



PLATFORM OF LABORATORIES FOR ADVANCES IN CARDIAC EXPERIENCE

**ROMA**

Centro Congressi  
di Confindustria

**Auditorium  
della Tecnica**

**9ª Edizione**

**30 Settembre**

**1 Ottobre**

**2022**

## **ARITMOLOGIA CLINICA E INTERVENTISTICA**

Sistema di mappaggio cardiaco non invasivo: quali opportunità cliniche e diagnostiche rivela nella fibrillazione atriale.

**Non solo vene polmonari (?)**

**Procolo Marchese, Ascoli Piceno**



# IMAGING ECG

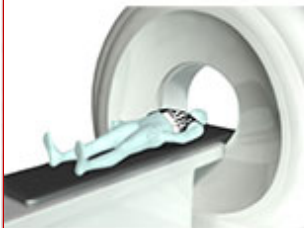
*La vita può essere capita solo tornando indietro; ma deve essere vissuta andando avanti.*

*Søren Kierkegaard*

252 ELECTRODE VEST



HEART-TORSO  
GEOMETRY (CT)



ECM\* ALGORITHMS SOLVES  
"INVERSE PROBLEM"



ECM MAPS



*Willem Einthoven 1901*



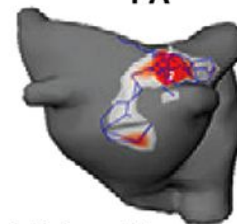
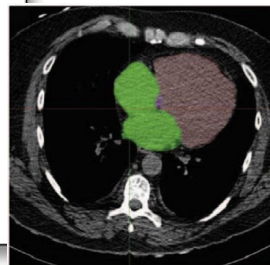
# iECG: ATRIAL FIBRILLATION



252 Electrode Vest



CT Scan with Vest

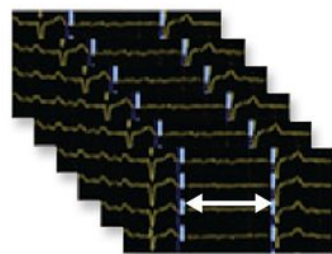


Re-entrant Driver Map

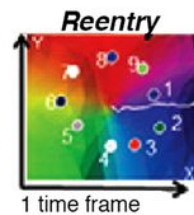


Focal Driver Map

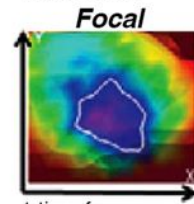
B



AF Analysis During Several Windows

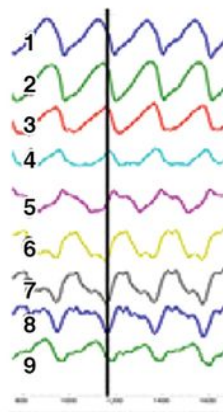


1 time frame

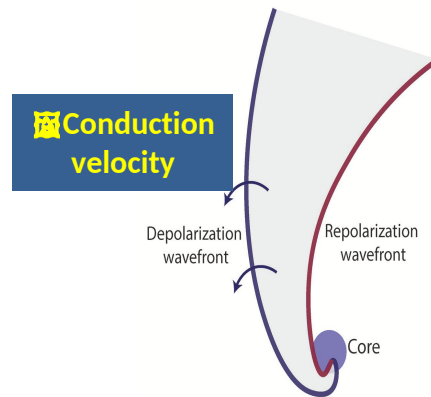
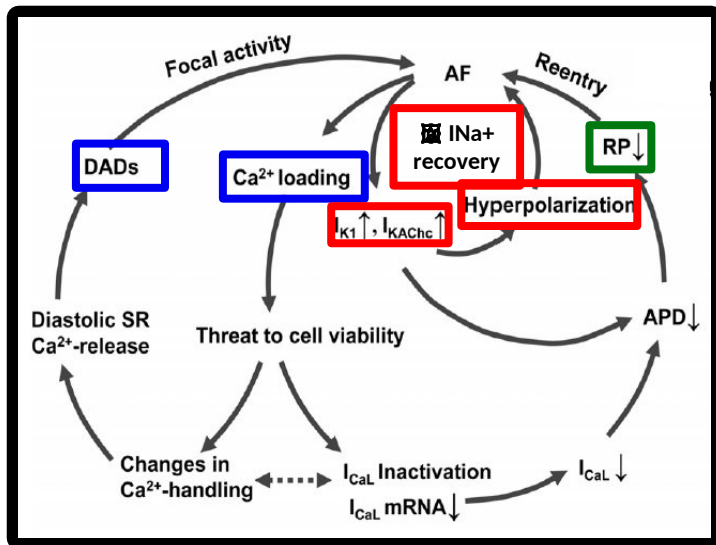
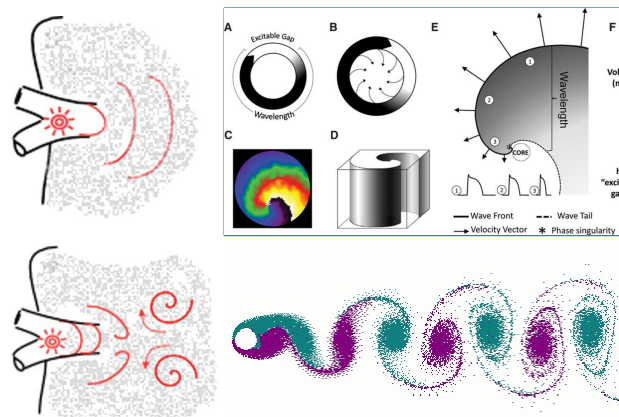
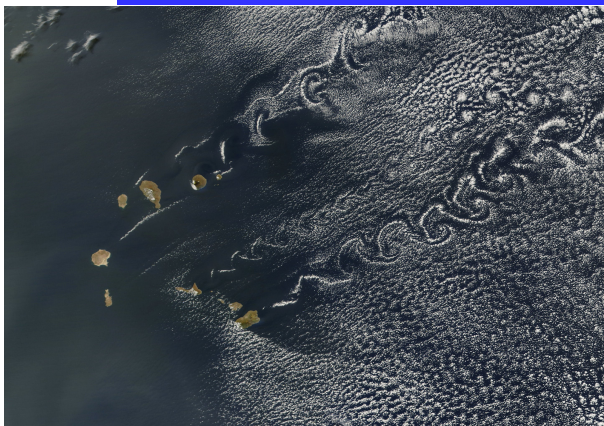


1 time frame

Phase Map Analysis



# Initiation of a Rotor via **VORTEX SHEDDING**



RP  
Excitability

## Multicentre evaluation of non-invasive biatrial mapping for persistent atrial fibrillation ablation: the AFACART study

Sébastien Knecht<sup>1,2</sup>, Manav Sohal<sup>1,2\*</sup>, Isabelle Deisenhofer<sup>3</sup>, Jean-Paul Albenque<sup>4</sup>, Thomas Arentz<sup>5</sup>, Thomas Neumann<sup>6</sup>, Bruno Cauchemez<sup>7</sup>, Mattias Duytschaever<sup>2</sup>, Khaled Ramoul<sup>1</sup>, Thierry Verbeet<sup>1</sup>, Sonia Thorsten<sup>3</sup>, Amir Jadidi<sup>5</sup>, Stephane Combes<sup>4</sup>, René Tavernier<sup>2</sup>, Yves Vandekerckhove<sup>2</sup>, Sabine Ernst<sup>8</sup>, Douglas Packer<sup>9</sup>, and Thomas Rostock<sup>10</sup>

<sup>1</sup>CHU-Brugmann, Brussels, Belgium; <sup>2</sup>Department of Cardiology, AZ Sint-Jan, Rudderhoeve 10, 8000 Brugge, Belgium; <sup>3</sup>Deutsches Herzzentrum München, Munich, Germany; <sup>4</sup>Clinique Pasteur, Toulouse, France; <sup>5</sup>Universitäts Herzzentrum Freiburg, Bad Krozingen, Germany; <sup>6</sup>Kerkhoff Klinik, Bad Nauheim, Germany; <sup>7</sup>Clinique Ambroise Paré, Paris, France; <sup>8</sup>Biomedical Research Unit, Royal Brompton and Harefield NHS Foundation Trust, Imperial College, London, UK; <sup>9</sup>Mayo Clinic, Rochester, NY, USA; and <sup>10</sup>II. Medizinische Klinik und Poliklinik, Universitätsmedizin Mainz, Mainz, Germany

Received 25 January 2016; accepted after revision 15 May 2016; online publish-ahead-of-print 15 February 2017

### Aims

Non-invasive electrocardiogram (ECG) mapping allows the activation of the entire atrial epicardium to be recorded simultaneously, potentially identifying mechanisms critical for atrial fibrillation (AF) persistence. We sought to evaluate the utility of ECG mapping as a practical tool prior to ablation of persistent AF (PsAF) in centres with no practical experience of the system.

