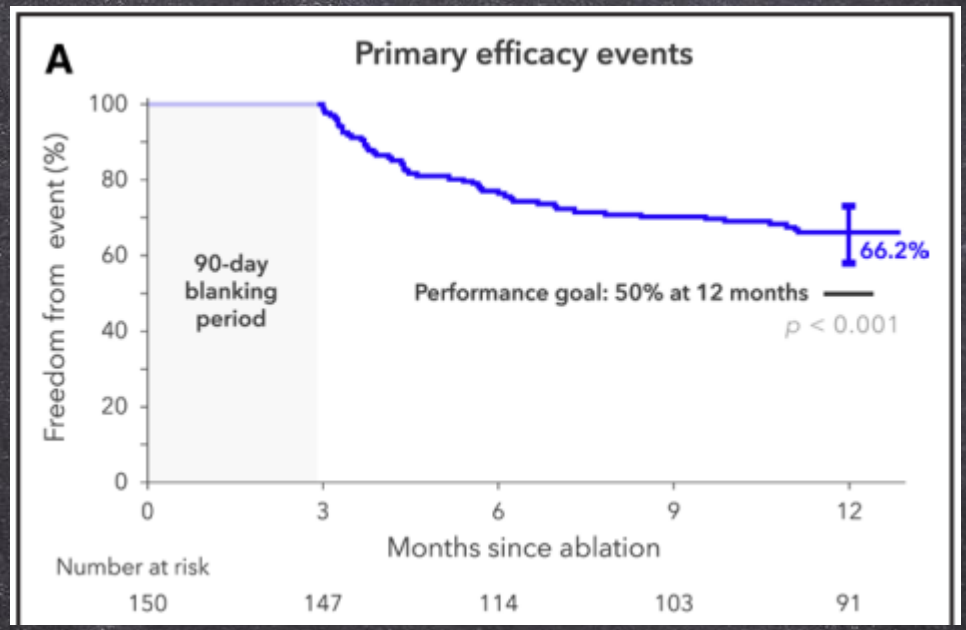


Figure 1. Catheter ablation method with pulsed field ablation system.
Alternating positive and negative electrodes sustains a bipolar electrical field around the catheter that extends into the tissue. The electrical field increases cell membrane permeabilization, which then leads to cell function disruption and eventually to cell death (ie, apoptosis and necrosis).



RESULTS: Pulsed field ablation was shown to be effective at 1 year in 66.2% (95% CI, 57.9 to 73.2) of patients with paroxysmal AF and 55.1% (95% CI, 46.7 to 62.7) of patients with persistent AF. The primary safety end point occurred in 1 patient (0.7%; 95% CI, 0.1 to 4.6) in both the paroxysmal and persistent AF cohorts.

CONCLUSIONS: PULSED AF demonstrated a low rate of primary safety adverse events (0.7%) and provided effectiveness consistent with established ablation technologies using a novel irreversible electroporation energy to treat patients with AF.

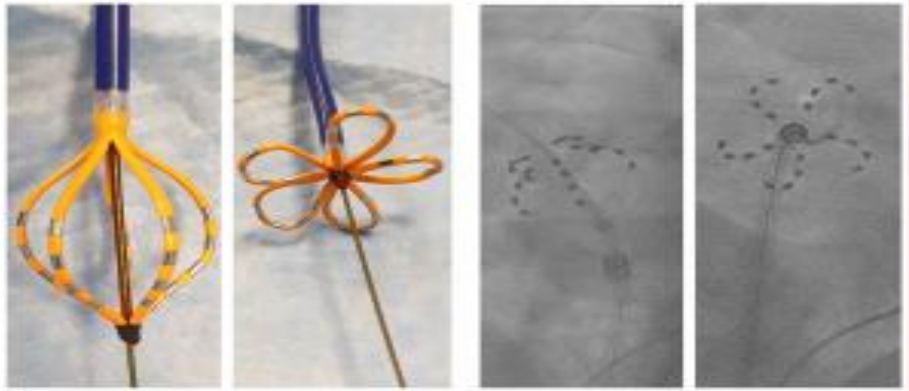
Verma A., et al. Circulation. 2023;147:00–00. DOI: 10.1161/CIRCULATIONAHA.123.063988

Pulsed-field ablation-based pulmonary vein isolation: acute safety, efficacy and short-term follow-up in a multi-center real world scenario

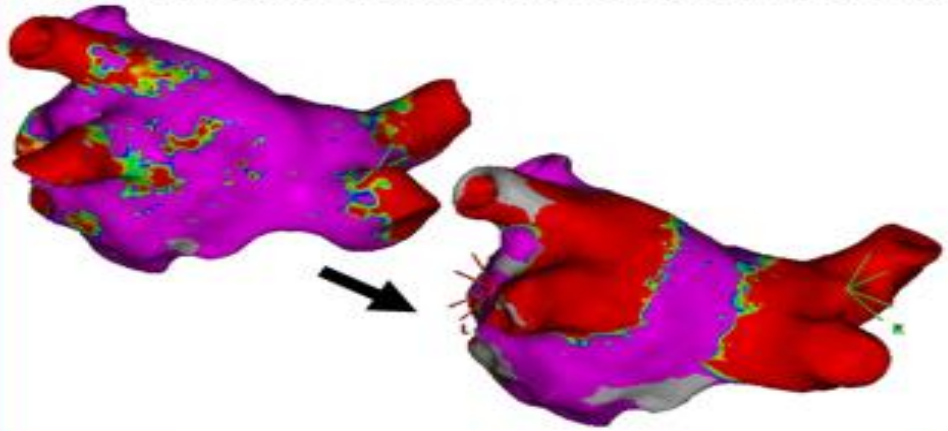
Marc D. Lemoine[1,2] · Thomas Fink[3] · Celine Mencke[1,2] · Ruben Schleberger[1,2] · Ilaria My[1,2] · Julius Obergassel[1,2] · Leonard Bergau[3] · Vanessa Sciacca[3] · Laura Rottner[1,2] · Julia Moser[1,2] · Shinwan Kany[1,2] · Fabian Moser[1,2] · Paula Münkler[1,2] · Leon Dinshaw[1,2] · Paulus Kirchhof[1,2,4] · Bruno Reissmann[1,2] · Feifan Ouyang[1,2] · Philipp Sommer[3] · Christian Sohns[3] · Andreas Rillig[1,2] · Andreas Metzner[1,2]

A total of 138 patients undergoing a first PVI (67 ± 12 years, 66% male, 62% persistent AF) were treated. PVI was achieved in all patients by deploying 4563 applications in 546 PVs (8.4 ± 1.0/PV). Disappearance of PV signals after the first application was demonstrated in 544/546 PVs (99.6%)

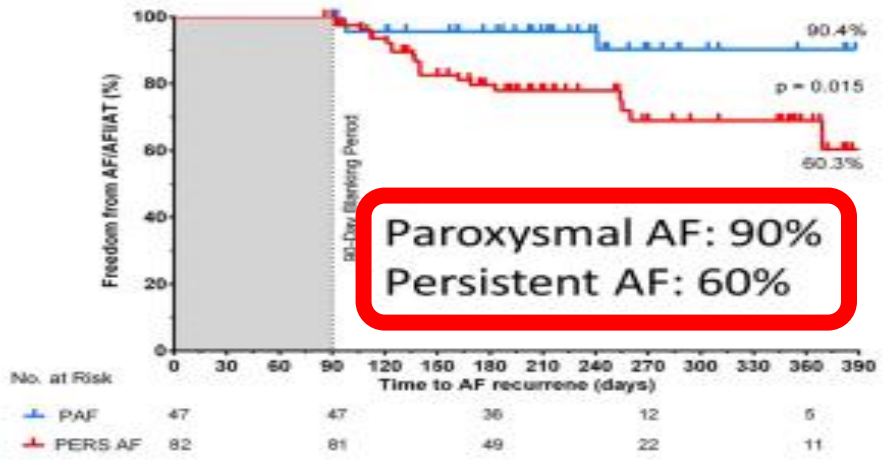
Pentaspline pulsed-field ablation catheter



Wide homogeneous antral ablation lesions

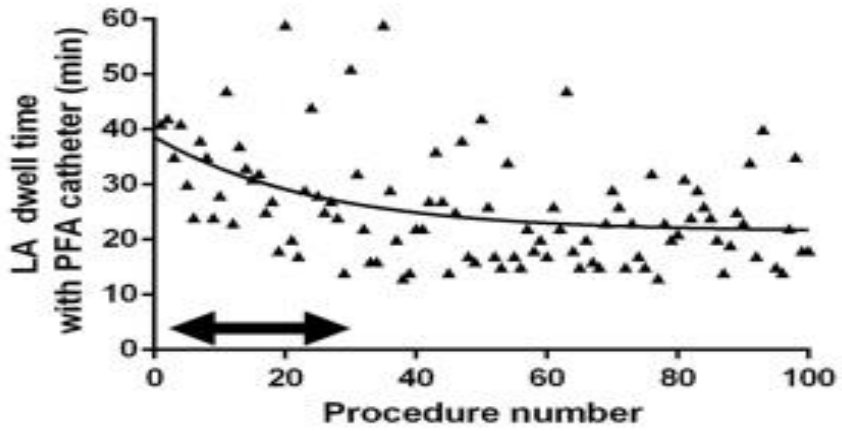


1-year freedom from arrhythmia



Paroxysmal AF: 90%
Persistent AF: 60%

Learning curve: ~30 patients



Clinical Research in Cardiology 2022, https://doi.org/10.1007/s00392-022-02091-2

Pulsed-field ablation-based pulmonary vein isolation: acute safety, efficacy and short-term follow-up in a multi-center real world scenario

138 patients undergoing a first PVI (67 ± 12 years, 66% male, 62% persistent AF)were treated

Results: A total of 138 patients undergoing a first PVI (67 ± 12 years, 66% male, 62% persistent AF) were treated. PVI was achieved in all patients by deploying 4563 applications in 546 PVs (8.4 ± 1.0/PV). Disappearance of PV signals after the first application was demonstrated in 544/546 PVs (99.6%). More than eight PFA applications were performed in 29/546 PVs (6%) following adapted catheter positioning or due to reconnection as assessed during remapping. Mean procedure time was 78 ± 22 min including pre- and post PVI high-density voltage mapping. PFA catheter LA dwell-time was 23 ± 9 min. Total fluoroscopy time and dose area product were 16 ± 7 min and 505 [275;747] cGy*cm^2. One pericardial tamponade (0.7%), one transient ST-elevation (0.7%) and three groin complications (2.2%) occurred. 1-year follow-up showed freedom of arrhythmia in 90% in patients with paroxysmal AF (n = 47) and 60% in patients with persistent AF (n = 82, p = 0.015).

Conclusions: PFA-based PVI is acutely highly effective and associated with a beneficial safety and low recurrence rate.

Lemoine MD, et al. Clin Res Cardiol 2022 Sep 22. doi: 10.1007/s00392-022-02091-2

J Interv Card Electrophysiol. 2023 Feb 8. doi: 10.1007/s10840-023-01495-y. Online ahead of print.

Pulsed field ablation in real-world atrial fibrillation patients: clinical recurrence, operator learning curve and re-do procedural findings

Martin H Ruwald [1], Arne Johannessen [2], Morten Lock Hansen [2], Martin Haugdal [2], Rene Worck [2], Jim Hansen [2]

121 consecutive AF who underwent PFA ablation and high-density mapping

Results: PVI was achieved with PFA-only in 119 (98%) of the cases. During the implementation phase the mean procedure and fluoroscopy time was reduced from 85 ± 34 to 72 ± 18 min (p = 0.044) and 22 ± 9 to 16 ± 4 (p = 0.034). We observed one phrenic nerve palsy with only partial remission at follow-up. Other adverse events were numerically comparable to standard PVI procedures. Over a mean follow-up of 308 ± 87 days, a total of 22/121 (18.2%) cases experienced clinically significant recurrence or initiation of anti-arrhythmic drugs with Kaplan-Meier event-free estimate at 365 days of 80% (88% for paroxysmal versus 69% for persistent). In five of eight re-do procedures, gaps were primarily located at the right pulmonary veins.

Conclusions: PFA was a highly efficient method to achieve PVI with reductions in procedure time and fluoroscopy over the implementation period. The procedural data and clinical recurrence rates from initial trials were confirmed in real-life non-selected AF patients. More data is needed to establish lesion durability and limitations of PFA.

Pulsed Field Ablation for the Treatment of Atrial Fibrillation: PULSED AF Pivotal Trial

Prospective, global, multicenter, nonrandomized, paired single-arm study in which patients with paroxysmal (n=150) or persistent (n=150) symptomatic atrial fibrillation (AF) refractory to class I or III antiarrhythmic drugs

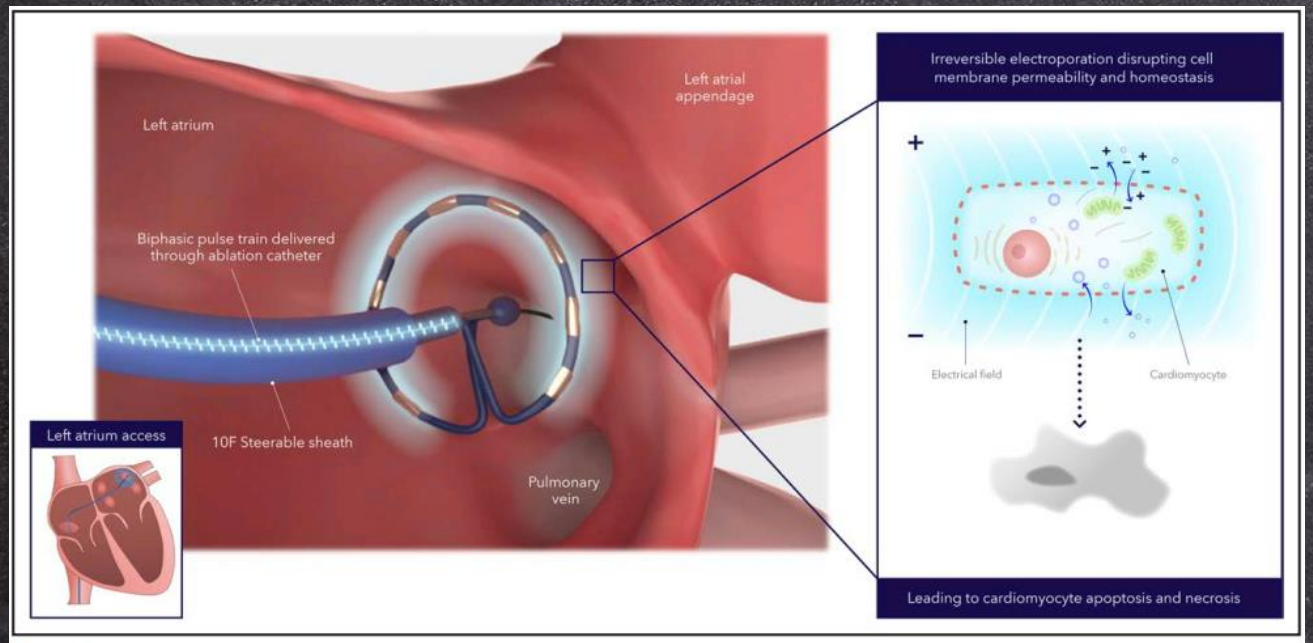
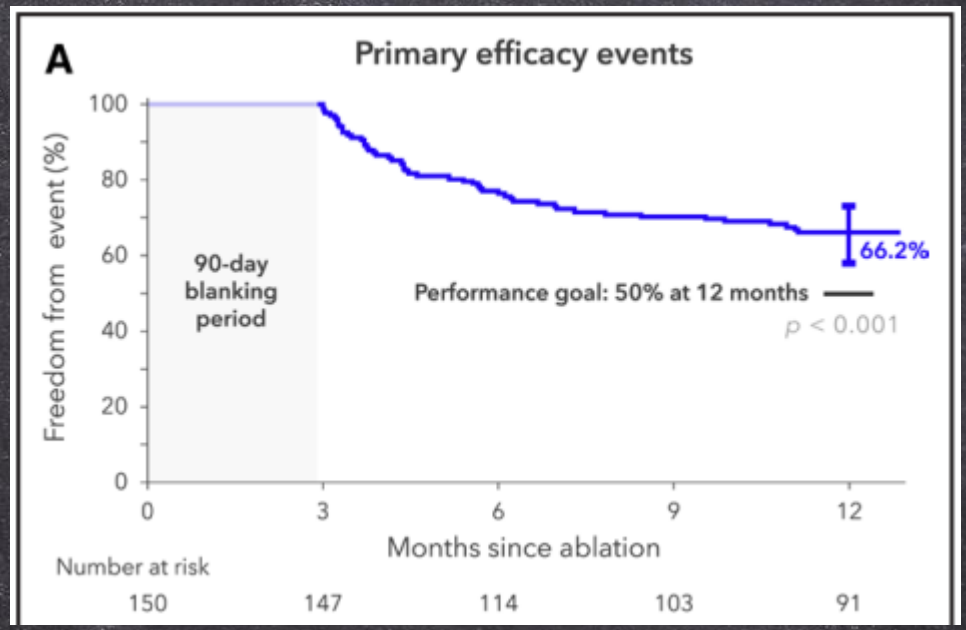


Figure 1. Catheter ablation method with pulsed field ablation system.
Alternating positive and negative electrodes sustains a bipolar electrical field around the catheter that extends into the tissue. The electrical field increases cell membrane permeabilization, which then leads to cell function disruption and eventually to cell death (ie, apoptosis and necrosis).



RESULTS: Pulsed field ablation was shown to be effective at 1 year in 66.2% (95% CI, 57.9 to 73.2) of patients with paroxysmal AF and 55.1% (95% CI, 46.7 to 62.7) of patients with persistent AF. The primary safety end point occurred in 1 patient (0.7%; 95% CI, 0.1 to 4.6) in both the paroxysmal and persistent AF cohorts.