### Methods and results

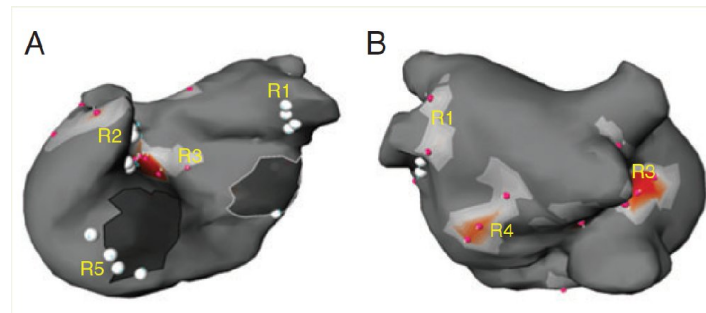
A total of 118 patients with continuous AF duration <1 year were prospectively studied at 8 European centres. Patients were on a median of 1 antiarrhythmic drug (AAD) that had failed to restore sinus rhythm. Electrocardiogram mapping (ECVUE™, Cardiolsight, USA) was performed prior to ablation to map AF drivers (local re-entrant circuits or focal breakthroughs). Ablation targeted drivers depicted by the system, followed by pulmonary vein (PV) isolation, and finally left atrial linear ablation if AF persisted. The primary endpoint was AF termination. Totally,  $4.9 \pm 1.0$  driver sites were mapped per patient with a cumulative mapping time of  $16 \pm 2$  s. Of these, 53% of drivers were located in the left atrium, 27% in the right atrium, and 20% in the anterior interatrial groove. Driver-only ablation resulted in AF termination in 75 of the 118 patients (64%) with a mean radiofrequency (RF) duration of  $46 \pm 28$  min. Acute termination rates were not significantly different amongst all 8 centres ( $P = 0.672$ ). Ten additional patients terminated with PV isolation and lines resulting in a total AF termination rate of 72%. Total RF duration was  $75 \pm 27$  min. At 1-year follow-up, 78% of the patients were off AADs and 77% of the patients were free from AF recurrence. Of the patients with no AF recurrence, 49% experienced at least one episode of atrial tachycardia (AT) which required either continued AAD therapy, cardioversion, or repeat ablation.

### Conclusion

Non-invasive mapping identifies biatrial drivers that are critical in PsAF. This is validated by successful AF termination in the majority of patients treated in centres with no experience of the system. Ablation targeting these drivers results in favourable AF-free survival at 1 year, albeit with a significant rate of AT recurrence requiring further management.

### Keywords

Persistent atrial fibrillation • Non-invasive mapping • Ablation • Multicentre evaluation



At 1-year follow-up, 78% of the patients were off AADs and **77% of the patients were free from AF recurrence**. Of the patients with no AF recurrence, **49% experienced at least one episode of AT** which required either continued AAD therapy, cardioversion, or repeat ablation.



Complete electrical isolation of the pulmonary veins is recommended during all AF catheter-ablation procedures.

If patient

atrial

CTI

independent

- Should be considered to improve survival

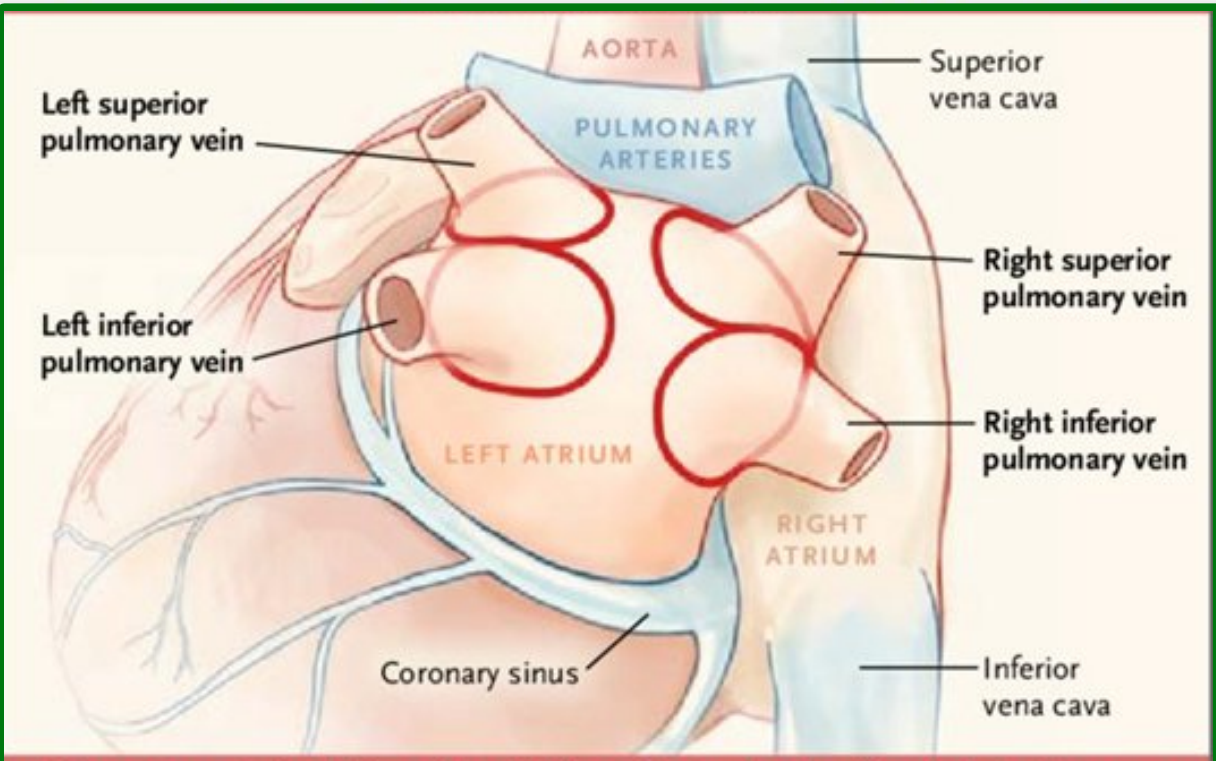
Catheter

using radio

Ablation

recurrent

mented



I

IIb

IIa

IIa

IIa

# PERSISTENT ATRIAL FIBRILLATION

## Randomized Ablation Strategies for the Treatment of Persistent Atrial Fibrillation

### RASTA Study

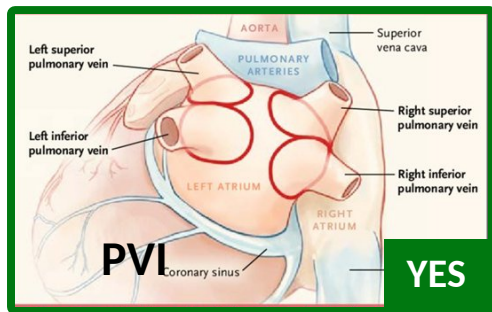
Sanjay Dixit, MD; Francis E. Marchlinski, MD; David Lin, MD; David J. Callans, MD; Rupa Bala, MD; Michael P. Riley, MD, PhD; Fermin C. Garcia, MD; Matthew D. Hutchinson, MD; Sarah J. Ratcliffe, PhD; Joshua M. Cooper, MD; Ralph J. Verdino, MD; Vickas V. Patel, MD, PhD; Frisca S. Zado, PA; Nancy R. Cash, PA; Tony Killian, RN, CCRC; Todd T. Tomson, MD; Edward P. Gerstenfeld, MD

**Background**—The single-procedure efficacy of pulmonary vein isolation (PVI) is less than optimal in patients with persistent atrial fibrillation (AF). Adjunctive techniques have been developed to enhance single-procedure efficacy in these patients. We conducted a study to compare 3 ablation strategies in patients with persistent AF.

**Methods and Results**—Subjects were randomized as follows: arm 1, PVI + ablation of non-PV triggers identified using a stimulation protocol (standard approach); arm 2, standard approach + empirical ablation at common non-PV AF trigger sites (mitral annulus, fossa ovalis, eustachian ridge, crista terminalis, and superior vena cava); or arm 3, standard approach + ablation of left atrial complex fractionated electrogram sites. Patients were seen at 6 weeks, 6 months, and 1 year; transtelephonic monitoring was performed at each visit. Antiarrhythmic drugs were discontinued at 3 to 6 months. The primary study end point was freedom from atrial arrhythmias off antiarrhythmic drugs at 1 year after a single-ablation procedure. A total of 156 patients (aged  $59 \pm 9$  years; 136 males; AF duration,  $47 \pm 50$  months) participated (arm 1, 55 patients; arm 2, 50 patients; arm 3, 51 patients). Procedural outcomes (procedure, fluoroscopy, and PVI times) were comparable between the 3 arms. More lesions were required to target non-PV trigger sites than a complex fractionated electrogram ( $33 \pm 9$  versus  $22 \pm 9$ ;  $P < 0.001$ ). The primary end point was achieved in 71 patients and was worse in arm 3 (29%) compared with arm 1 (49%;  $P = 0.04$ ) and arm 2 (58%;  $P = 0.004$ ).

**Conclusions**—These data suggest that additional substrate modification beyond PVI does not improve single-procedure efficacy in patients with persistent AF.

**Clinical Trial Registration**—URL: <http://www.clinicaltrials.gov>. Unique identifier: NCT00379301. (*Circ Arrhythm Electrophysiol.* 2012;5:287-294.)