CONCLUSIONS: PULSED AF demonstrated a low rate of primary safety adverse events (0.7%) and provided effectiveness consistent with established ablation technologies using a novel irreversible electroporation energy to treat patients with AF.

Verma A., et al. Circulation. 2023;147:00–00. DOI: 10.1161/CIRCULATIONAHA.123.063988

ESC European Society of Cardiology

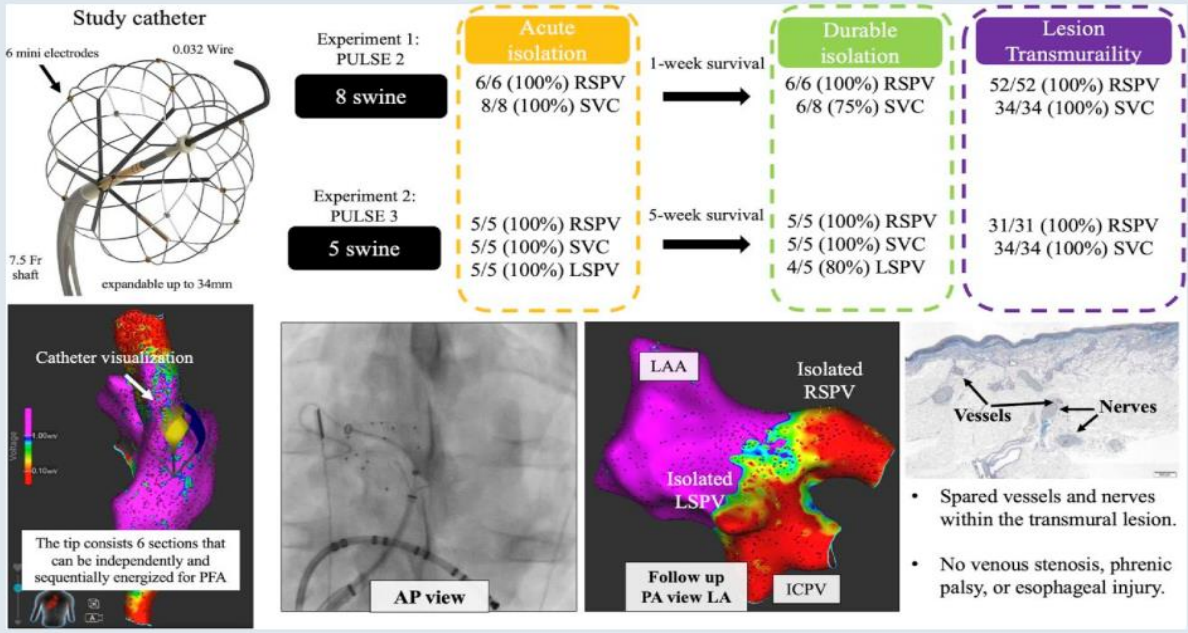
Europace (2023) **25**, 1369–1378
https://doi.org/10.1093/europace/euad030

CLINICAL RESEARCH

Preclinical assessment of the feasibility, safety and lesion durability of a novel 'single-shot' pulsed field ablation catheter for pulmonary vein isolation

Jacob Koruth [1]*, Iwanari Kawamura [1], Srinivas R. Dukkipati[1], Petr Neuzil [2], and Vivek Y. Reddy [1]

Graphical Abstract



Aims

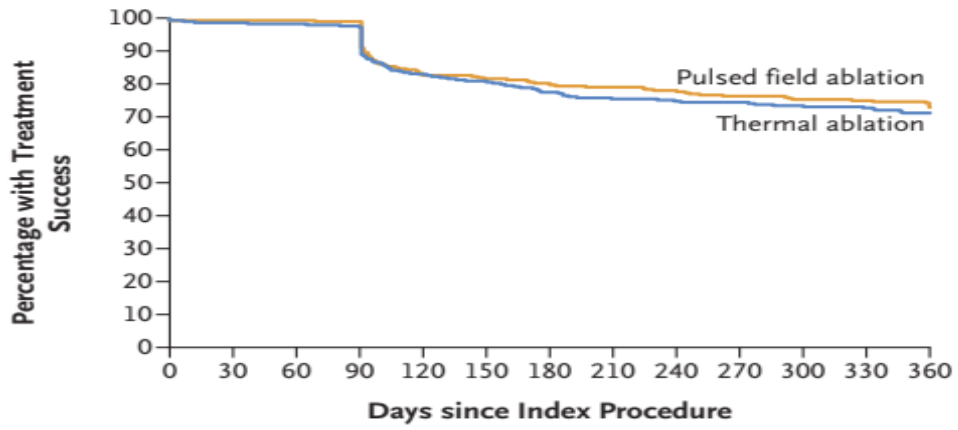
Single-shot pulmonary vein isolation can improve procedural efficiency. To assess the capability of a novel, expandable lattice-shaped catheter to rapidly isolate thoracic veins using pulsed field ablation (PFA) in healthy swine.

Methods and results

The study catheter (SpherePVI; Affera Inc) was used to isolate thoracic veins in two cohorts of swine survived for 1 and 5 weeks. In Experiment 1, an initial dose (PULSE2) was used to isolate the superior vena cava (SVC) and the right superior pulmonary vein (RSPV) in six swine and the SVC only in two swine. In Experiment 2, a final dose (PULSE3) was used for SVC, RSPV, and left superior pulmonary vein (LSPV) in five swine. Baseline and follow-up maps, ostial diameters, and phrenic nerve were assessed. Pulsed field ablation was delivered atop the oesophagus in three swine. All tissues were submitted for pathology. In Experiment 1, all 14/14 veins were isolated acutely with durable isolation demonstrated in 6/6 RSPVs and 6/8 SVC. Both reconnections occurred when only one application/vein was used. Fifty-two and 32 sections from the RSPVs and SVC revealed transmural lesions in 100% with a mean depth of 4.0 ± 2.0 mm. In Experiment 2, 15/15 veins were isolated acutely with 14/15 veins (5/5 SVC, 5/5 RSPV, and 4/5 LSPV) durably isolated. Right superior pulmonary vein (31) and SVC (34) sections had 100% transmural, circumferential ablation with minimal inflammation. Viable vessels and nerves were noted without evidence of venous stenosis, phrenic palsy, or oesophageal injury.

Pulsed Field or Conventional Thermal Ablation for Paroxysmal Atrial Fibrillation

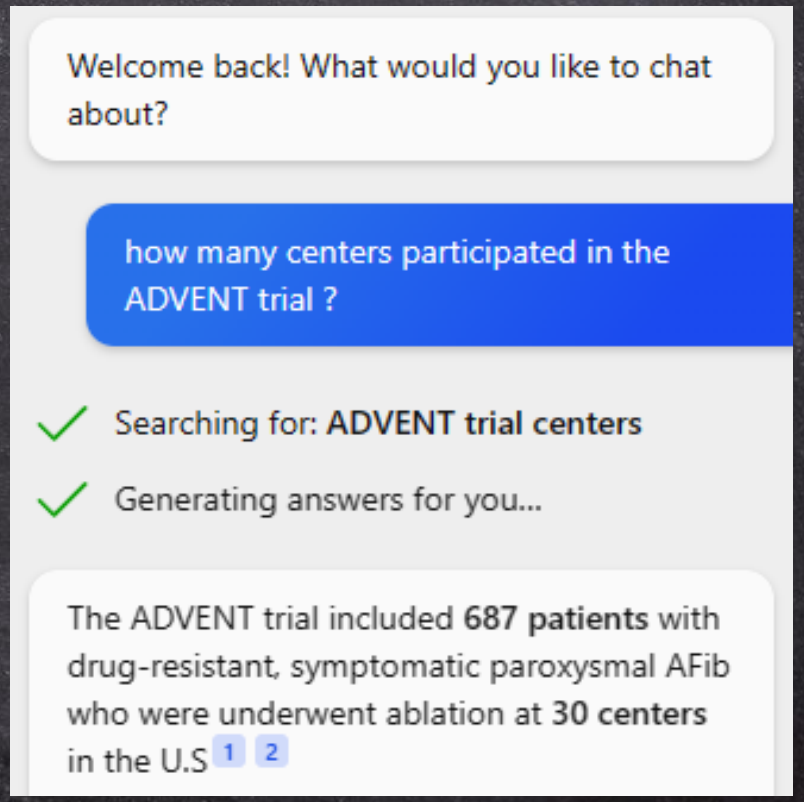
The **ADVENT** trial was a multicenter, randomized, noninferiority, single-blind, pivotal trial with blinded end-point adjudication. A total of 305 patients were assigned to undergo pulsed field ablation, and 302 were assigned to undergo thermal ablation. At 1 year, the primary efficacy end point was met (i.e., no events occurred) in 204 patients (estimated probability, 73.3%) who underwent pulsed field ablation and 194 patients (estimated probability, 71.3%) who underwent thermal ablation.



No. at Risk					
Pulsed field ablation	301	298	238	228	176
Thermal ablation	296	292	228	219	150
Treatment Success (%)					
Pulsed field ablation	99.3	99.0	79.7	76.4	73.1
Thermal ablation	98.7	97.3	77.5	74.5	71.3

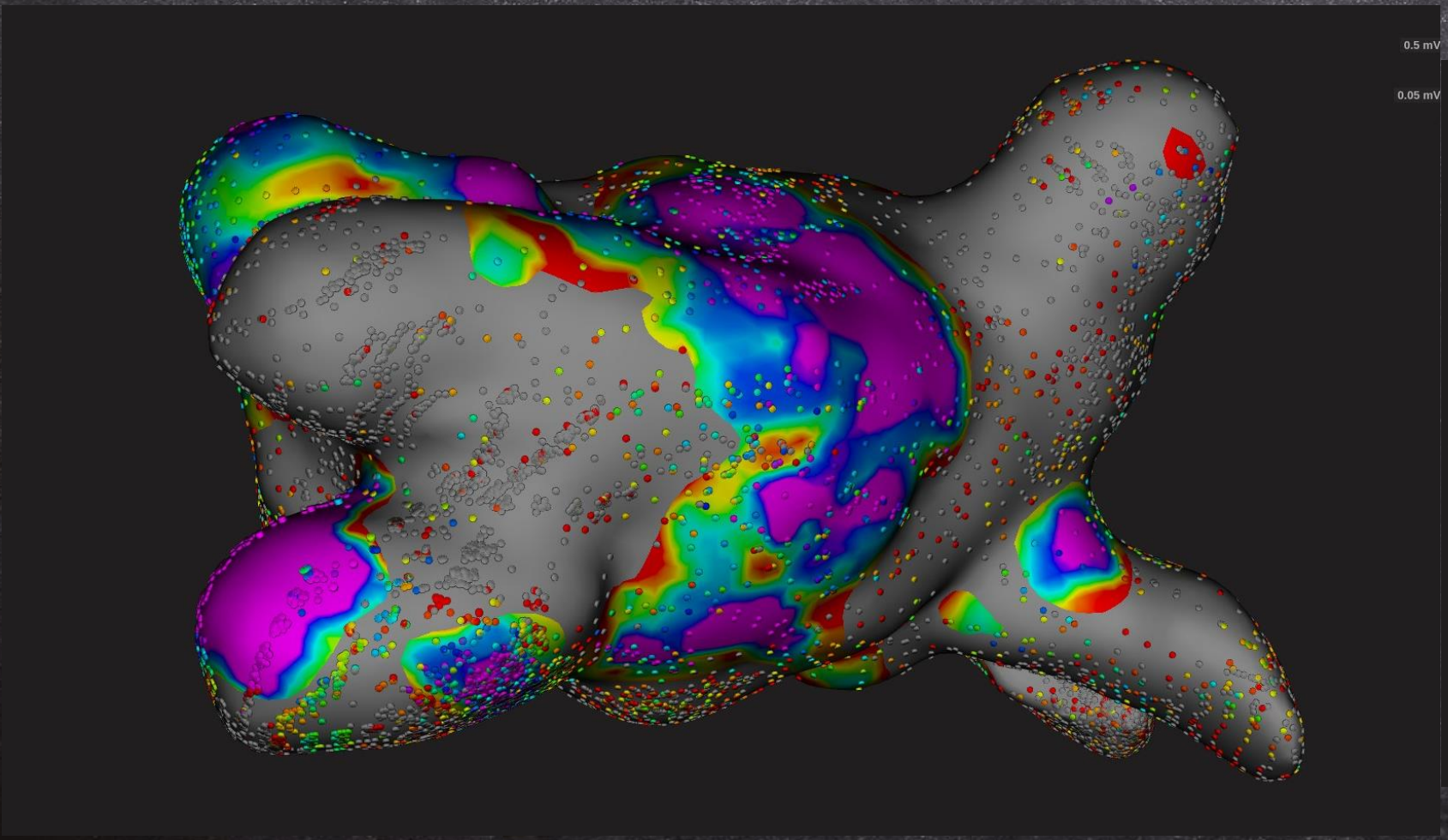
Figure 2. Efficacy Outcomes of Pulsed Field Ablation as Compared with Thermal Ablation.

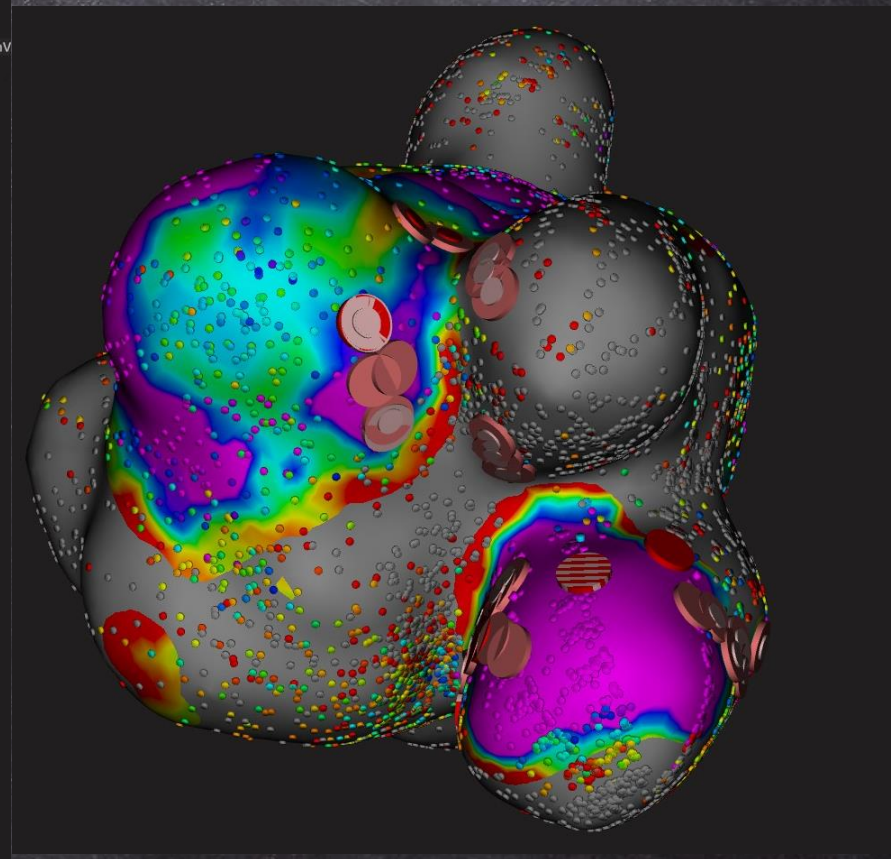
AI



Reddy VY, et al. Pulsed Field or Conventional Thermal Ablation for Paroxysmal Atrial Fibrillation. N Engl J Med. 2023. PMID: 37634148

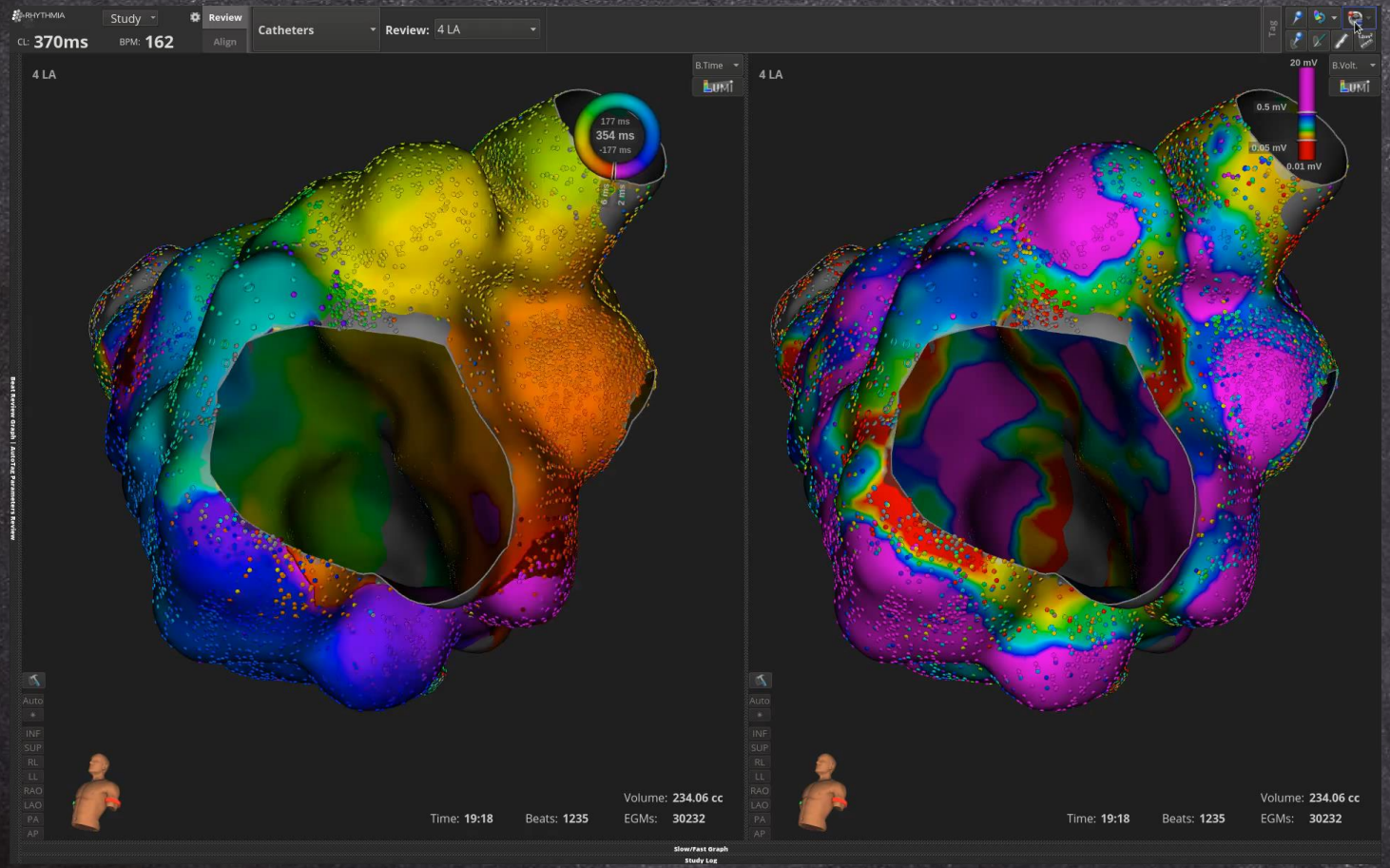
Ασθενής με εμμένουσα ΚΜ αγνώστου ενάρξεως και δυσλειτουργία ΑΚ προσέρχεται για PFA ablation (πρώτα 20 περιστατικά)
Συχνές υποτροπές το πρώτο τρίμηνο και νέο RF ablation 4 μήνες μετά

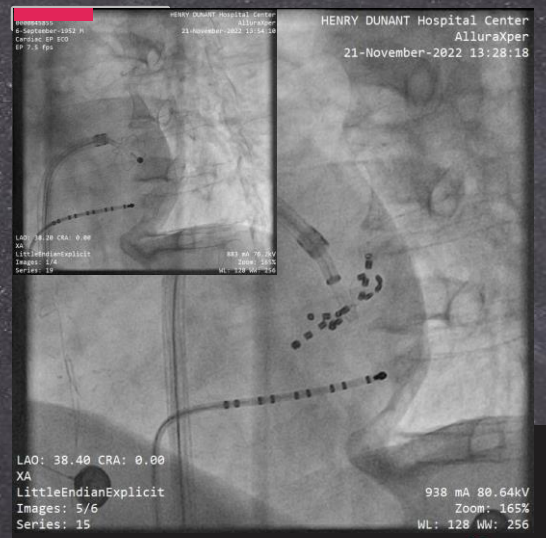


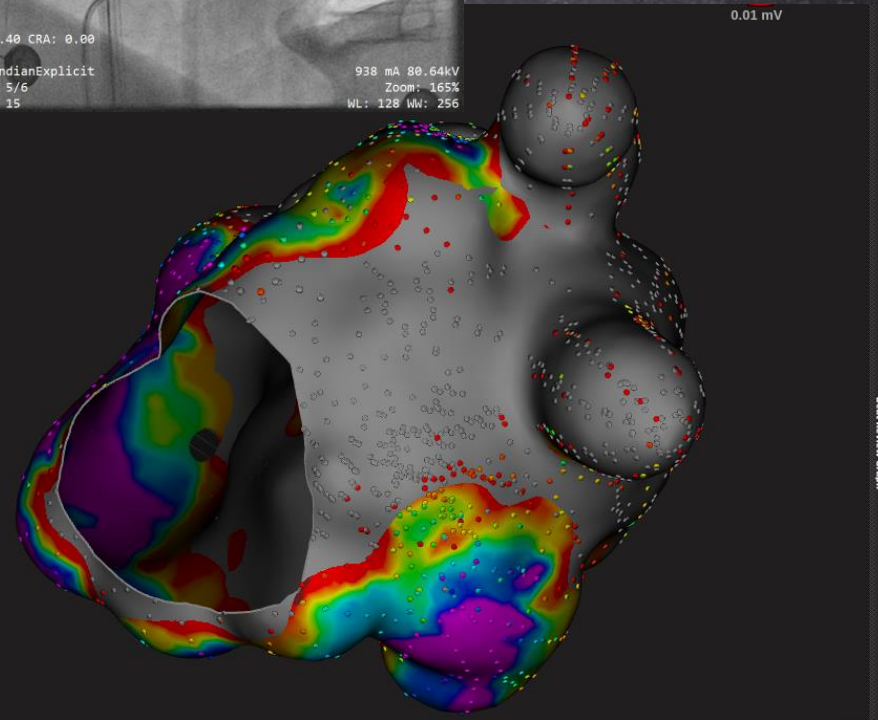


Αρχείο Γ.Ανδρικόπουλου, 2023

Fluoroscopy guided “modified anterior line” with PFA (Is it another way to treat perimitral tachycardias?)



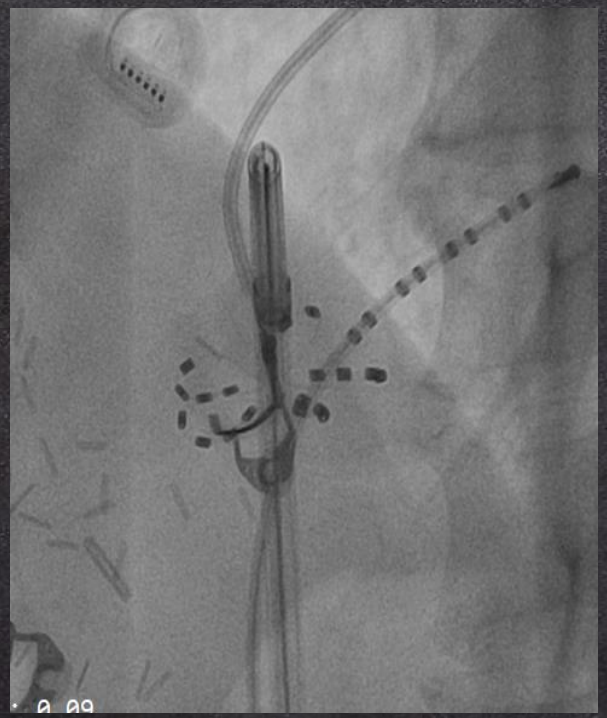


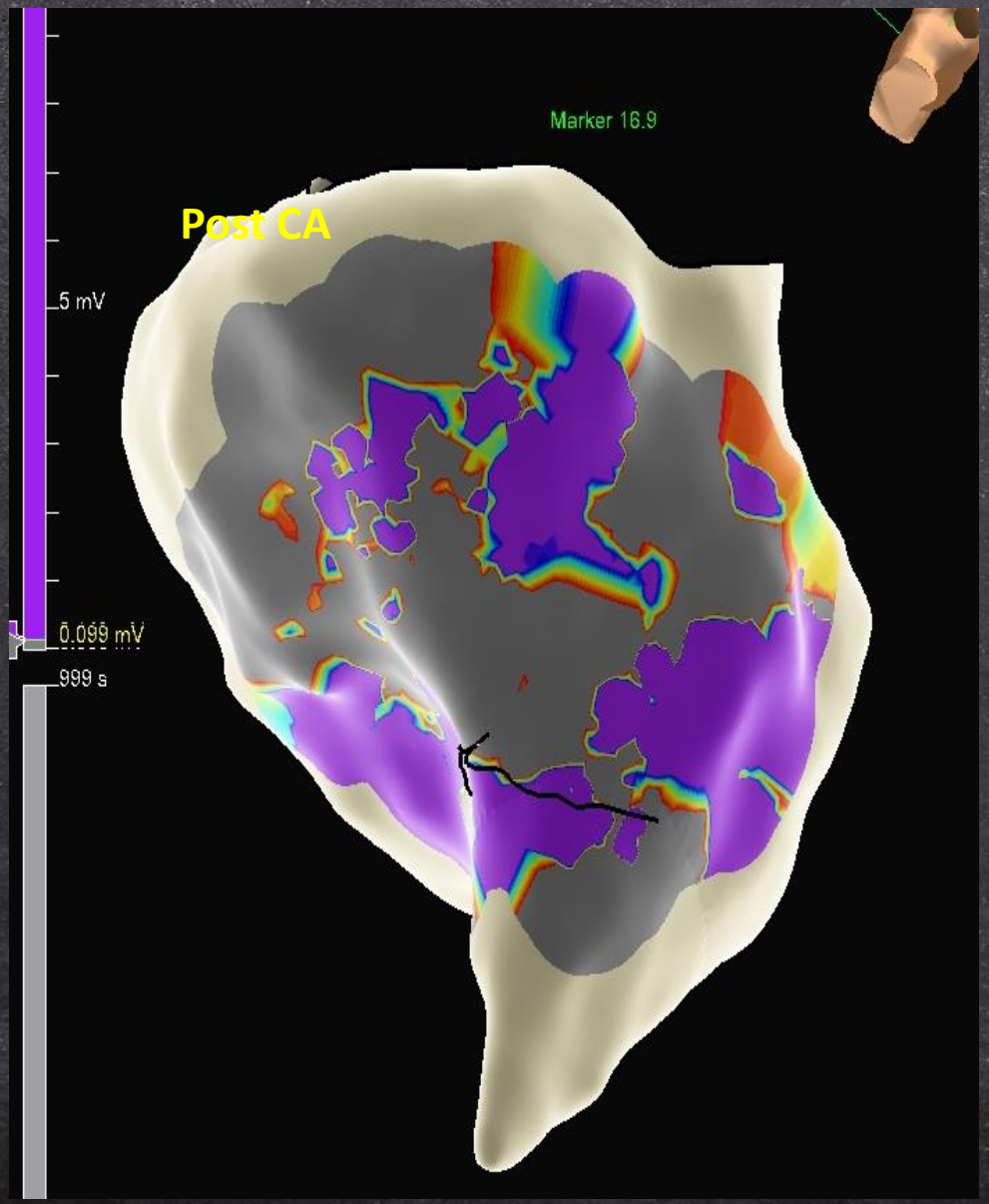


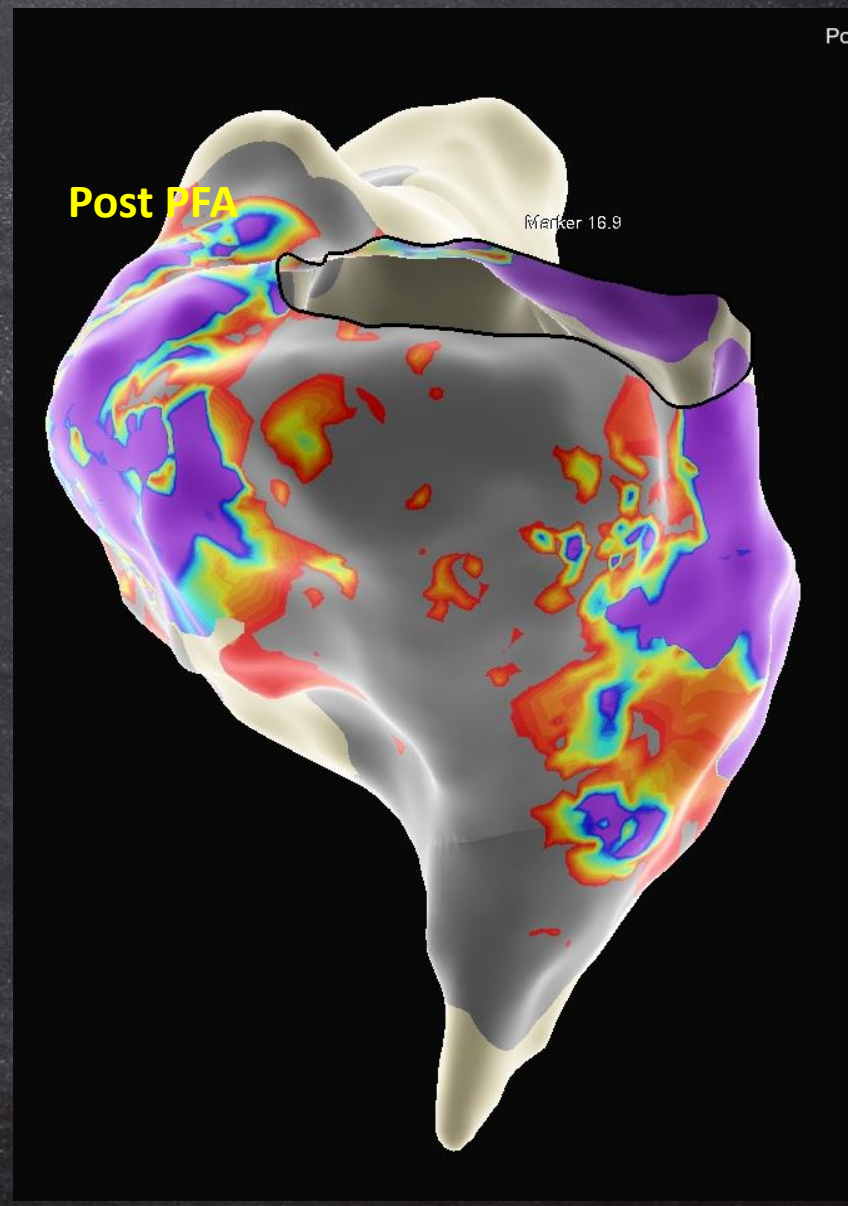
Ερρίκος Ντυνάν Hospital Center, Νοέμβριος 2022

Fluoroscopy guided PF CTI ablation in a patient with peculiar anatomy

(CTI bidirectional block NOT feasible with irrigated catheter and electroanatomic mapping)



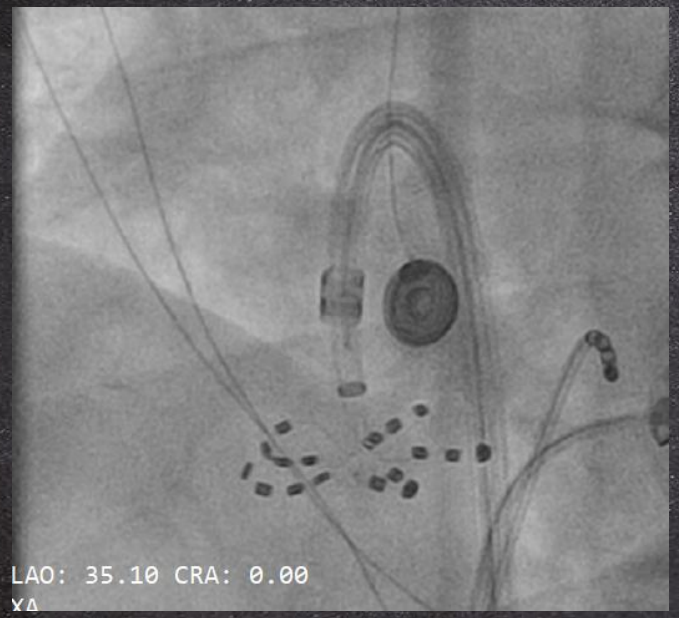


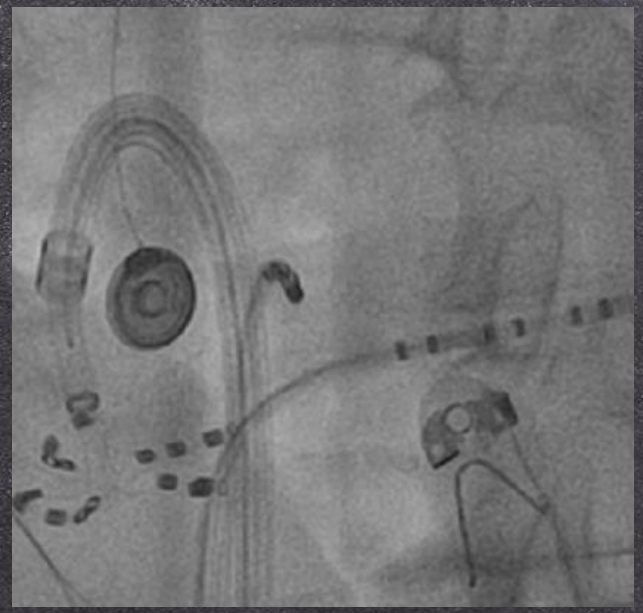


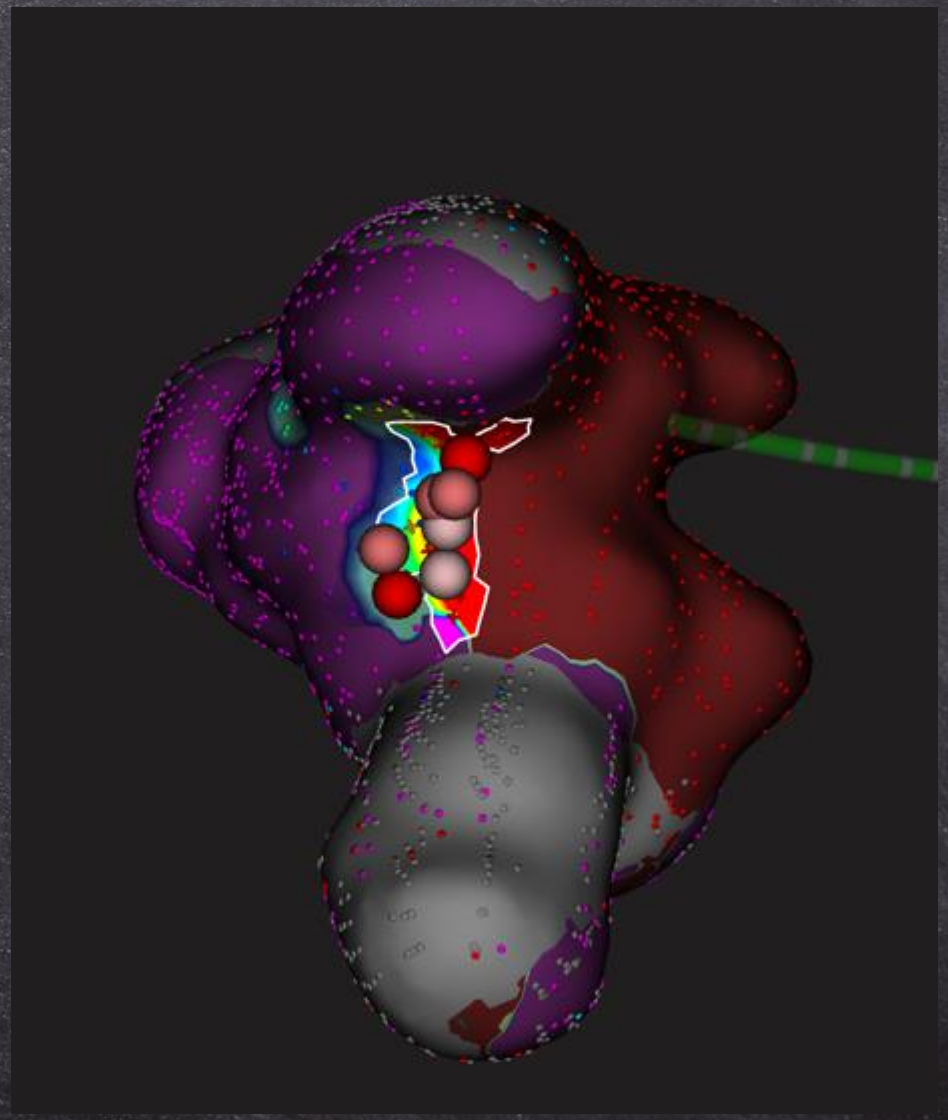
Ερρίκος Ντυνάν Hospital Center, Ιανουάριος 2023