THE NEW ENGLAND JOURNAL of MEDICINE

### ORIGINAL ARTICLE

## Approaches to Catheter Ablation for Persistent Atrial Fibrillation

Atul Verma, M.D., Chen-yang Jiang, M.D., Timothy R. Betts, M.D., M.B., Ch.B., Jian Chen, M.D., Isabel Deisenhofer, M.D., Roberto Mantovan, M.D., Ph.D., Laurent Macle, M.D., Carlos A. Morillo, M.D., Wilhelm Haverkamp, M.D., Ph.D., Rukshen Weerasooriya, M.D., Jean-Paul Albenque, M.D., Stefano Nardi, M.D., Endry Menardi, M.D., Paul Novak, M.D., and Prashanthan Sanders, M.B., B.S., Ph.D., for the STAR AF II Investigators\*

### ABSTRACT

#### BACKGROUND

Catheter ablation is less successful for persistent atrial fibrillation than for paroxysmal atrial fibrillation. Guidelines suggest that adjunct substrate modification in addition to pulmonary-vein isolation is required in persistent atrial fibrillation.

#### METHODS

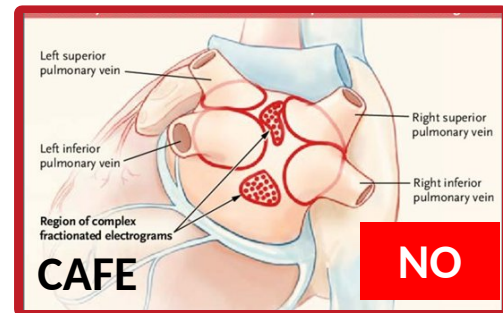
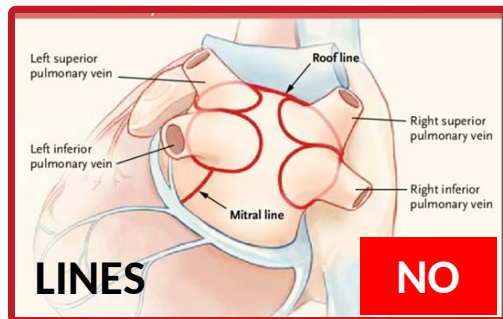
We randomly assigned 589 patients with persistent atrial fibrillation in a 1:4:4 ratio to ablation with pulmonary-vein isolation alone (67 patients), pulmonary-vein isolation plus ablation of electrograms showing complex fractionated activity (263 patients), or pulmonary-vein isolation plus additional linear ablation across the left atrial roof and mitral valve isthmus (259 patients). The duration of follow-up was 18 months. The primary end point was freedom from any documented recurrence of atrial fibrillation lasting longer than 30 seconds after a single ablation procedure.

#### RESULTS

Procedure time was significantly shorter for pulmonary-vein isolation alone than for the other two procedures ( $P < 0.001$ ). After 18 months, 59% of patients assigned to pulmonary-vein isolation alone were free from recurrent atrial fibrillation, as compared with 49% of patients assigned to pulmonary-vein isolation plus complex electrogram ablation and 46% of patients assigned to pulmonary-vein isolation plus linear ablation ( $P = 0.15$ ). There were also no significant differences among the three groups for the secondary end points, including freedom from atrial fibrillation after two ablation procedures and freedom from any atrial arrhythmia. Complications included tamponade (three patients), stroke or transient ischemic attack (three patients), and atrioesophageal fistula (one patient).

#### CONCLUSIONS

Among patients with persistent atrial fibrillation, we found no reduction in the rate of recurrent atrial fibrillation when either linear ablation or ablation of complex fractionated electrograms was performed in addition to pulmonary-vein isolation. (Funded by St. Jude Medical; ClinicalTrials.gov number, NCT01203748.)





*Sistema di mappaggio cardiaco non invasivo: quali opportunità cliniche e diagnostiche rivela nella fibrillazione atriale.*

***Non solo vene polmonari (?)***

***“Comprendere non significa scoprire un senso già dato, ma al contrario costruirlo a partire da un dato manifesto”***



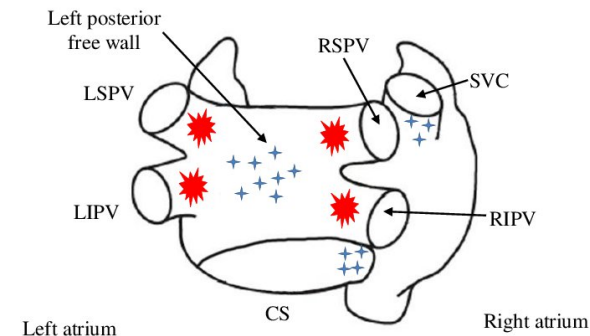
***Eric Landowski***

## SPONTANEOUS INITIATION OF ATRIAL FIBRILLATION BY ECTOPIC BEATS ORIGINATING IN THE PULMONARY VEINS

MICHEL HAÏSSAGUERRE, M.D., PIERRE JAÏS, M.D., DIPEN C. SHAH, M.D., ATSUSHI TAKAHASHI, M.D., MÈLÈZE HOCINI, M.D.,  
GILLES QUINIOU, M.D., STÉPHANE GARRIGUE, M.D., ALAIN LE MOUROUX, M.D., PHILIPPE LE MÉTAYER, M.D.,  
AND JACQUES CLÉMENTY, M.D.

**45 patients** enrolled consecutively who met the following criteria:

- atrial fibrillation resistant to more than two drugs
- at least one episode of atrial fibrillation every two days
- receiving anticoagulant treatment
- the patient had to have frequent isolated atrial ectopic beats (more than 700 per 24 hours)**
- the ectopic beat initiating atrial fibrillation had a short coupling interval (a P-on-T pattern) and morphologic features similar to those of isolated ectopic beats.**

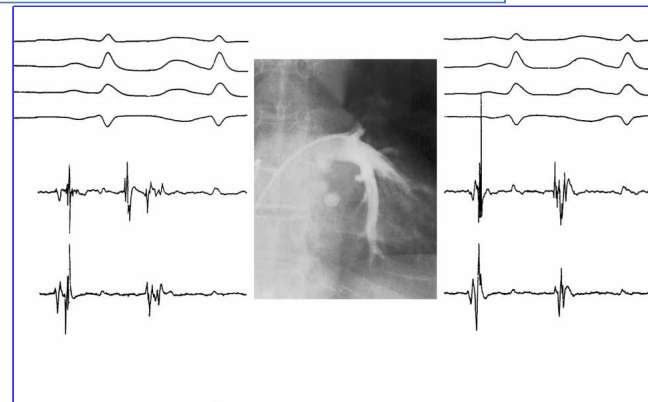
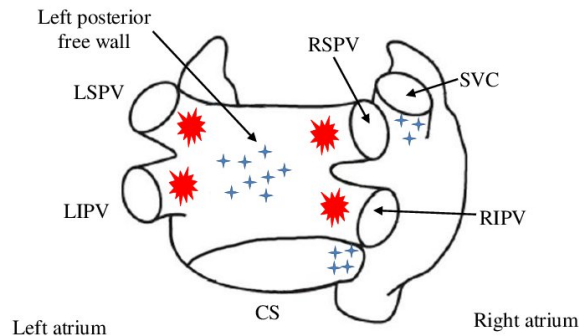


## SPONTANEOUS INITIATION OF ATRIAL FIBRILLATION BY ECTOPIC BEATS ORIGINATING IN THE PULMONARY VEINS

MICHEL HAÏSSAGUERRE, M.D., PIERRE JAÏS, M.D., DIPEN C. SHAH, M.D., ATSUSHI TAKAHASHI, M.D., MÈLÈZE HOCINI, M.D.,  
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AND JACQUES CLÉMENTY, M.D.

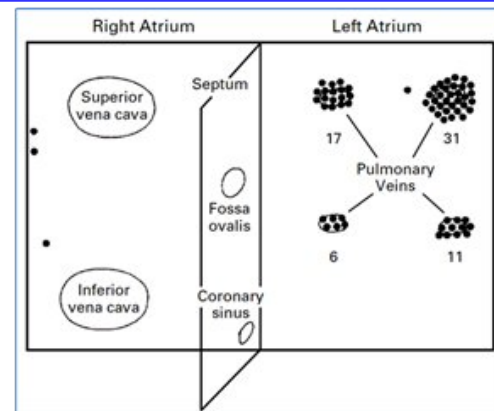
69 ectopic foci

- 1 point in 29 pts
- 2 points in 9 pts
- 3 points in 6 pts
- 4 points in 1 pt



❑ pulmonary veins (“venous foci”) in 41 pts (94 %)

❑ “atrial foci”: in 4 patients (3 RA ; 1 posterior LA)



1998

62% success

2010

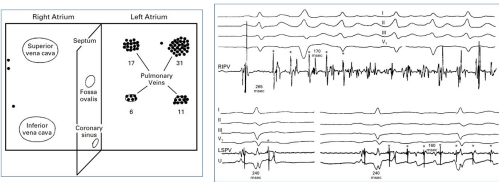
66% success

2018

65% success

# SPONTANEOUS INITIATION OF ATRIAL FIBRILLATION BY ECTOPIC BEATS ORIGINATING IN THE PULMONARY VEINS

MICHEL HAÏSSAGUERRE, M.D., PIERRE JAIS, M.D., DIPEN C. SHAH, M.D., ATSUSHI TAKAHASHI, M.D., MÈLEZE HOCINI, M.D., GILLES QUINQUIN, M.D., STEPHANE GARRIGUE, M.D., ALAIN LE MOUËDUC, M.D., PHILIPPE LE METAYER, M.D., AND JACQUES CLEMENTY, M.D.



## Comparison of Antiarrhythmic Drug Therapy and Radiofrequency Catheter Ablation in Patients With Paroxysmal Atrial Fibrillation A Randomized Controlled Trial

*JAMA. 2010;303(4):333-340*

### Original Investigation

## Radiofrequency Ablation vs Antiarrhythmic Drugs as First-Line Treatment of Paroxysmal Atrial Fibrillation (RAAFT-2) A Randomized Trial

*JAMA. 2014;311(7):692-699.*

Carlos A. Morillo, MD, FRCP; Atul Verma, MD, FRCP; Stuart J. Connolly, MD, FRCP; Karl H. Kuck, MD, FHRS; Girish M. Nair, MBBS, FRCP; Jean Champagne, MD, FRCP; Laurence D. Sterns, MD, FRCP; Heather Beresh, MSc; Jeffrey S. Healey, MD, MSc, FRCP; Andrea Natale, MD, for the RAAFT-2 Investigators

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

## Cryoballoon or Radiofrequency Ablation for Paroxysmal Atrial Fibrillation

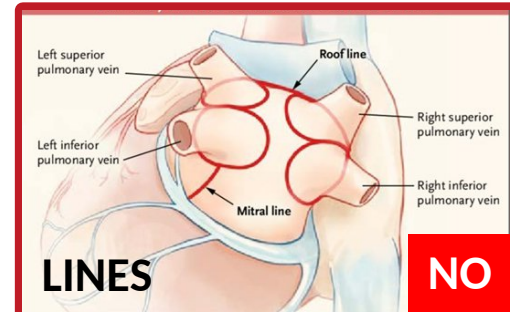
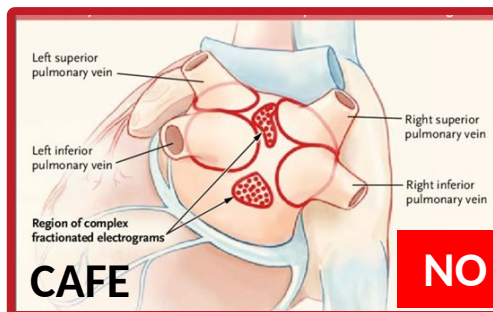
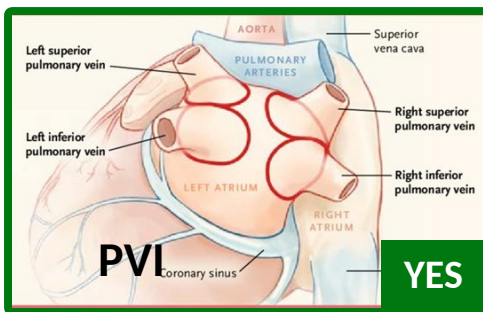
Karl-Heinz Kuck, M.D., Josep Brugada, M.D., Alexander Fürnkranz, M.D., Andreas Metzner, M.D., Feifan Ouyang, M.D., K.R. Julian Chun, M.D., Arif Elvan, M.D., Ph.D., Thomas Arentz, M.D., Kurt Bestehorn, M.D., Stuart J. Pocock, Ph.D., Jean-Paul Albenque, M.D., Ph.D., and Claudio Tondo, M.D., Ph.D., for the FIRE AND ICE Investigators\*

1998

2014

46% success

2018





# Pulmonary Vein Antrum Isolation in Patients With Paroxysmal Atrial Fibrillation More Than a Decade of Follow-Up

Yalçın Gökoğlu, MD; Sanghamitra Mohanty, MD, MS, FHRS; Mahmut F. Güneş, MD;  
 Chintan Trivedi, MD, MPH; Pasquale Santangeli, MD; Carola Gianni, MD; Issa K. Asfour, BS;  
 Rong Bai, MD, FHRS; J. David Burkhardt, MD, FHRS; Rodney Horton, MD, FHRS;  
 Javier Sanchez, MD; Steven Hao, MD; Richard Hongo, MD; Salwa Beheiry, RN;  
 Luigi Di Biase, MD, PhD, FHRS; Andrea Natale, MD, FHRS, FESC

**Background**—We report the outcome of pulmonary vein (PV) antrum isolation in paroxysmal atrial fibrillation (AF) patients over more than a decade of follow-up.

**Methods and Results**—A total of 513 paroxysmal AF patients (age  $54 \pm 11$  years, 73% males) undergoing catheter ablation at our institutions were included in this analysis. PV antrum isolation extended to the posterior wall between PVs plus empirical isolation of the superior vena cava was performed in all. Non-PV triggers were targeted during repeat procedure(s). Follow-up was performed quarterly for the first year and every 6 to 9 months thereafter. The outcome of this study was freedom from recurrent AF/atrial tachycardia. At 12 years, single-procedure arrhythmia-free survival was achieved in 58.7% of patients. Overall, the rate of recurrent arrhythmia (AF/atrial tachycardia) was 21% at 1 year, 11% between 1 and 3 years, 4% between 3 and 6 years, and 5.3% between 6 and 12 years. Repeat procedure was performed in 74% of patients. Reconnection in the PV antrum was found in 31% of patients after a single procedure and in no patients after 2 procedures. Non-PV triggers were found and targeted in all patients presenting with recurrent arrhythmia after  $\geq 2$  procedures. At 12 years, after multiple procedures, freedom from recurrent AF/atrial tachycardia was achieved in 87%.

**Conclusions**—In patients with paroxysmal AF undergoing extended PV antrum isolation, the rate of late recurrence is lower than what previously reported with segmental or less extensive antral isolation. However, over more than a decade of follow-up, nearly 14% of patients developed recurrence because of new non-PV triggers. (*Circ Arrhythm Electrophysiol.* 2016;9:e003660. DOI: 10.1161/CIRCEP.115.003660.)



# Pulmonary Vein Antrum Isolation in Patients With Paroxysmal Atrial Fibrillation More Than a Decade of Follow-Up

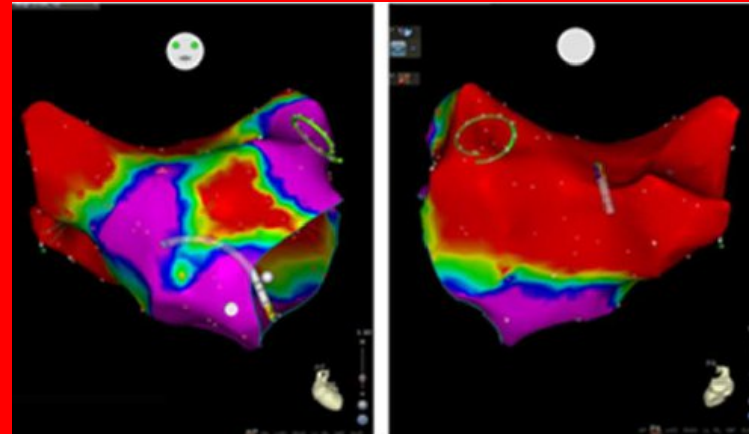
**1° PROCEDURE: PVAI (PVI and posterior wall) + SVC= 58,7% SUCCESS**

**2° procedure: 75.6% SUCCESS**

Reconnection of the PVs 31%

**Non-PV triggers 69%**

- LAA (10%)
- CS (59%)
- interatrial septum (17%)
- crista terminalis (22%)
- SVC (13%)
- undetermined (empirical lesions were deployed that included left septal line, CS ablation, mitral isthmus line, and more recently LAA isolation)



**12 yrs 4 PROCEDURE CUMULATIVE SUCCESS RATE 86.9%**

20.1% 3 procedures, 3.8% 4 procedures

# Is it a technology matter?

Journal of Interventional Cardiac Electrophysiology (2021) 61:63–69  
<https://doi.org/10.1007/s10840-020-00780-4>

**Long-term safety and effectiveness of paroxysmal atrial fibrillation ablation using a porous tip contact force-sensing catheter from the SMART SF trial**



Andrea Natale<sup>1</sup> • George Monir<sup>2</sup> • Anshul M. Patel<sup>3</sup> • Robert S. Fishel<sup>4</sup> • Francis E. Marchlinski<sup>5</sup> • M. Craig Delaughter<sup>6</sup> • Charles A. Athill<sup>7</sup> • Daniel P. Melby<sup>8</sup> • Mario D. Gonzalez<sup>9</sup> • Ramesh Hariharan<sup>10</sup> • Brett Gidney<sup>11</sup> • Tiffany Tan<sup>12</sup> • Larry A. Chinitz<sup>13</sup>