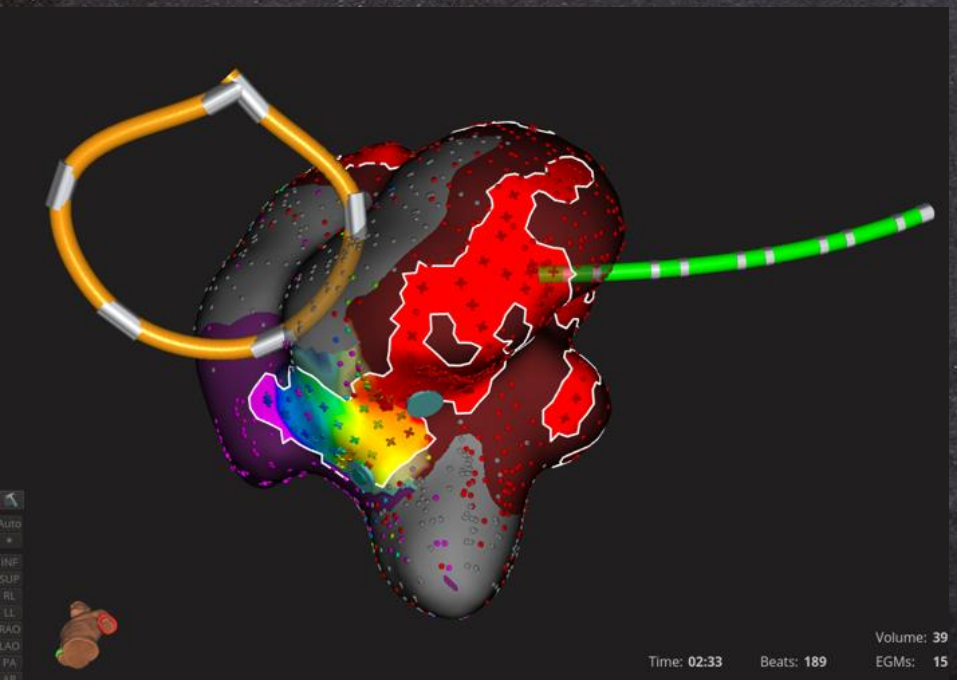
Ασθενής 52 ετών, απουσία οργανικής καρδιοπάθειας, συχνά επεισόδια ρυθμικής ταχυκαρδίας τελευταίο 6μηνο

AF ablation 2016 (cryo – άλλο κέντρο) - AF ablation 2019 (RF Rhythmia – Ερρίκος Ντυνάν)









PFA is NOT Always the solution for everything

Ερρίκος Ντυνάν Hospital Center, Τετάρτη 23 Νοεμβρίου 2022

ESC European Society of Cardiology

European Heart Journal - Case Reports (2023) 7, 1–5
https://doi.org/10.1093/ehjcr/ytad370

CASE REPORT
Electrophysiology

Transient conduction disturbances acutely after pulsed-field cavotricuspid isthmus ablation: a case report

George Andrikopoulos, Konstantinos Tampakis *, Alexandros Sykiotis, and Sokratis Pastromas

First Department of Cardiology/Electrophysiology and Pacing, Henry Dunant Hospital Center, 107 Mesogeion ave, 11526 Athens, Greece

Received 26 March 2023; revised 24 July 2023; accepted 31 July 2023; online publish-ahead-of-print 2 August 2023

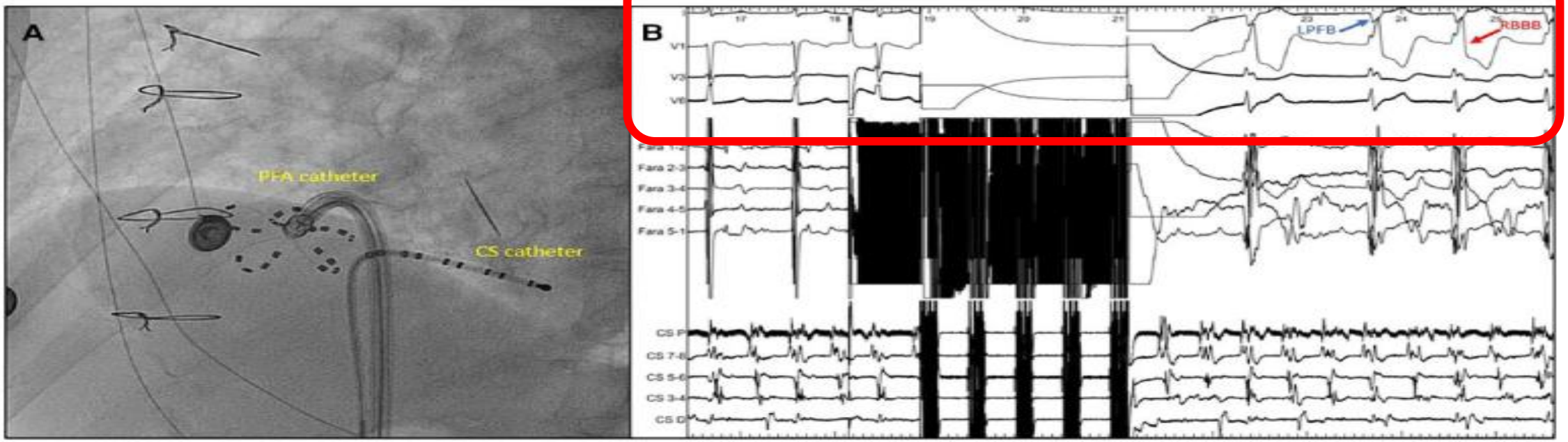
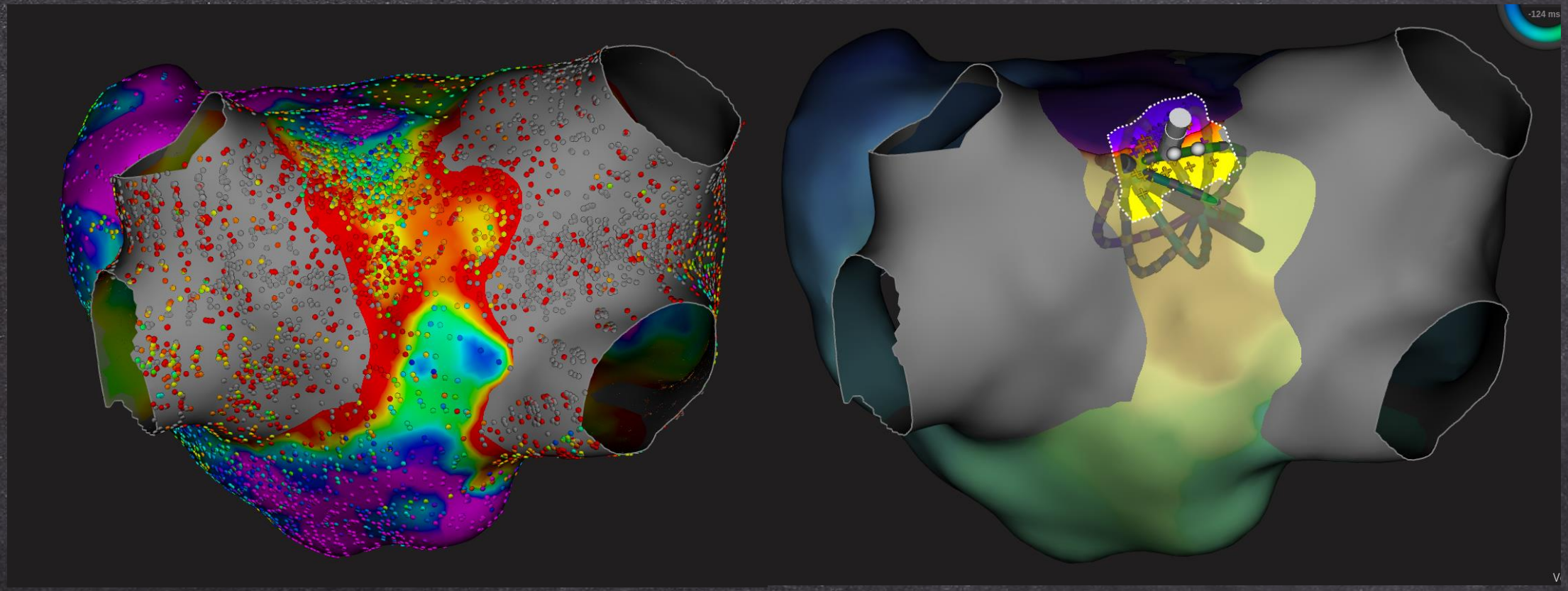


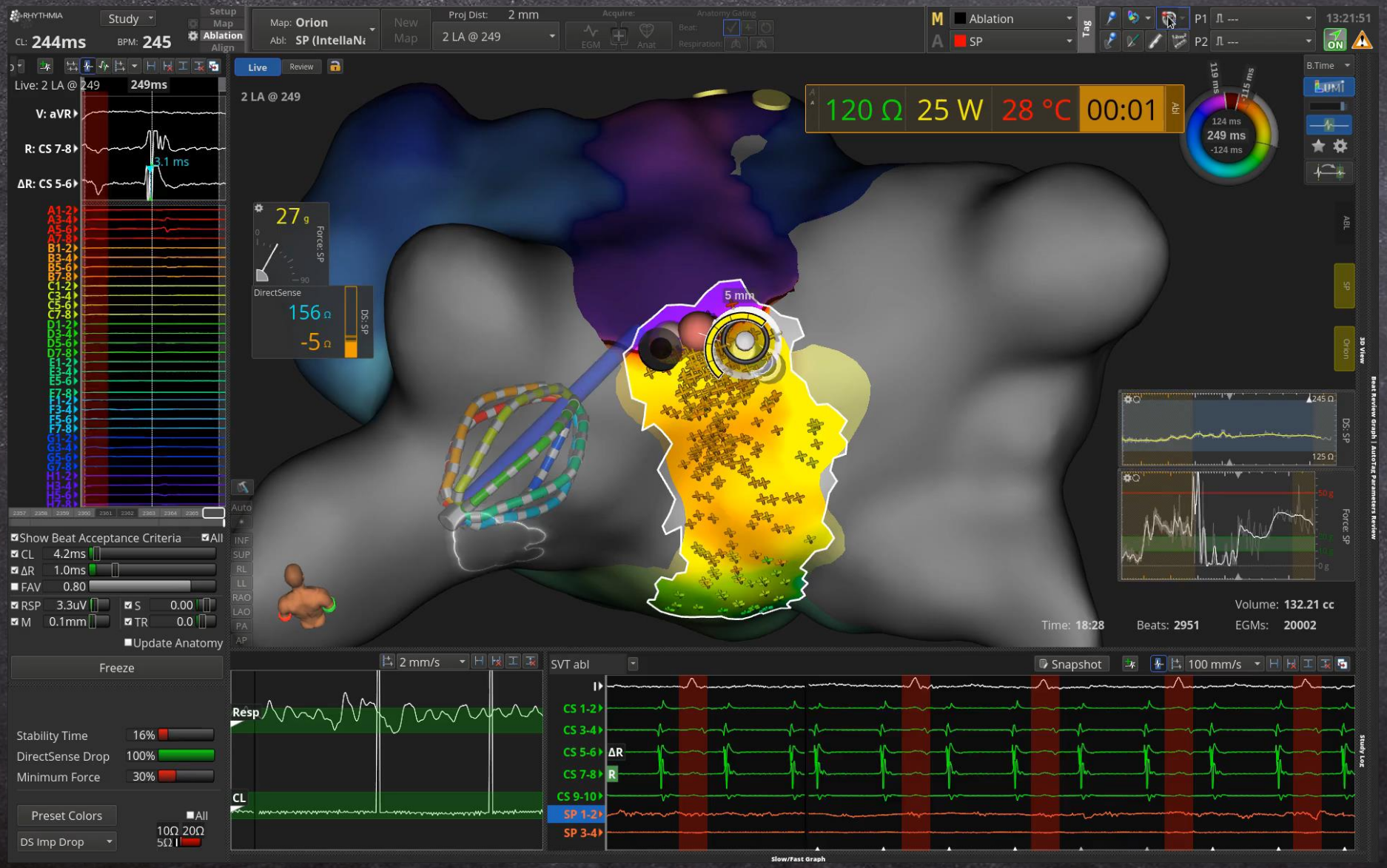
Figure 2 (*A*) After administration of 2 mg of intravenous nitroglycerine, a single pulsed-field application (with a peak voltage of 2.0 kV), in flower configuration, was delivered at the lateral annular portion of the cavotricuspid isthmus. (*B*) Acute occurrence of RBBB and LPFB without flutter termination. CS, coronary sinus; PFA, pulsed-field ablation; RBBB, right bundle branch block; LPFB, left posterior fascicular block.

Roof-depended flutter 7 χρόνια μετά από επέμβαση κρυοκατάλυσης εμμένουσας κολπικής μαρμαρυγής