**Freedom from 12-months  
atrial tachyarrhythmia was  
74.9%**

**159 pts**

**37.7% only PV isolation**

**49.1% atrial linear lesions**

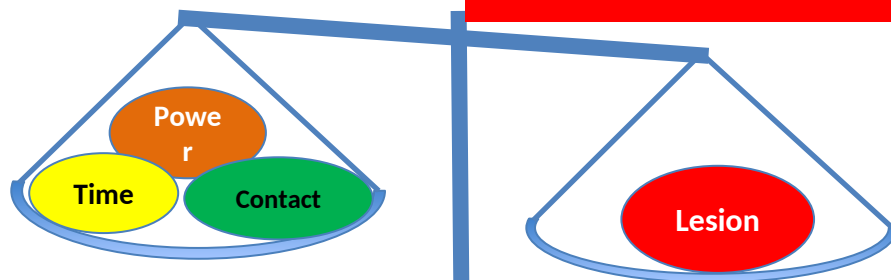
**3.1% Other AF foci in 5**

**10.1% atrial linear lesions + other AF foci**

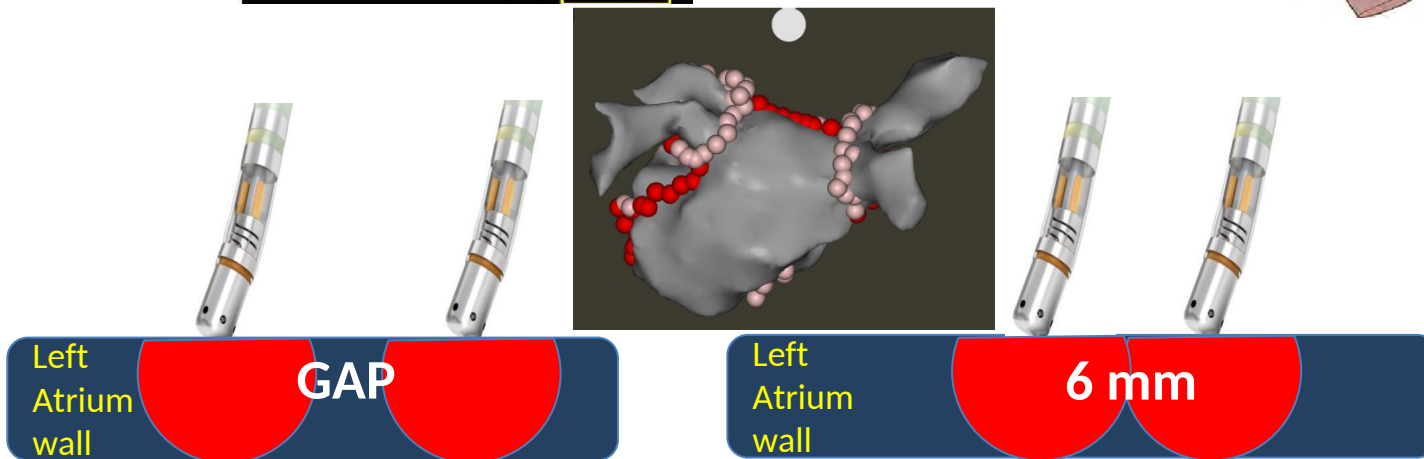
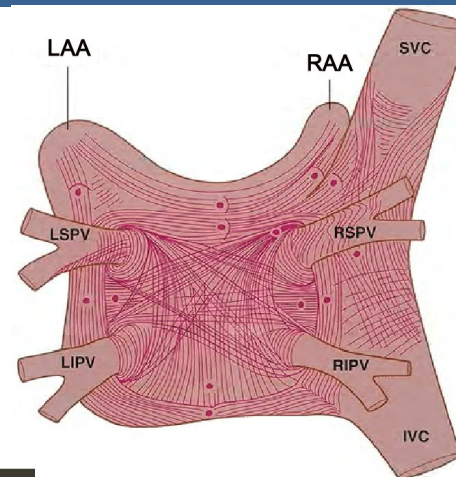
# How to improve outcome?

**Lesion control** = safety, efficacy, standardisation/tailoring

## ABLATION INDEX



Sec	°C	W	Imp	f
34	52.0	17	122	526



# Is it a technology matter?

HeartRhythm  Heart Rhythm Society

Log in

CLINICAL ATRIAL FIBRILLATION | VOLUME 17, ISSUE 4, P535-543, APRIL 01, 2020

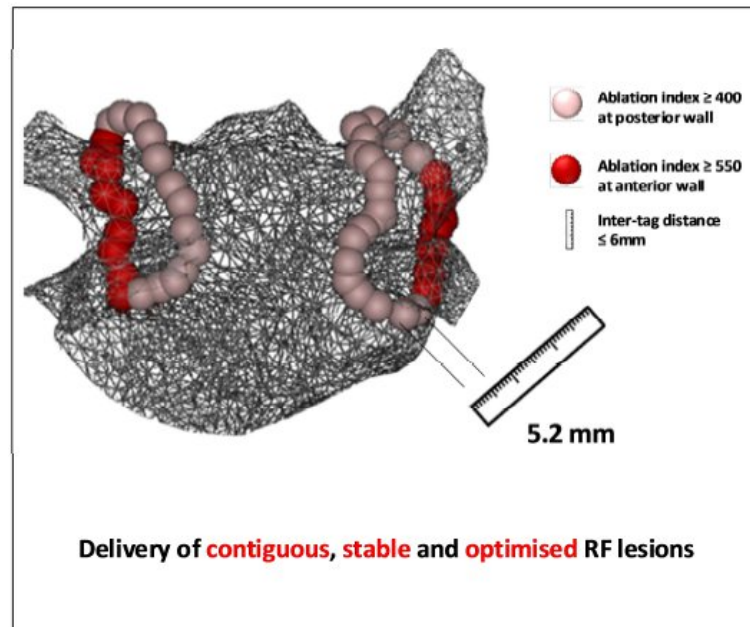
 Purchase

## Long-term impact of catheter ablation on arrhythmia burden in low-risk patients with paroxysmal atrial fibrillation: The CLOSE to CURE study

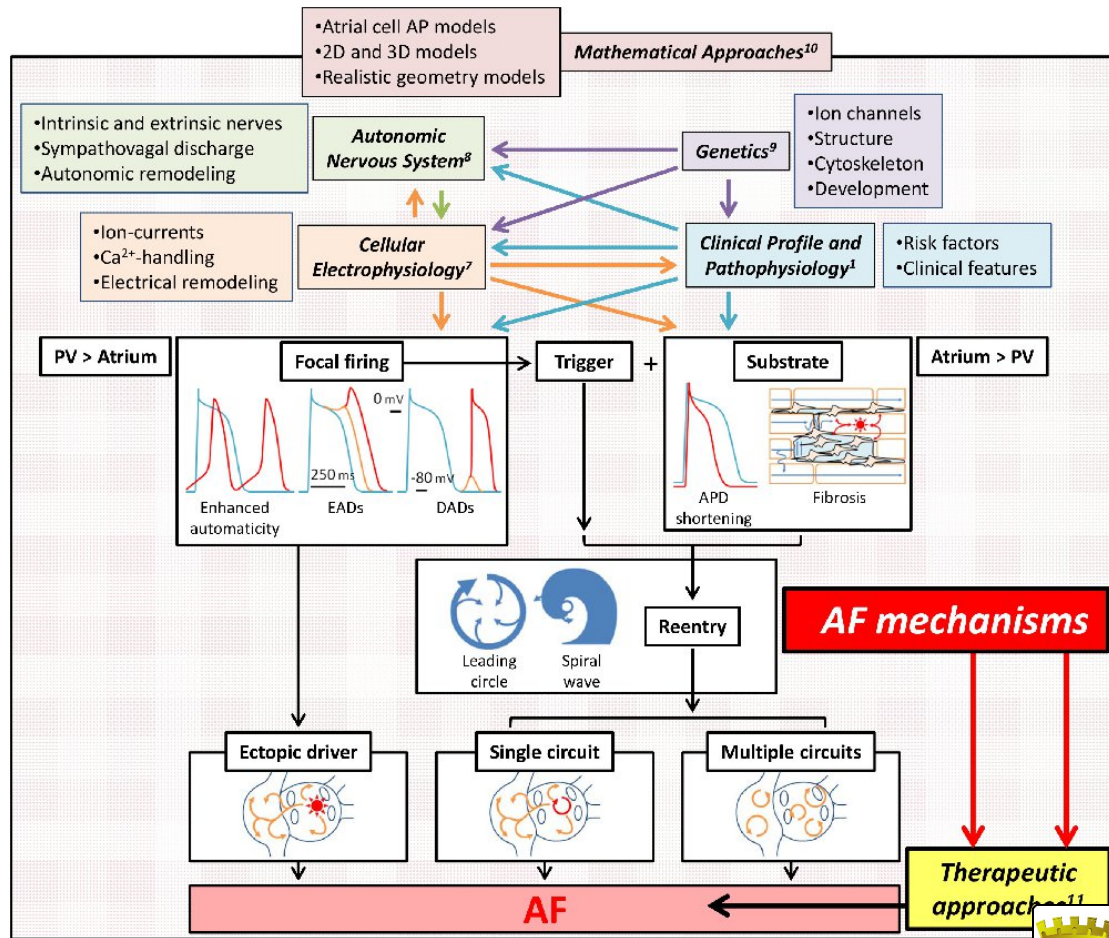
Mattias Duytschaever, MD, PhD • Jan De Poorter, MD, PhD • Anthony Demolder, MD • ...  
Yves Vandekerckhove, MD • Sebastien Knecht, MD, PhD • Rene Tavernier, MD, PhD • Show all authors

Published: November 07, 2019 • DOI: <https://doi.org/10.1016/j.hrthm.2019.11.004> •  Check for updates