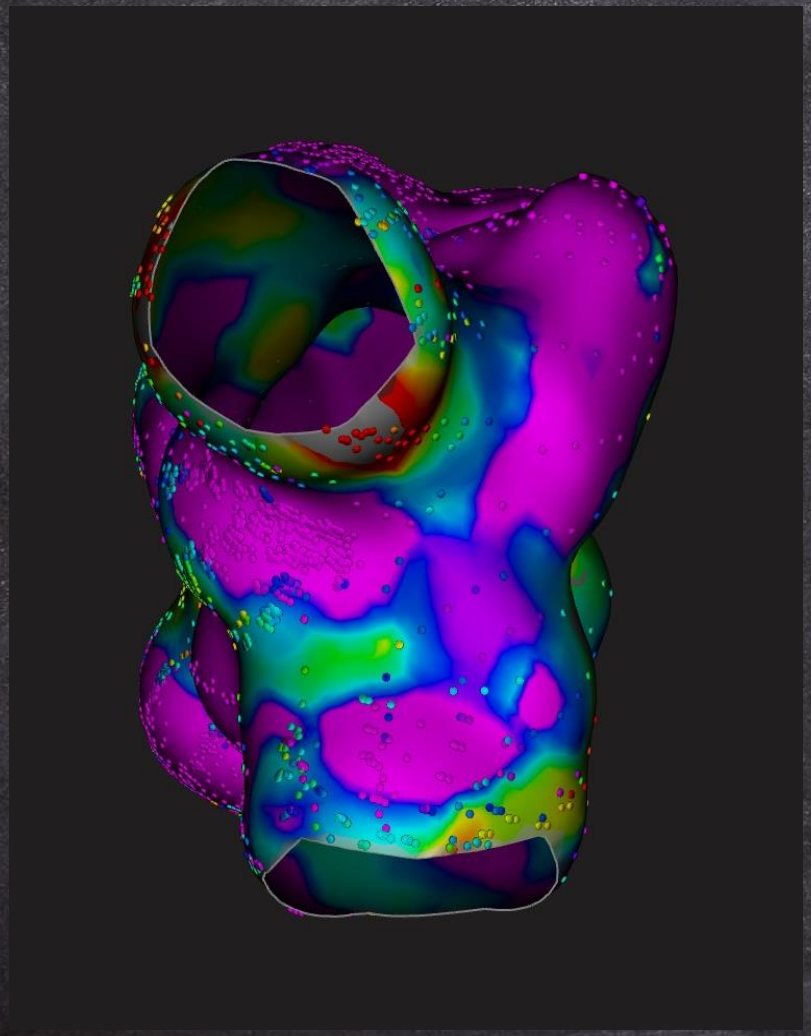
Αρχείο Γ.Ανδρικόπουλου, 2021

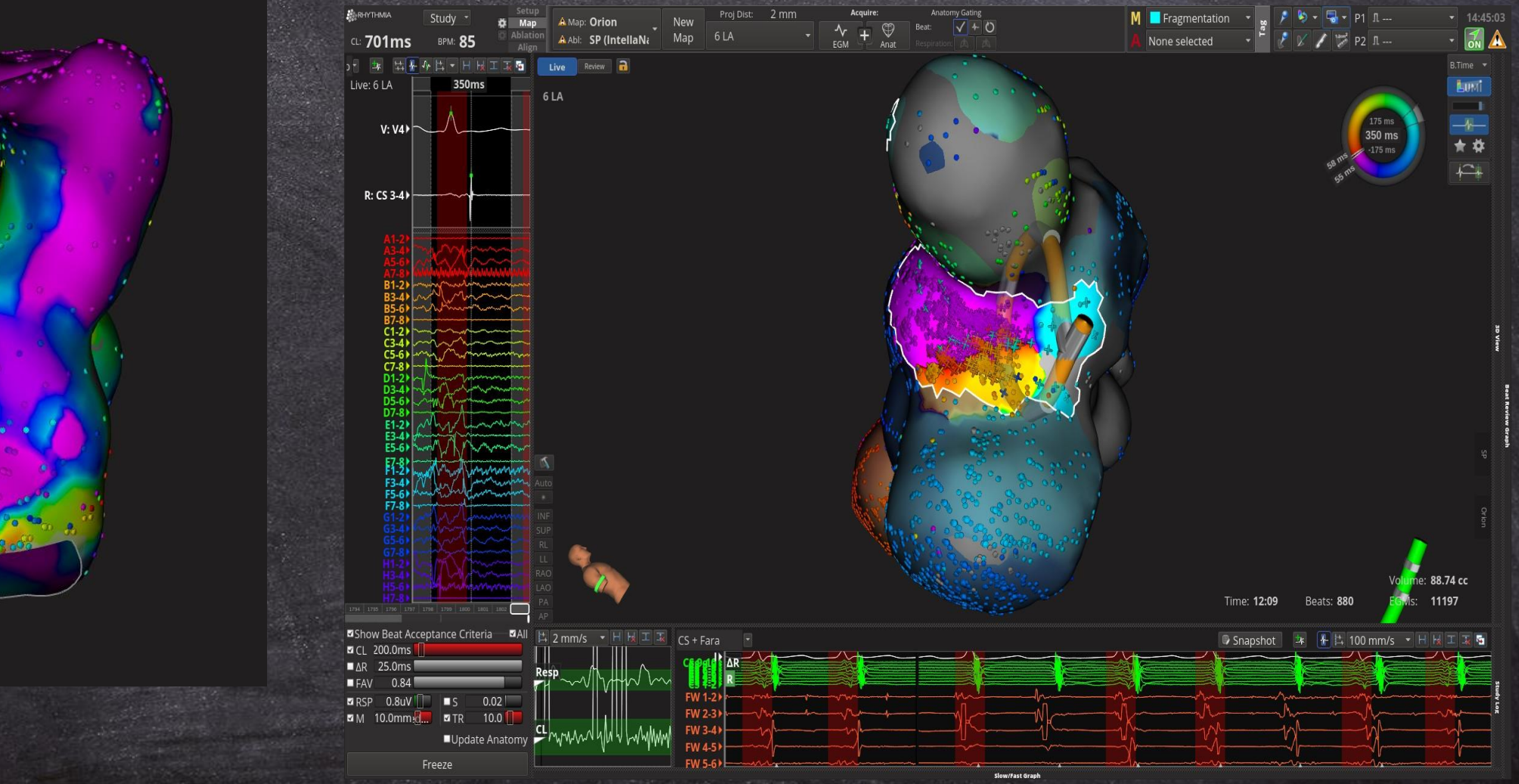
Roof-depended flutter 7 χρόνια μετά από επέμβαση κρυοκατάλυσης εμμένουσας κολπικής μαρμαρυγής



Αρχείο Γ.Ανδρικόπουλου Δεκέμβριος 2021, Ερρίκος Ντυνάν Hospital Center

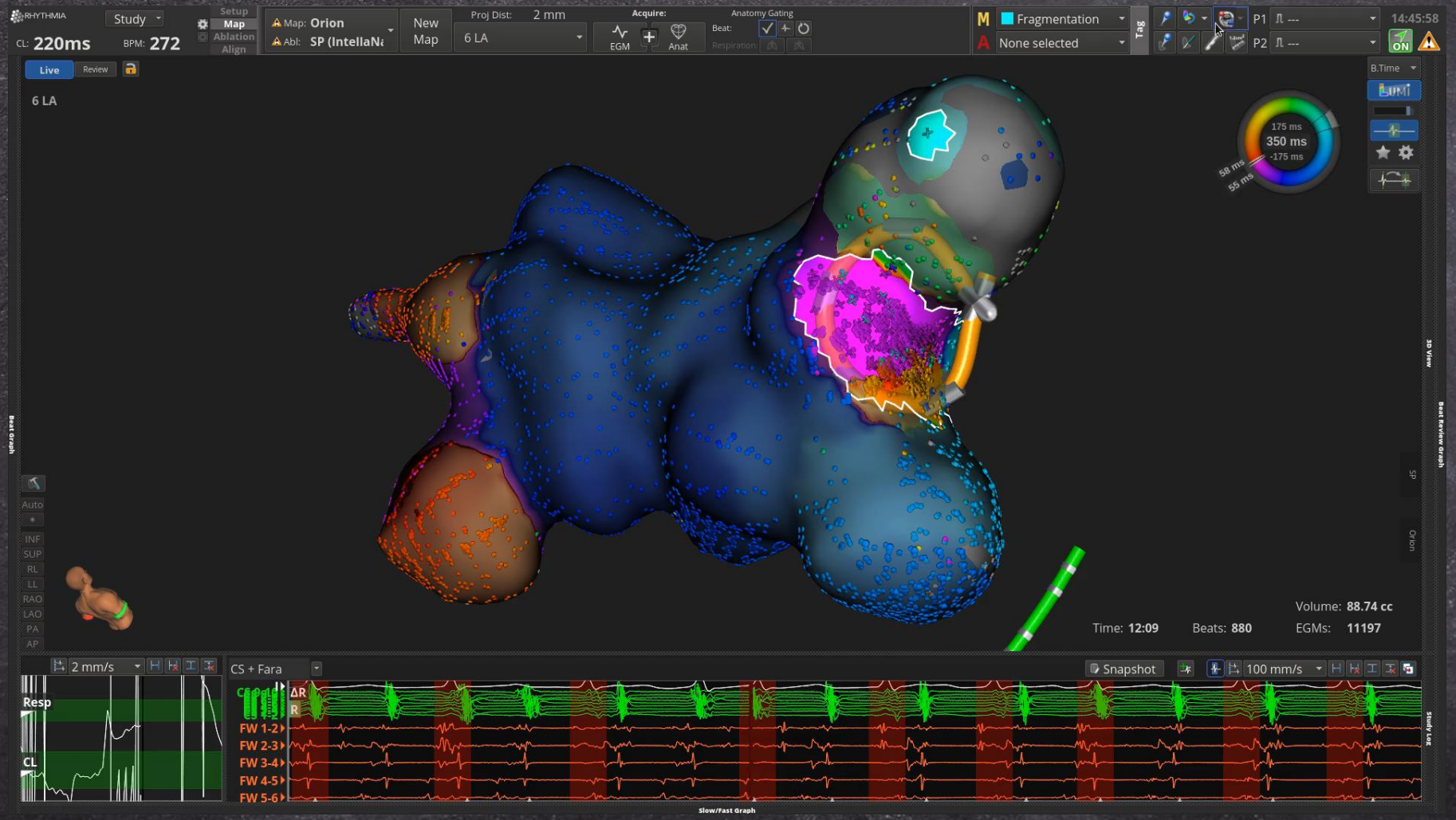
Ασθενής 61 ετών, ιατρός, προσέρχεται λόγω πολλαπλών κρίσεων κολπικής ταχυκαρδίας και κολπικής μαρμαρυγής μετά από RF ablation





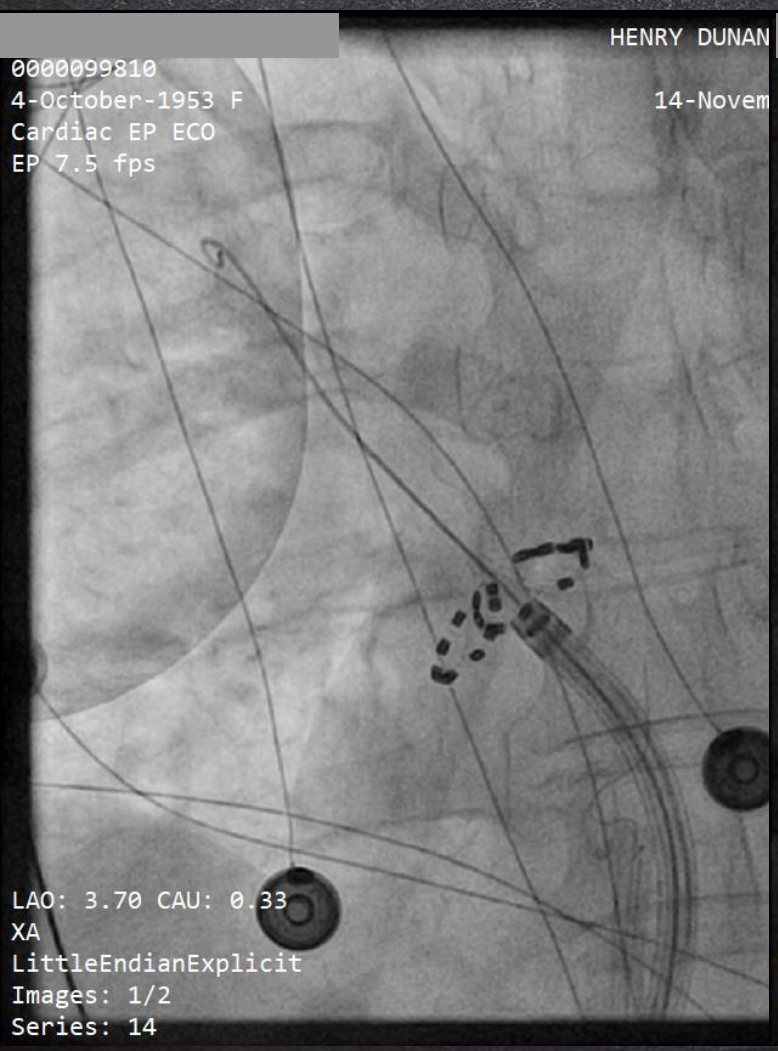
Αρχείο Γ.Ανδρικόπουλου, 2023

Ασθενής 61 ετών, ιατρός, προσέρχεται λόγω πολλαπλών κρίσεων κολπικής ταχυκαρδίας και κολπικής μαρμαρυγής μετά από RF ablation



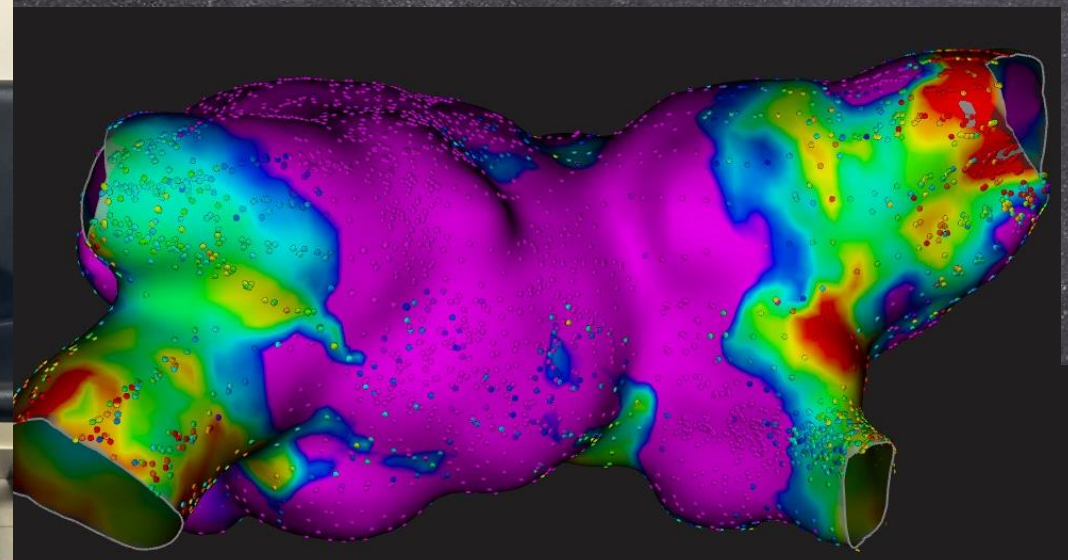
Αρχείο Γ.Ανδρικόπουλου, 2023

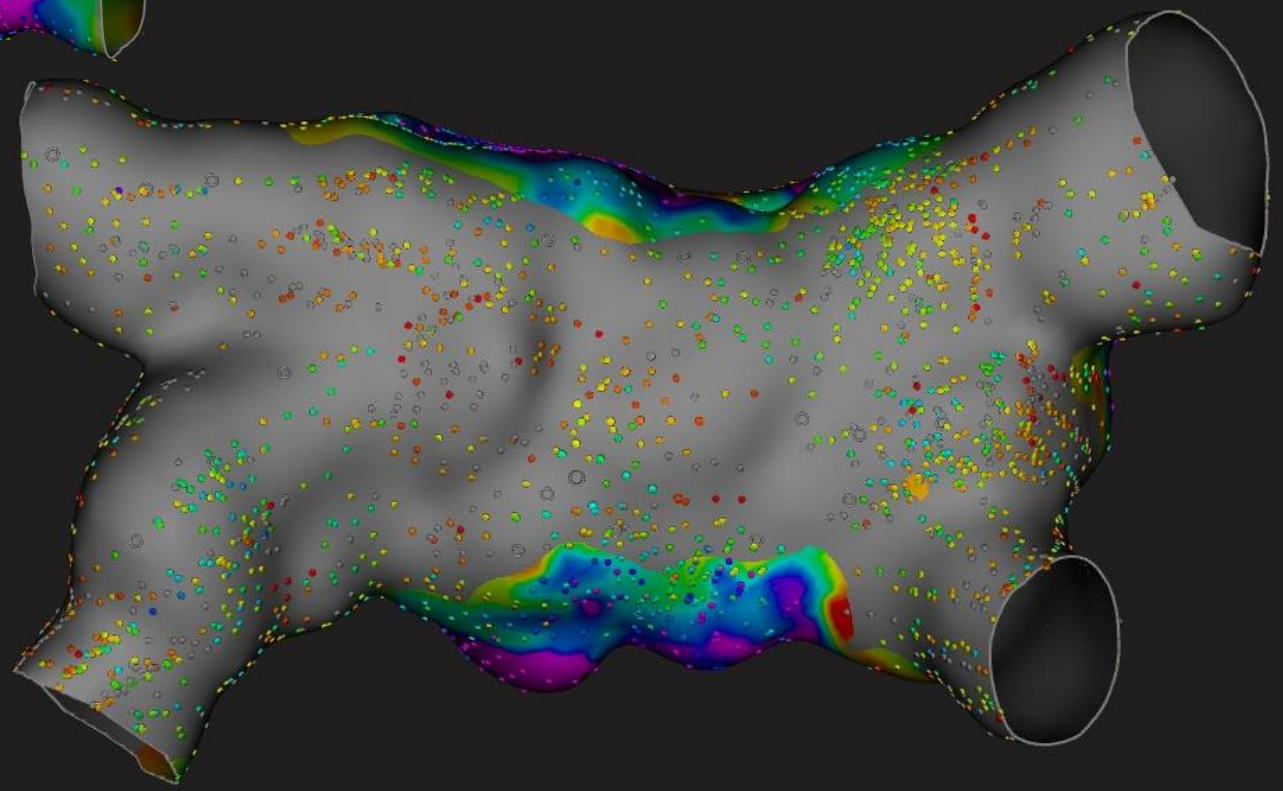
LA Roof “Line” with PFA



Αρχείο Γ.Ανδρικόπουλου, Νοέμβριος 2022

Posterior Wall Isolation – NOW FEASIBLE

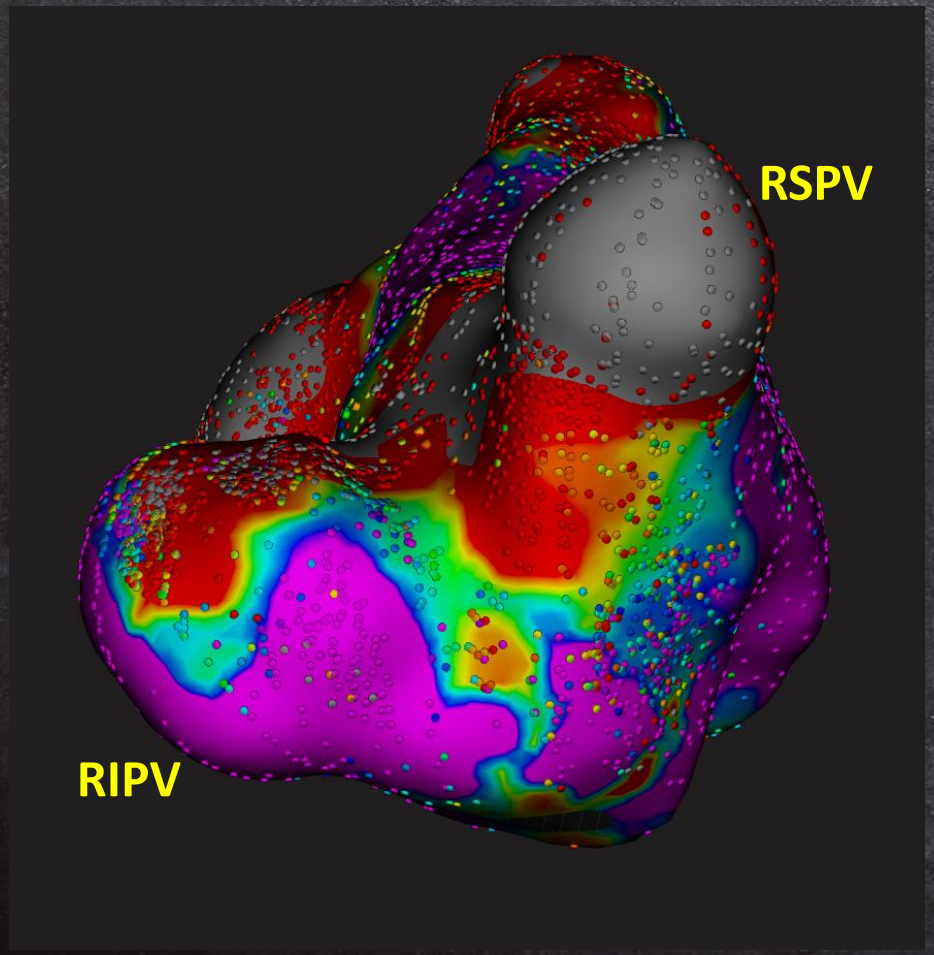


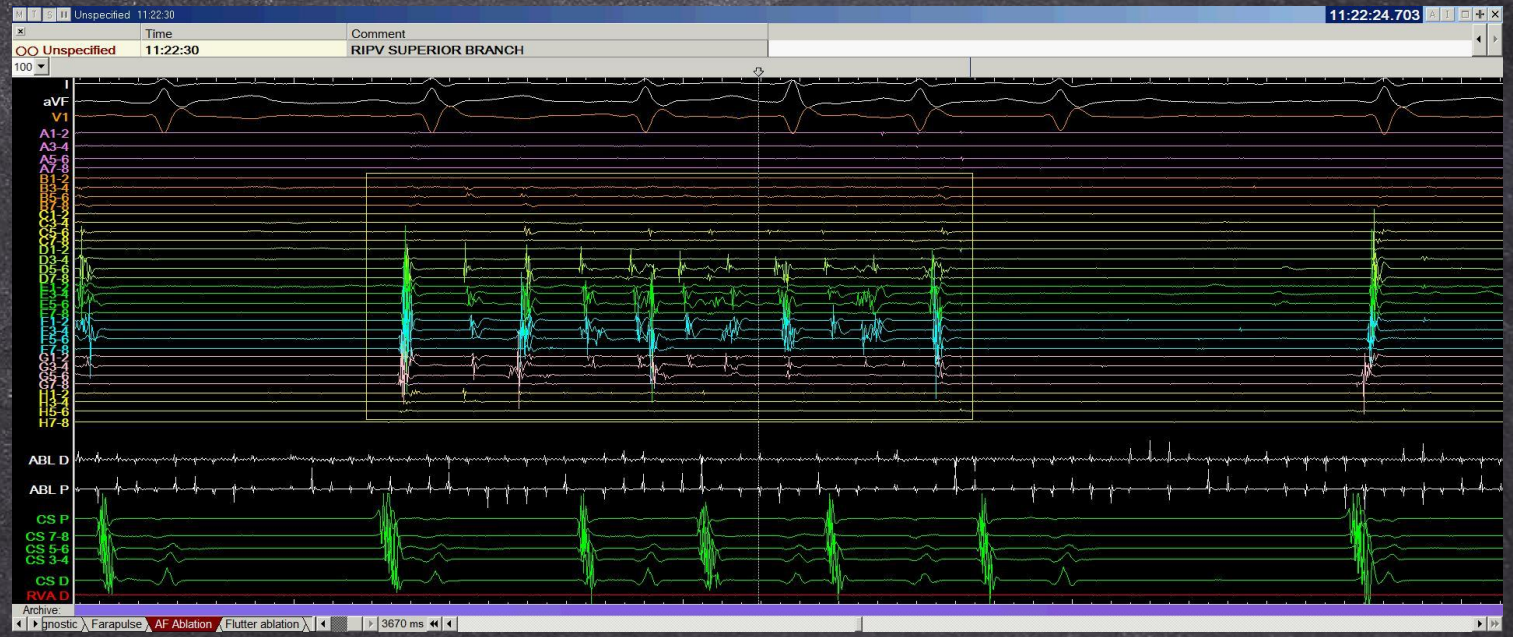


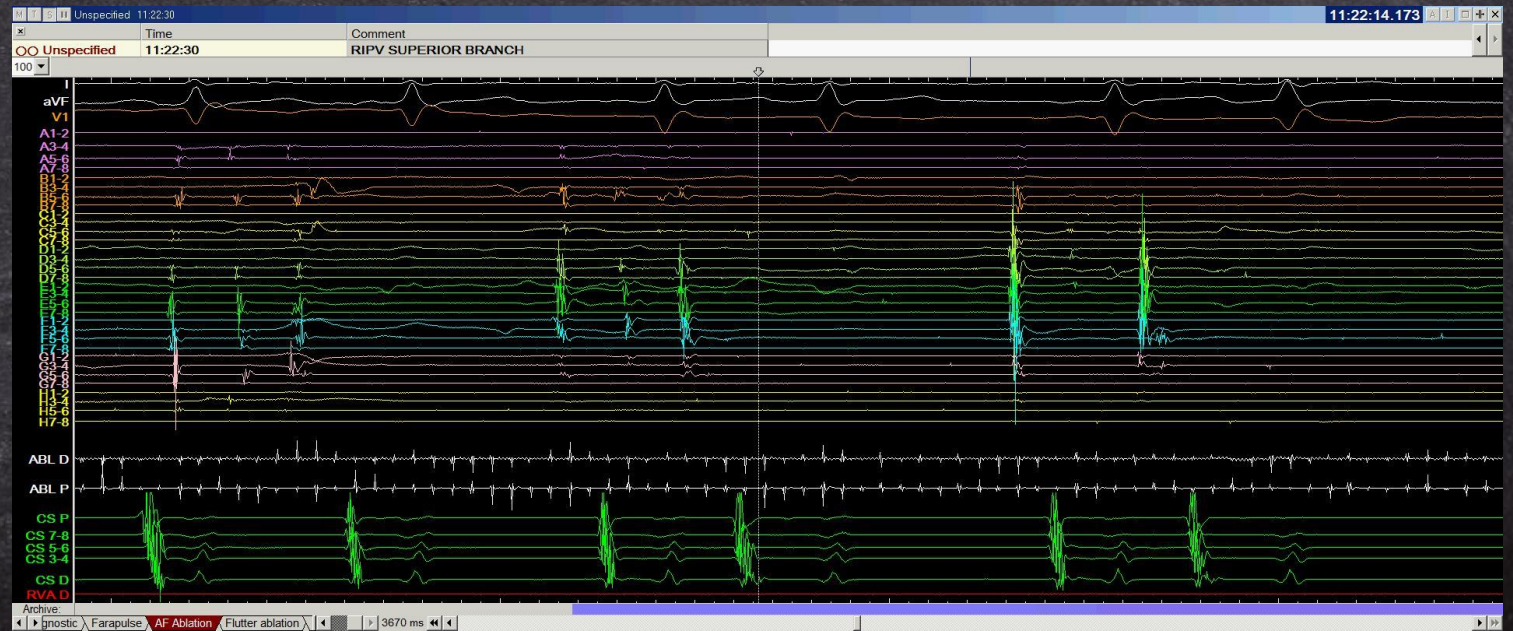
Ερρίκος Ντυνάν Hospital Center,
Σεπτέμβριος 2023

Ασθενής 33 ετών προσέρχεται προ 1,5 έτος με αγνώστου ενάρξεως ΚΜ
3/2022 Cryoablation - 7/2022 RF ablation (Rhythmia) - 5/4/2023 PFA

Χάρτης πριν το PFA ablation
(8 μήνες μετά το RF ablation)

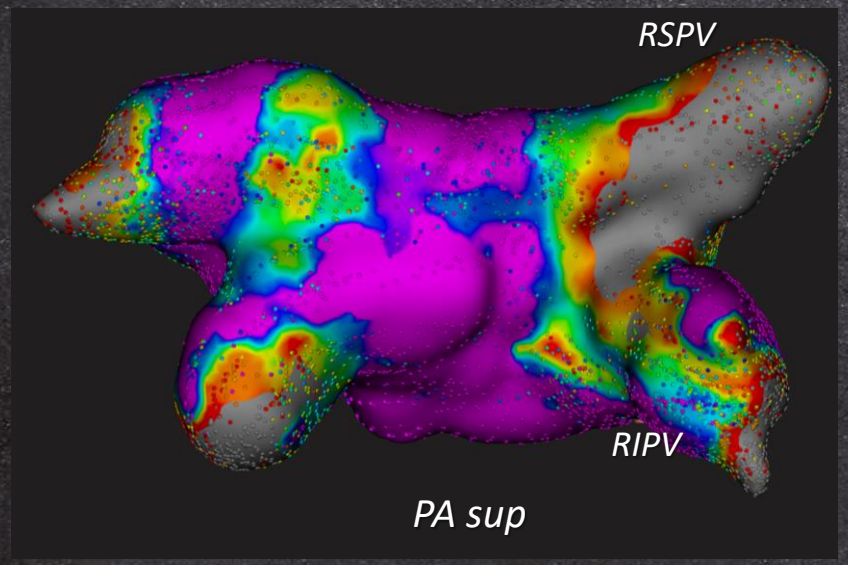


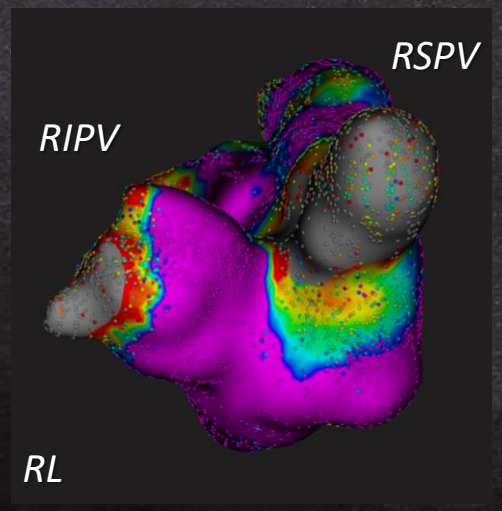




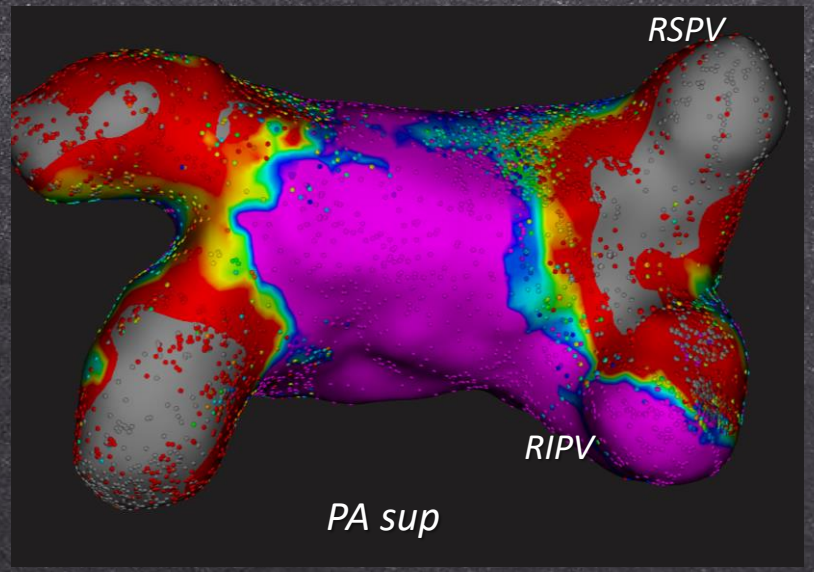
Ασθενής 33 ετών προσέρχεται προ 1,5 έτος με αγνώστου ενάρξεως ΚΜ
3/2022 Cryoablation - 7/2022 RF ablation (Rhythmia) - 5/4/2023 PFA

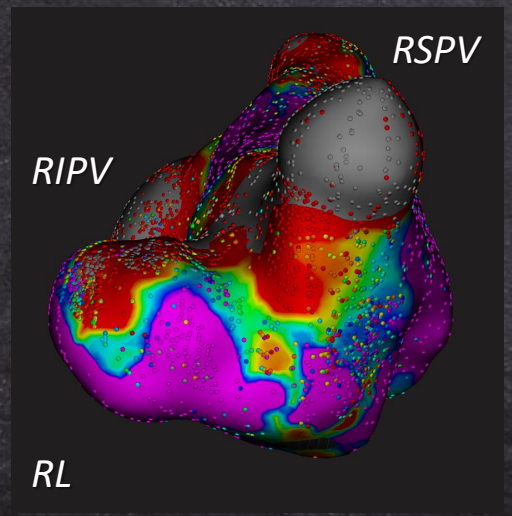
Χάρτης πριν το RF ablation
(4 μήνες μετά το cryoablation)



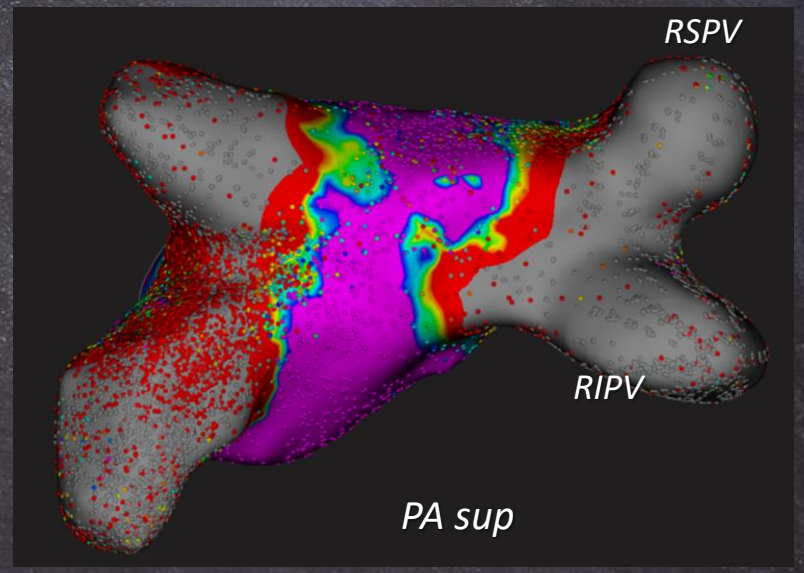


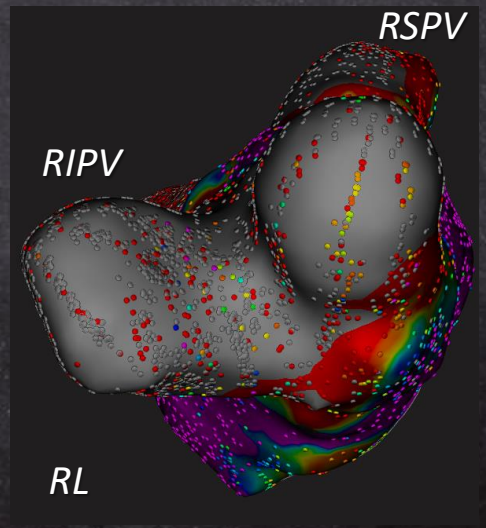
Χάρτης πριν το PFA ablation
(8 μήνες μετά το RF ablation)