Freedom from any ATA was  
**78% at 2 years**

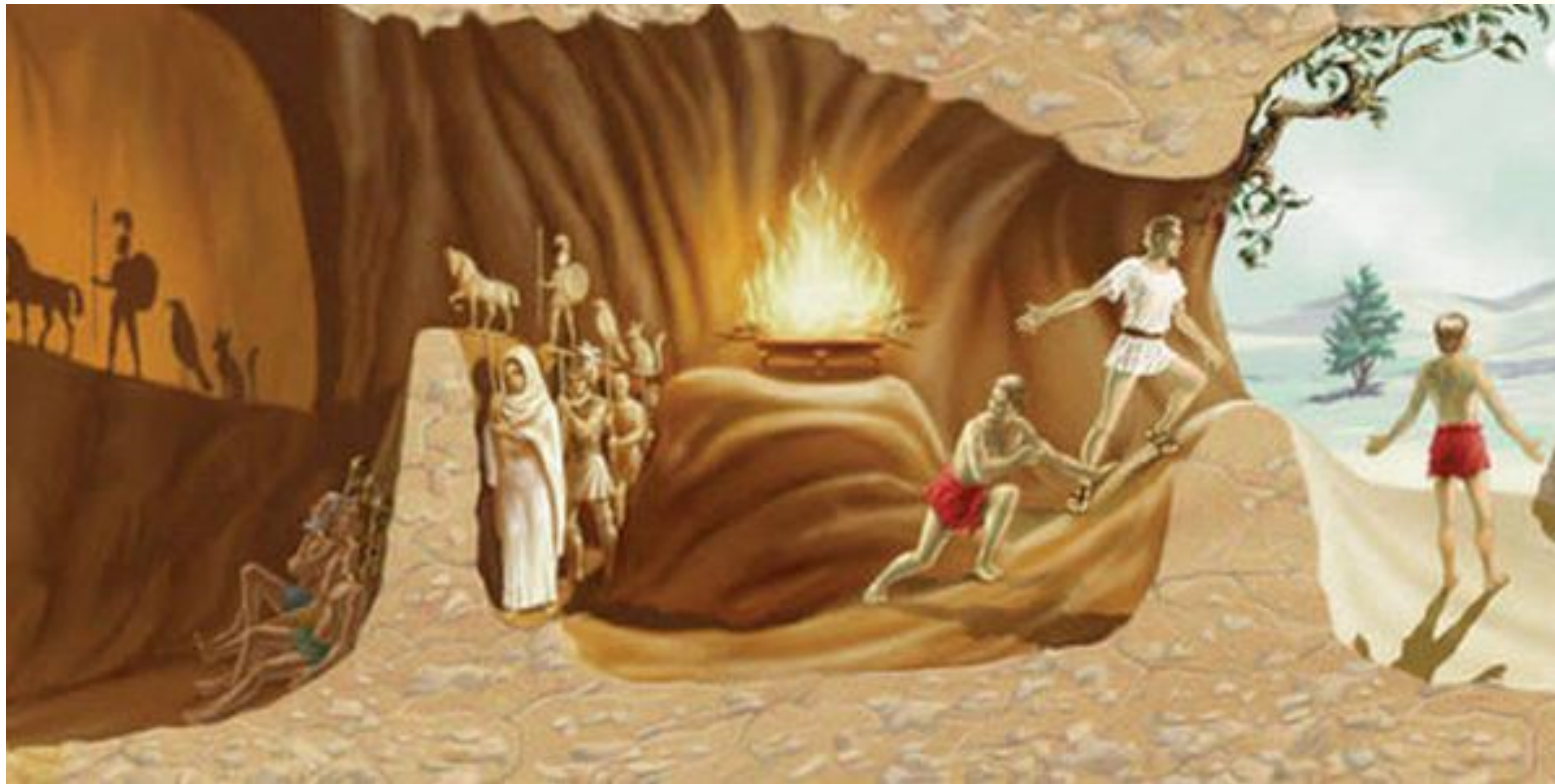


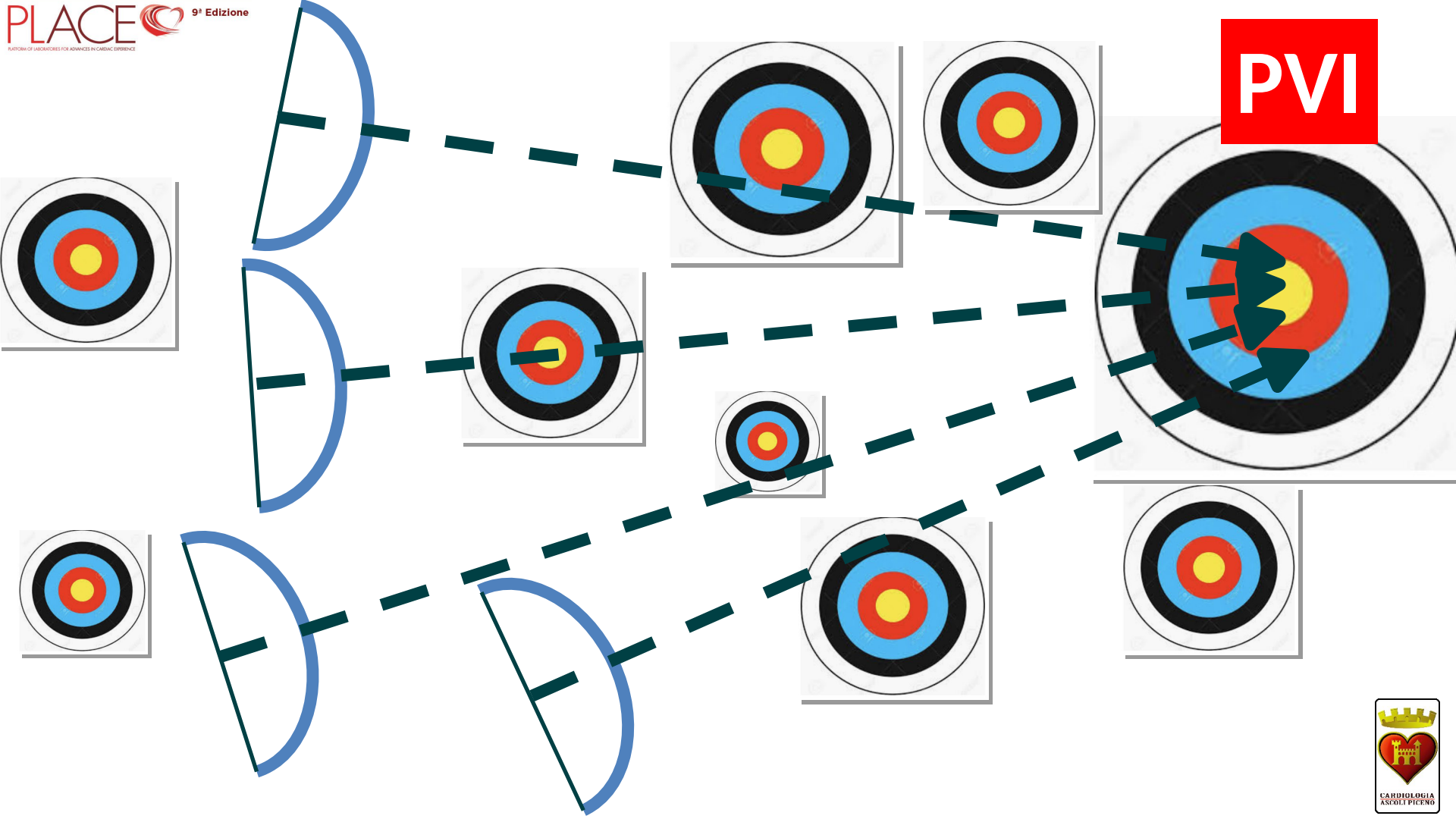




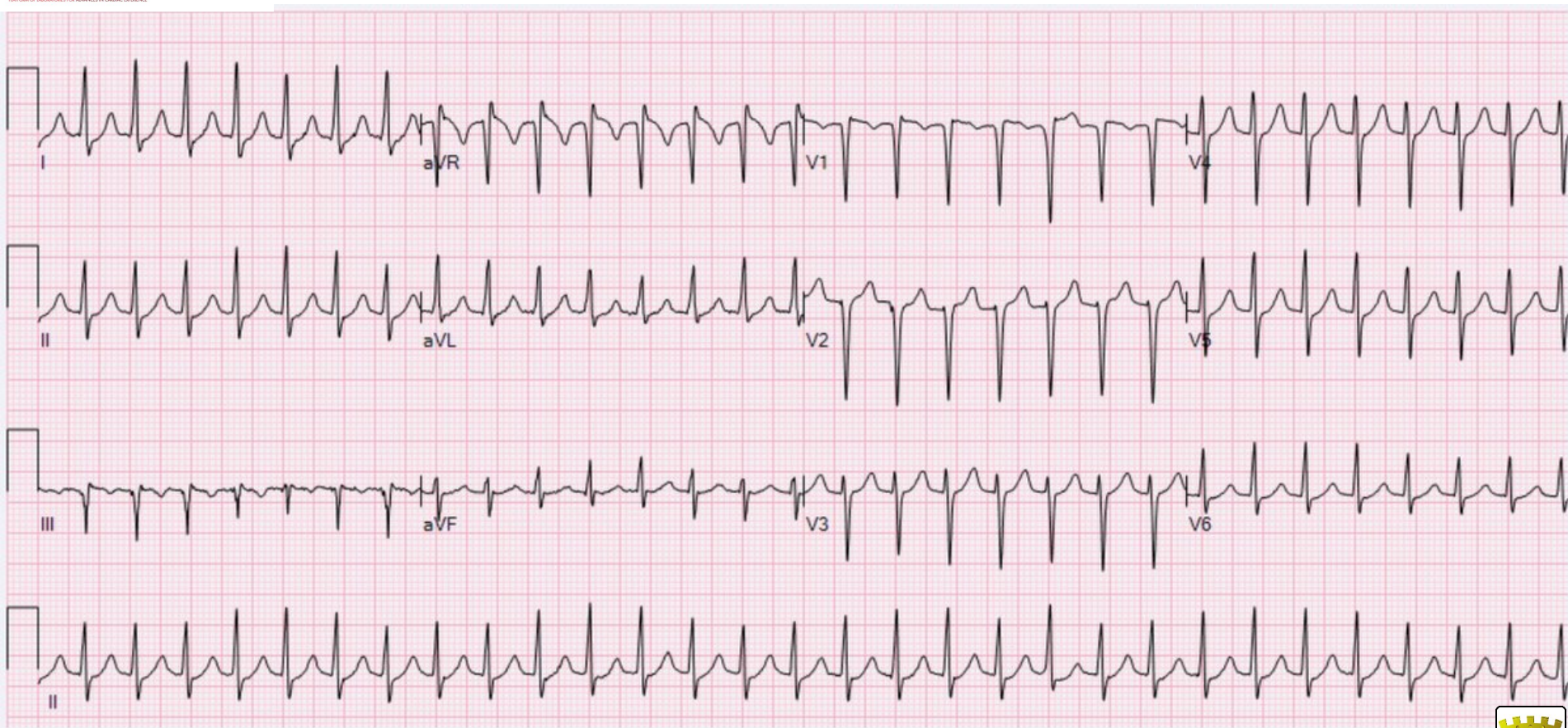


*Platone et. basta*  
**IL MITO DELLA CAVERNA**  
*La Repubblica (Politéia). Libro settimo. 380 AC*





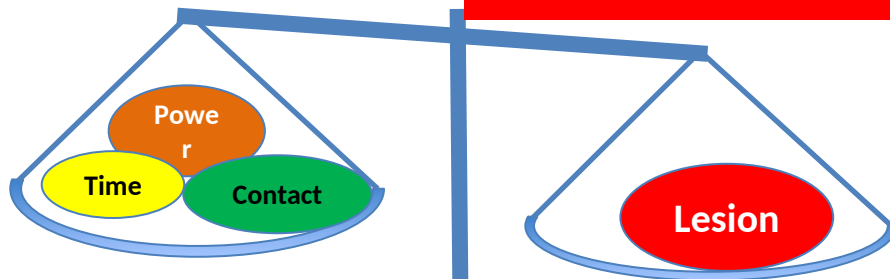




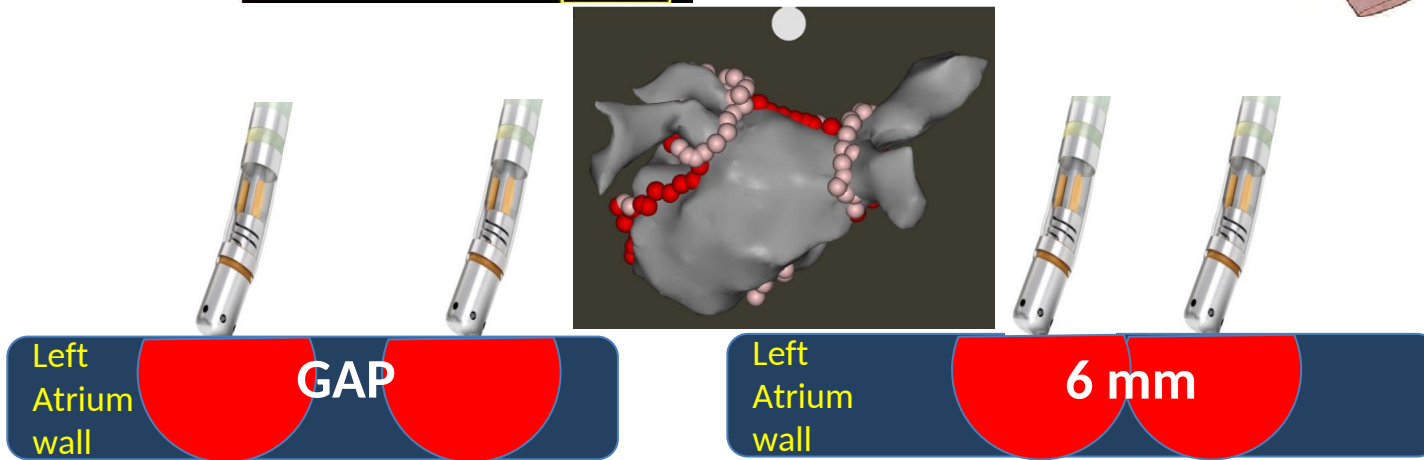
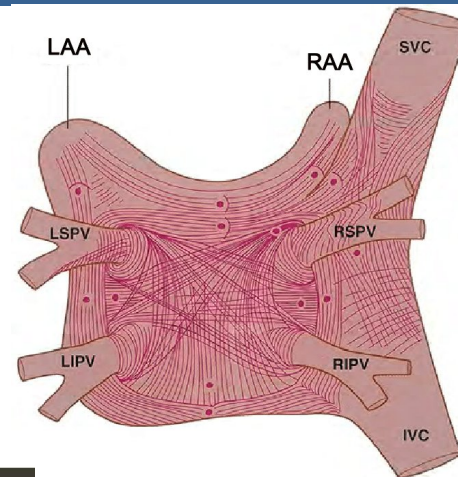
# How to improve outcome?

**Lesion control** = safety, efficacy, standardisation/tailoring

## ABLATION INDEX



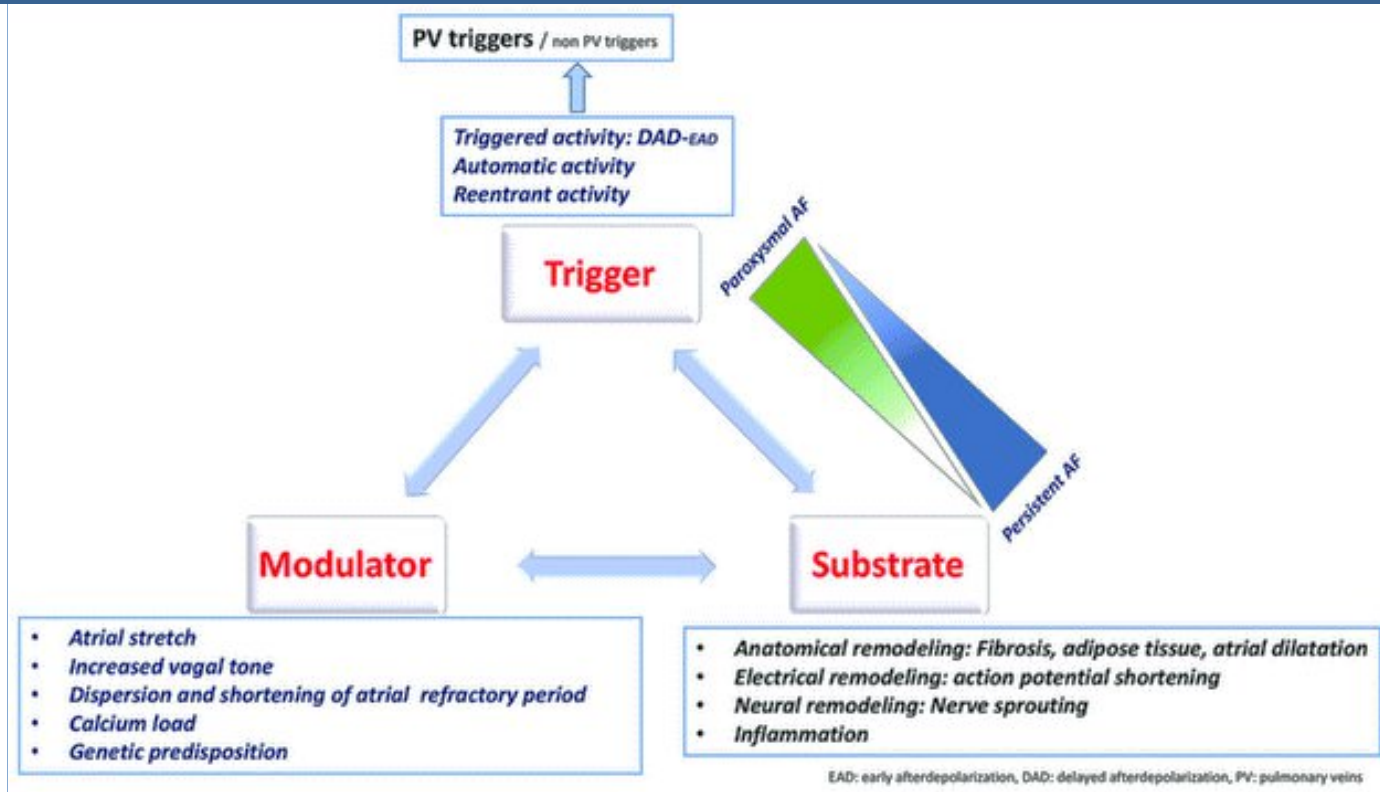
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# HOW TO IMPROVE OUTCOME?