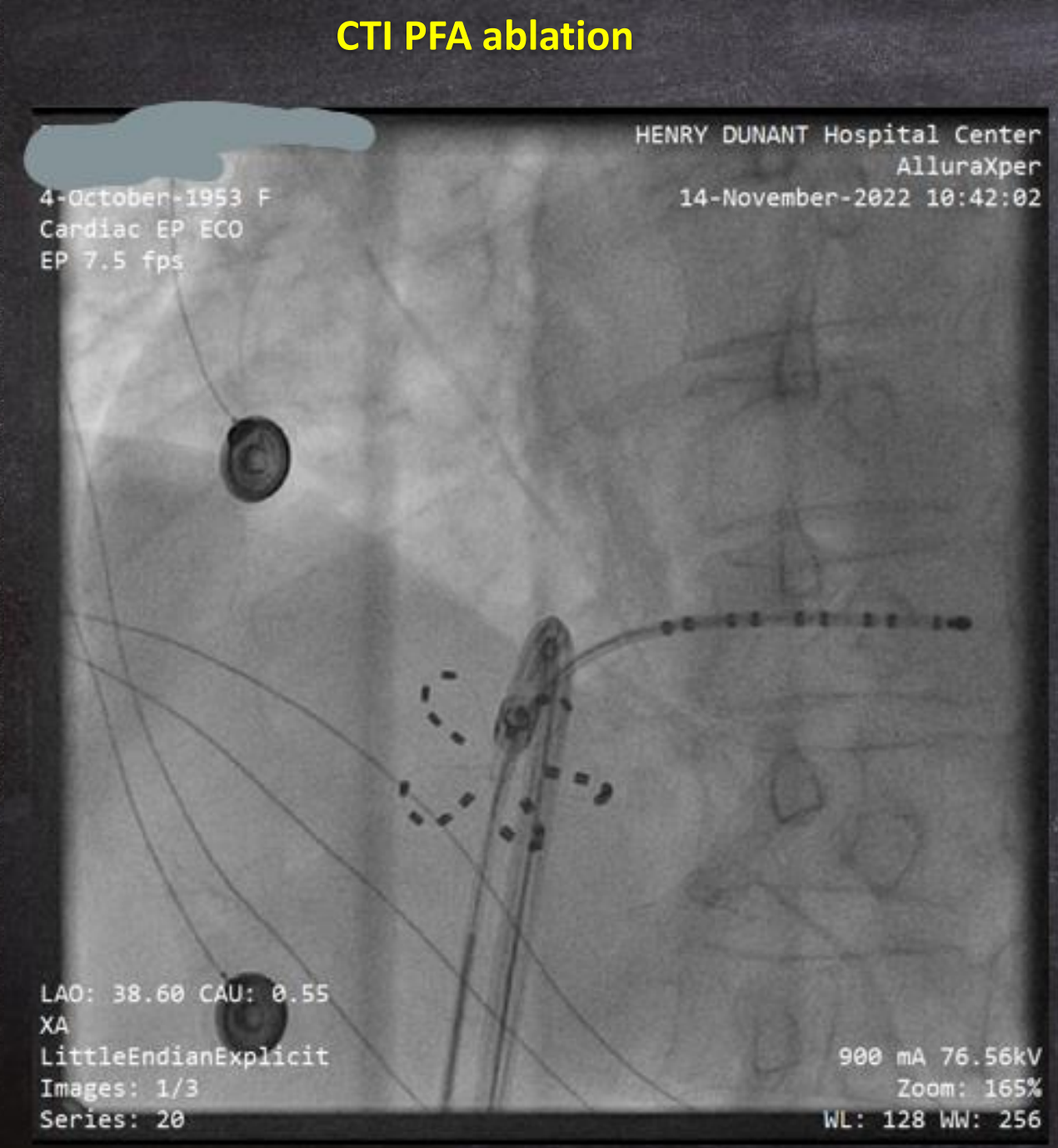


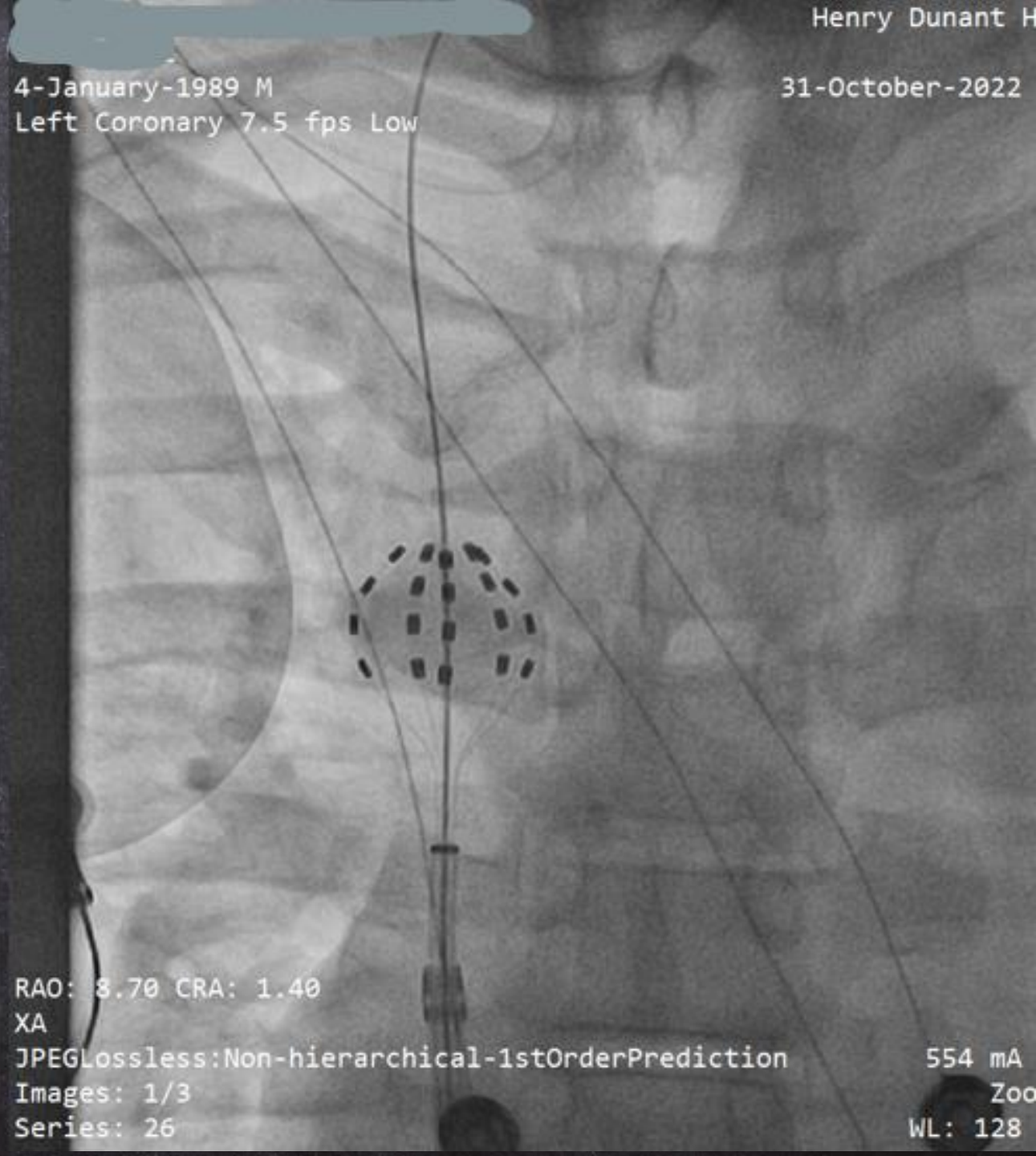
Χάρτης μετά το PFA ablation
(8 μήνες μετά το RF ablation)



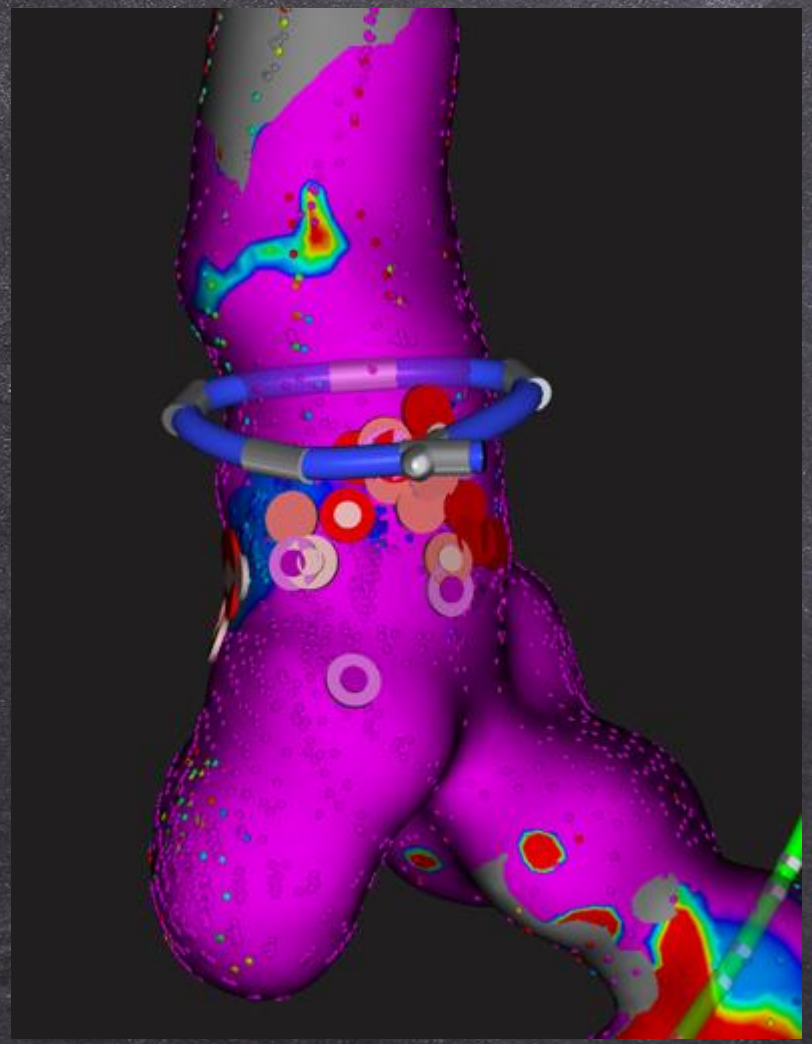


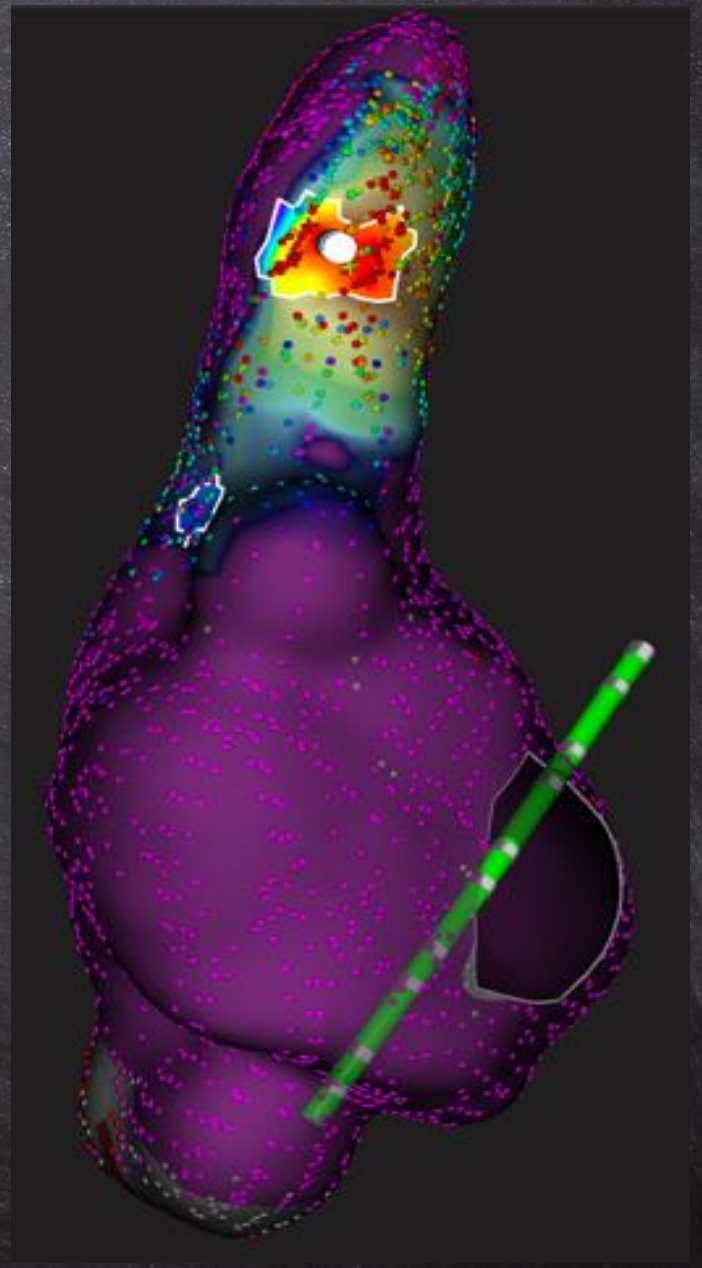
CTI PFA ablation



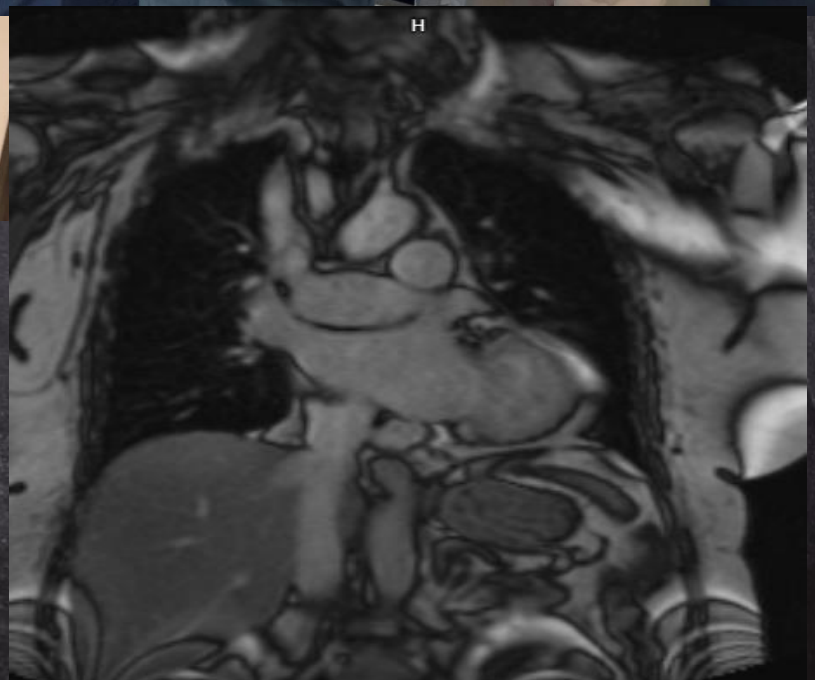


Ασθενής 40 ετών με συχνές κρίσεις NQRS ταχυκαρδίας που είχε χαρακτηριστεί «απρόσφορη φλεβοκομβική ταχυκαρδία κατά τη διάρκεια των πολλών νοσηλειών της



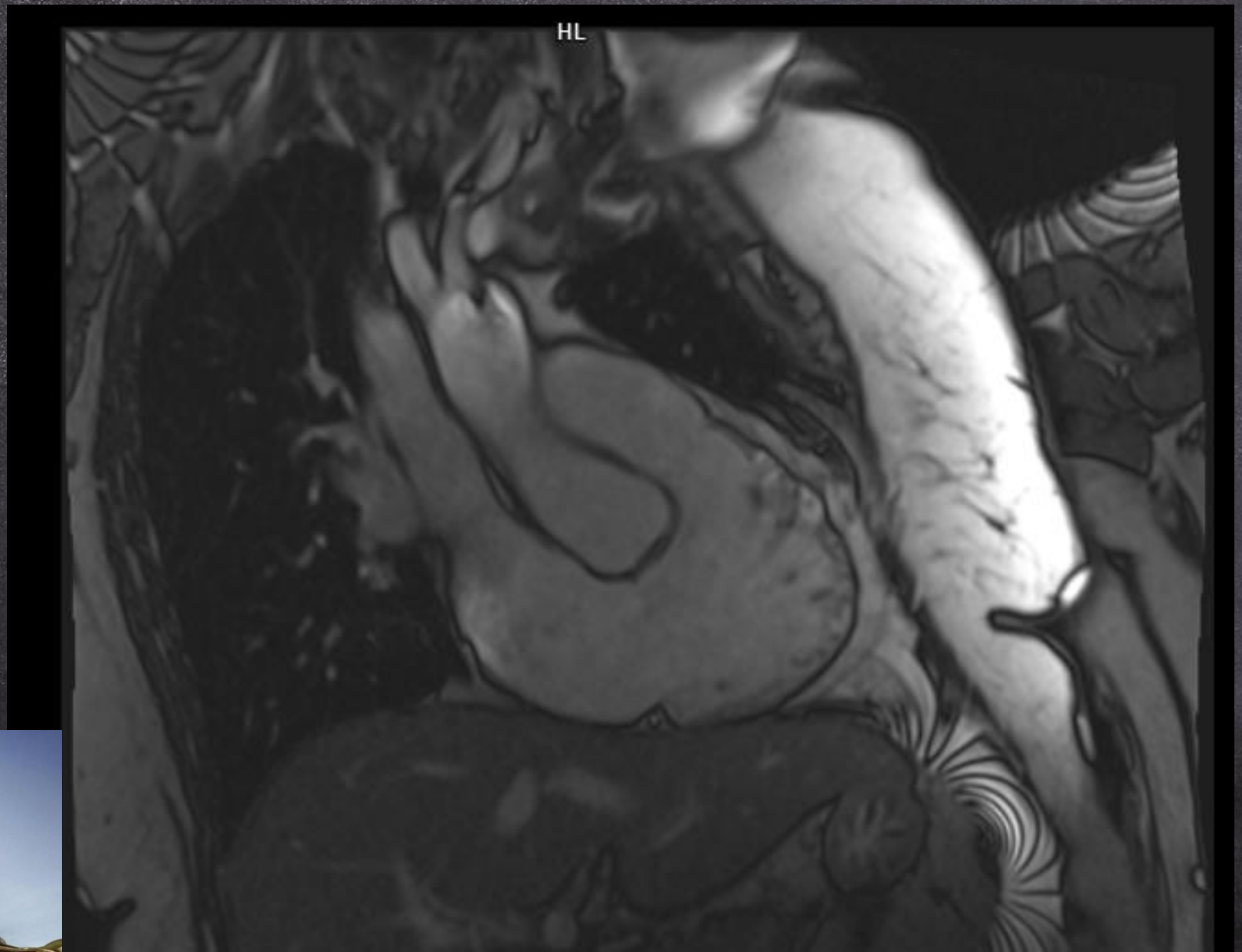


Ερρίκος Ντυνάν Hospital Center, Μάιος 2023

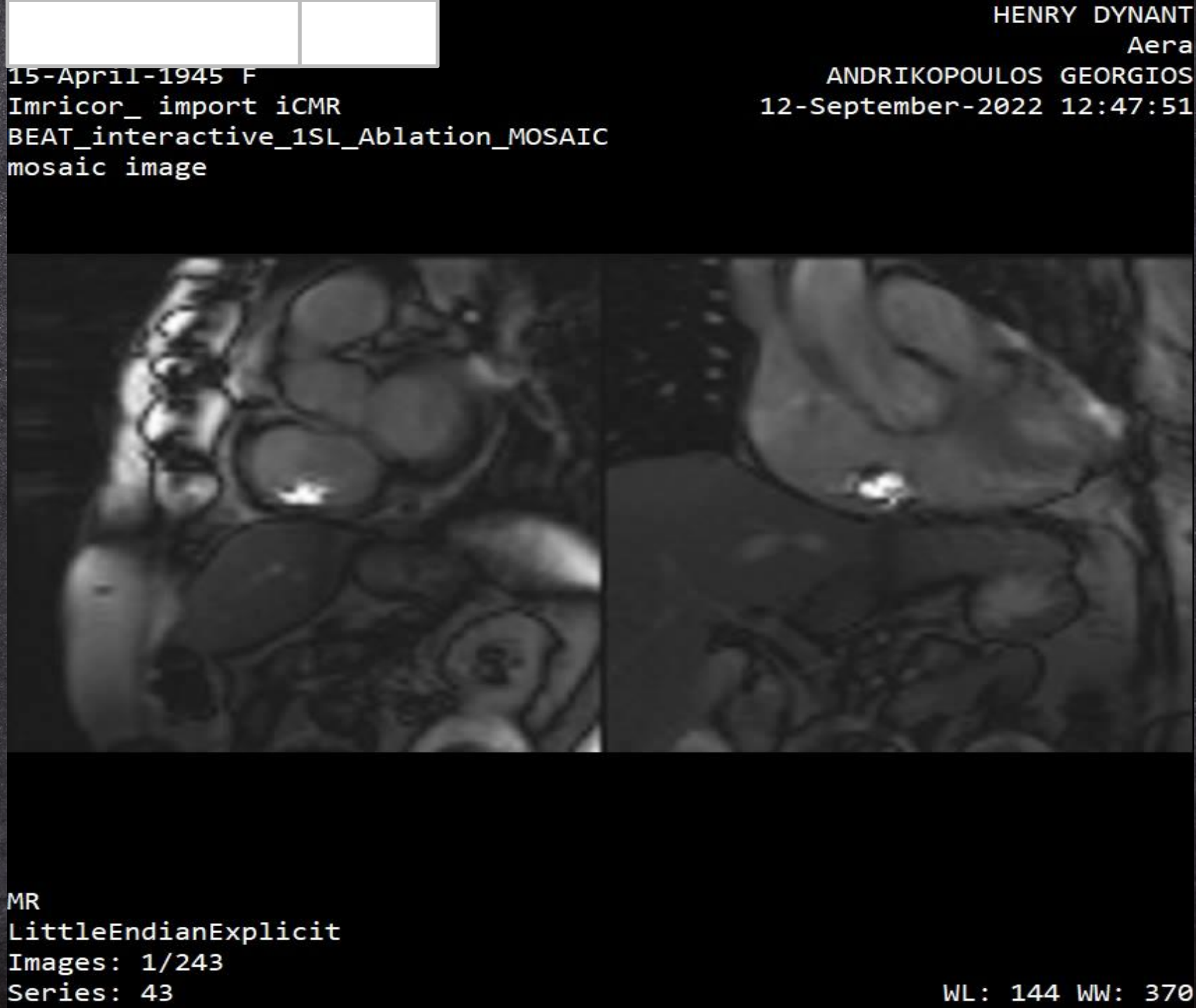


1st case
MRI ablation
(9/2022)

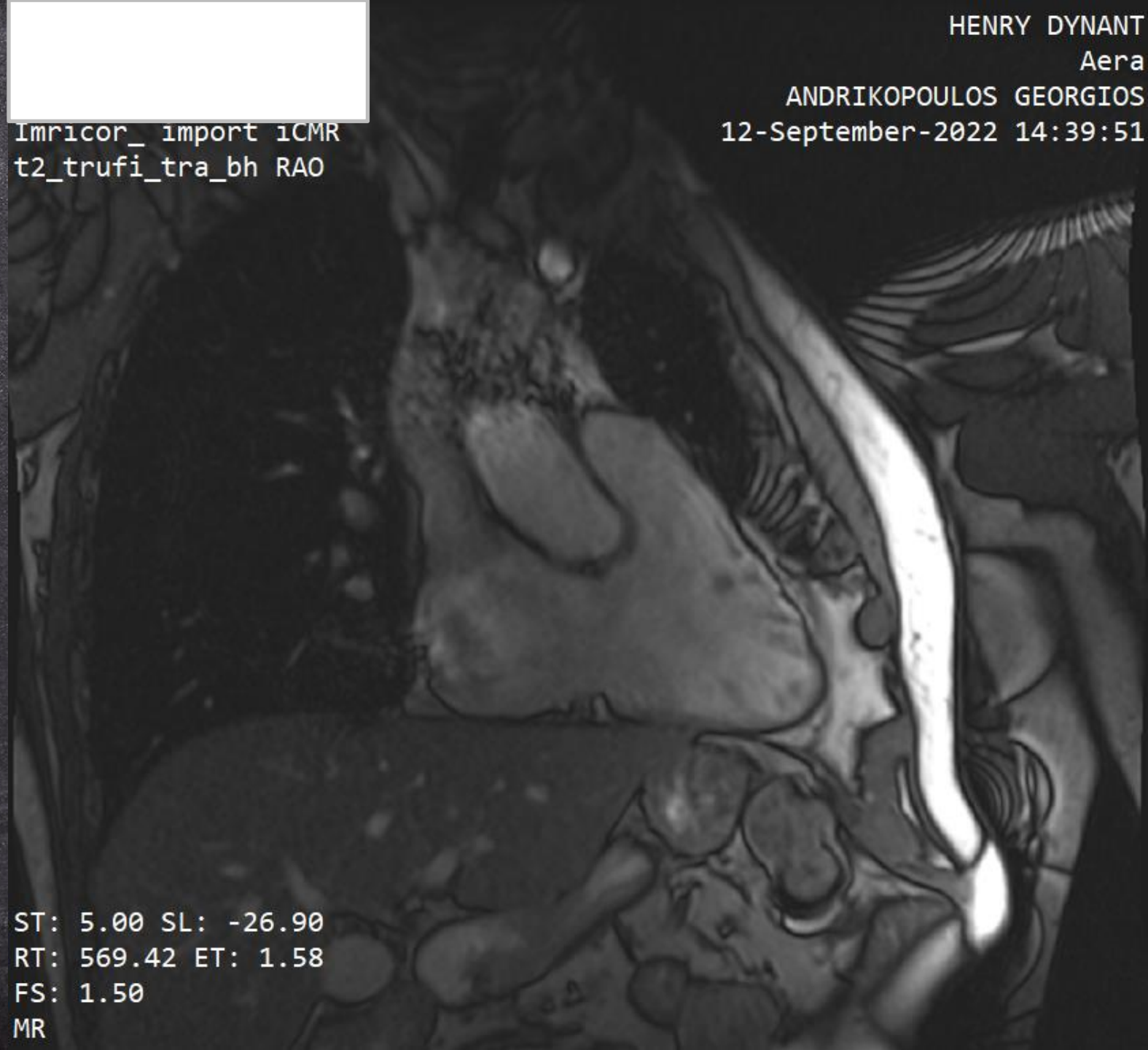
First case: 77-year old female with common atrial flutter



First case:
77-year old female with common atrial flutter



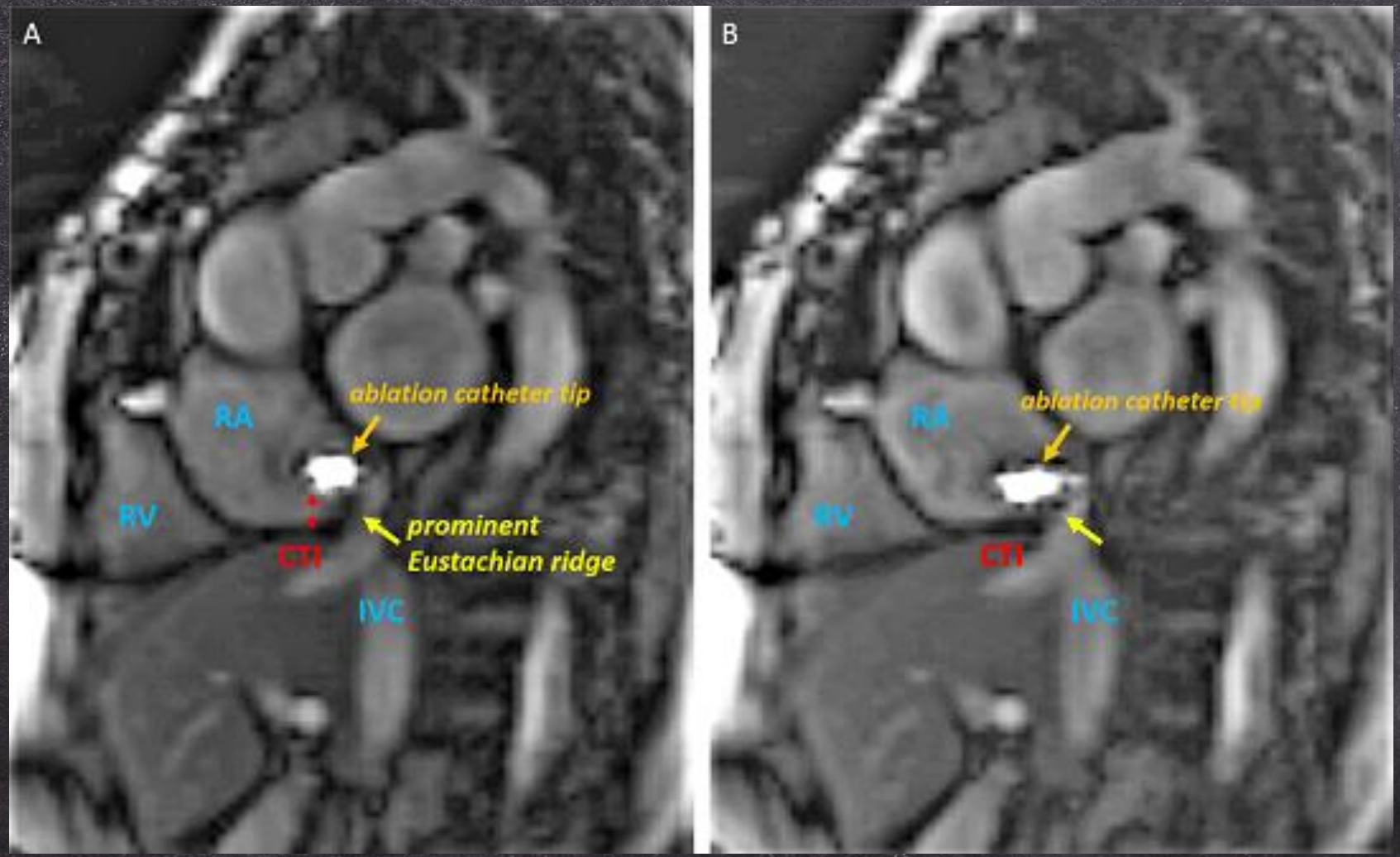
Second case: 78-year old male with common atrial flutter



Real-time cardiovascular magnetic resonance-guided cavotricuspid isthmus catheter ablation

Konstantinos Tampakis[1], Sokratis Pastromas[1], Alexandros Sykiotis[1], Stamatina Kampanarou[2], George Andrikopoulos[1]

[1]Department of Electrophysiology & Pacing, Henry Dunant Hospital Center, Athens, Greece



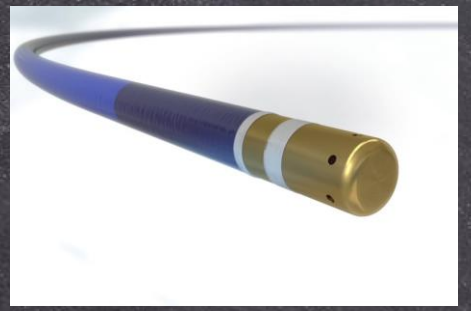
(upon submission 2023)

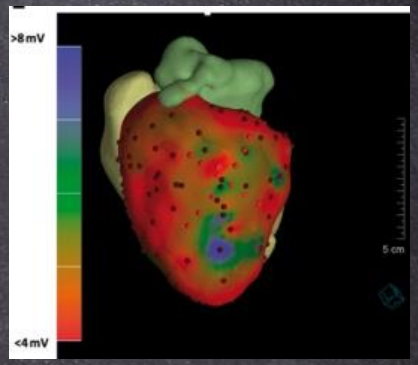
In this figure, a prominent Eustachian ridge impedes contact between the tip of the ablation catheter and the CTI (panel A). During active tracking, the tip of the catheter is visualized in real-time and permits avoidance of the prominent Eustachian ridge (panel B) and navigation towards the CTI to obtain adequate tissue contact.

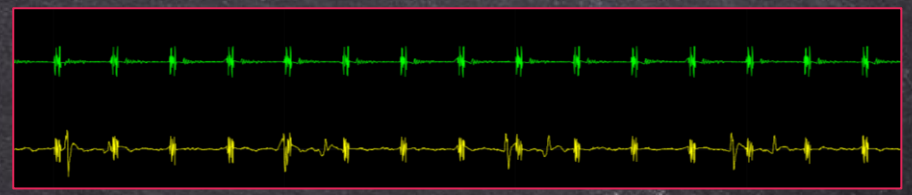
Real-time Cardiovascular Magnetic Resonance-Guided Radiofrequency Ablation: a comprehensive review

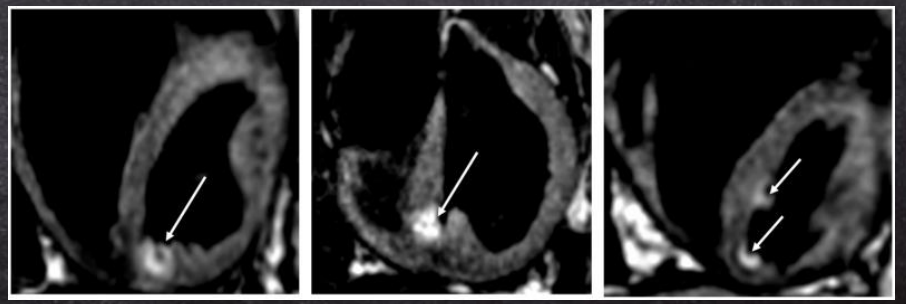
Tampakis K[1], Pastromas S[1], Sykiotis A[1], Kourgiannidis G[1], Kampanarou S[2], Mpousoula M[3], Rozakis D[3], Andrikopoulos G[1].

Animal studies					
	N	Subject	Cardiac chamber/site	Procedure type	Publication year
Lardo et al.[21]	6	mongrel dog	RV apex	Ablation	2000
Nazarian et al.[15]	10	mongrel dog	RA, His bundle, RV	EP study	2008
Nordbeck et al.[30]	8	swine	RA, RV, AV node	Ablation	2009
Hoffmann et al.[31]	20	swine	CTI	Ablation	2010
Nordbeck et al.[32]	9	swine	CTI	Ablation	2011
Vergara et al.[33]	6	swine	RA, LA	Ablation	2011
Ranjan et al.[34]	7	mongrel dog	RA	Ablation	2011
Ganesan et al.[35]	11	sheep	PV, CTI	Ablation	2012
Grothoff et al.[36]	14	swine	RA, LA, AV node	Ablation	2017
Krahn et al.[24]	12	swine	LV	Ablation	2018
Mukherjee et al.[37]	6	swine	LV epicardium	Ablation	2018
Chubb et al.[10]	5	swine	CTI	Ablation	2017
Lichter et al.[38]	8	canine	PV, SVC, focal	(Cryo)ablation	2019
Human studies					
	N		Cardiac chamber/site	Procedure type	Publication year
Nazarian et al.[15]	2		RA	EP study	2008
Sommer et al.[9]	5		RA	EP study	2013
Grothoff et al.[7]	10		CTI	Ablation	2014
Hilbert et al.[18]	6		CTI	Ablation	2016
Chubb et al.[10]	10		CTI	Ablation	2017
Paetsch et al.[28]	30		CTI	Ablation	2019
Ulbrich et al.[29]	15		CTI	Ablation	2022







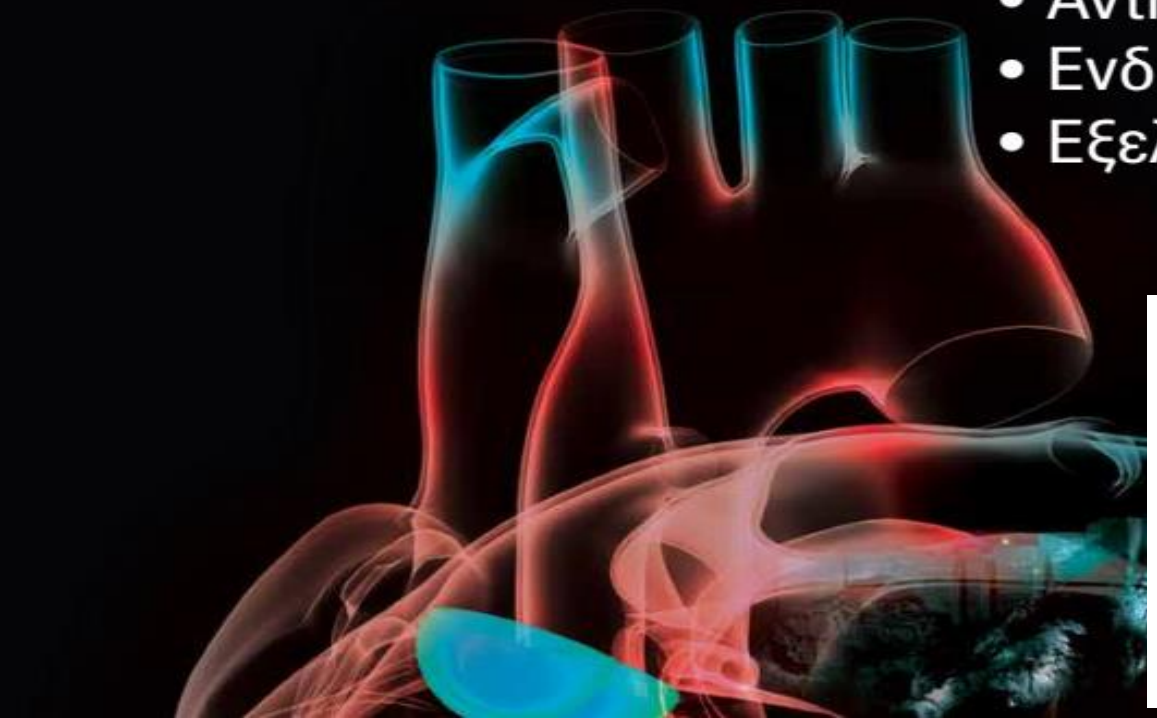


(in press 2023)

9ο WORKSHOP

Αρρυθμιών & Βηματοδότησης

- Ενδιαφέροντα ηλεκτροκαρδιογραφήματα
- Αντιπαραθέσεις
- Ενδιαφέροντα περιστατικά
- Εξελίξεις στην αντιμετώπιση των αρρυθμιών



SAVE THE DATE

9ο Workshop Αρρυθμιών & Βηματοδότησης

8 – 10 Δεκεμβρίου 2023 | Divani Caravel, Αθήνα