## STANDARDIZED TAILORED APPROACH

### Coumel's Triangle neutralization







Received: 1 April 2019 | Revised: 30 June 2019 | Accepted: 26 July 2019

DOI: 10.1111/pace.13777

PACE 

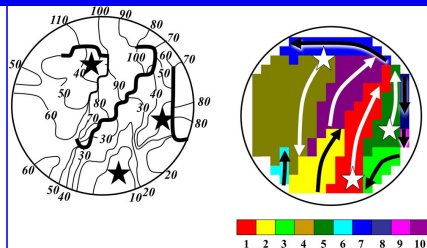
## REVIEW

# Pathophysiology of atrial fibrillation: Focal patterns of activation

Natasja M. S. de Groot MD, PhD  | Maurits A. Allessie MD, PhD



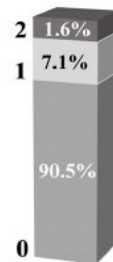
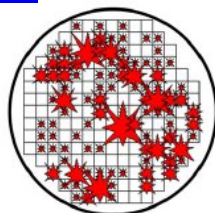
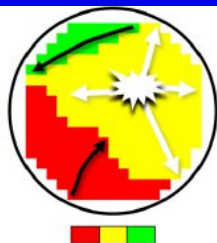
## ROTATIONAL ACTIVITY



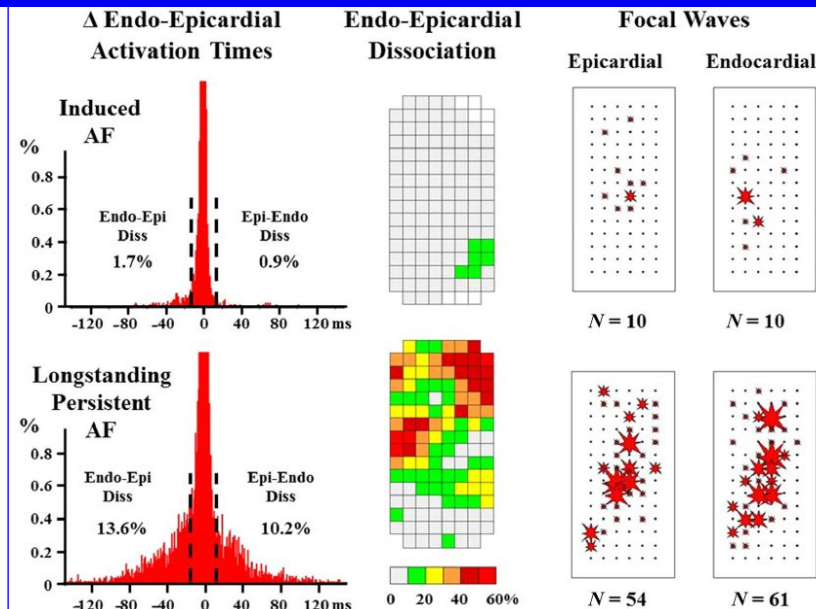
## FOCAL WAVES

patial Distribution

Repetitiveness

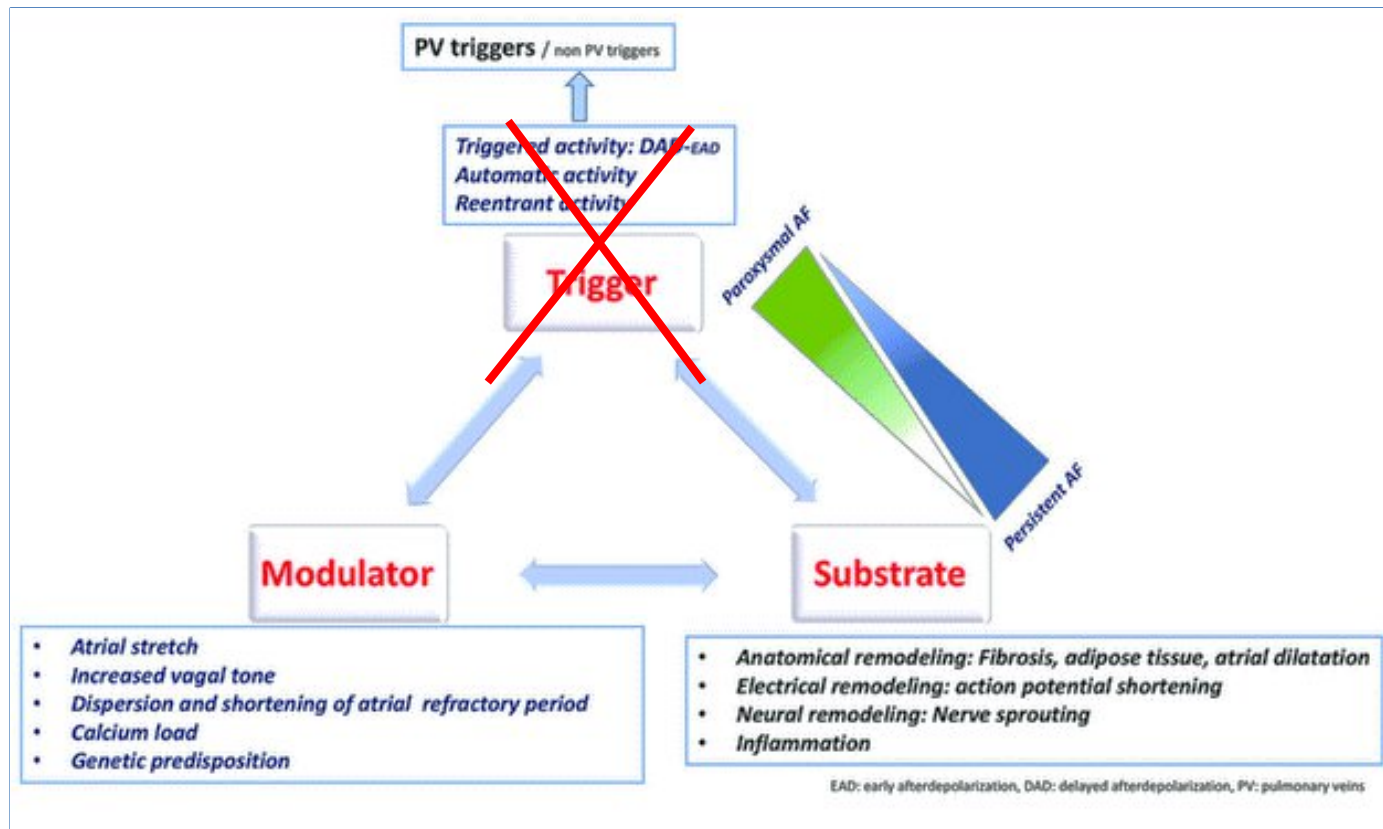


## DOUBLE LAYER (ENDO-EPI) HYPOTHESIS



# HOW TO IMPROVE OUTCOME?

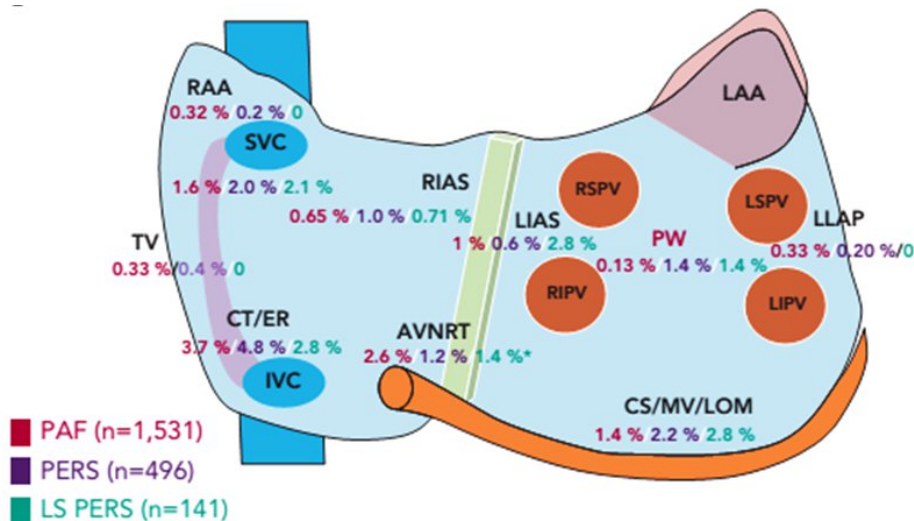
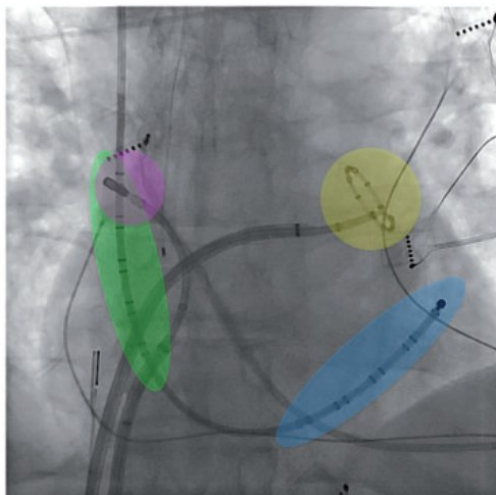
## Coumel's Triangle neutralization: Triggers



## Novel concepts and approaches in ablation of atrial fibrillation: the role of non-pulmonary vein triggers

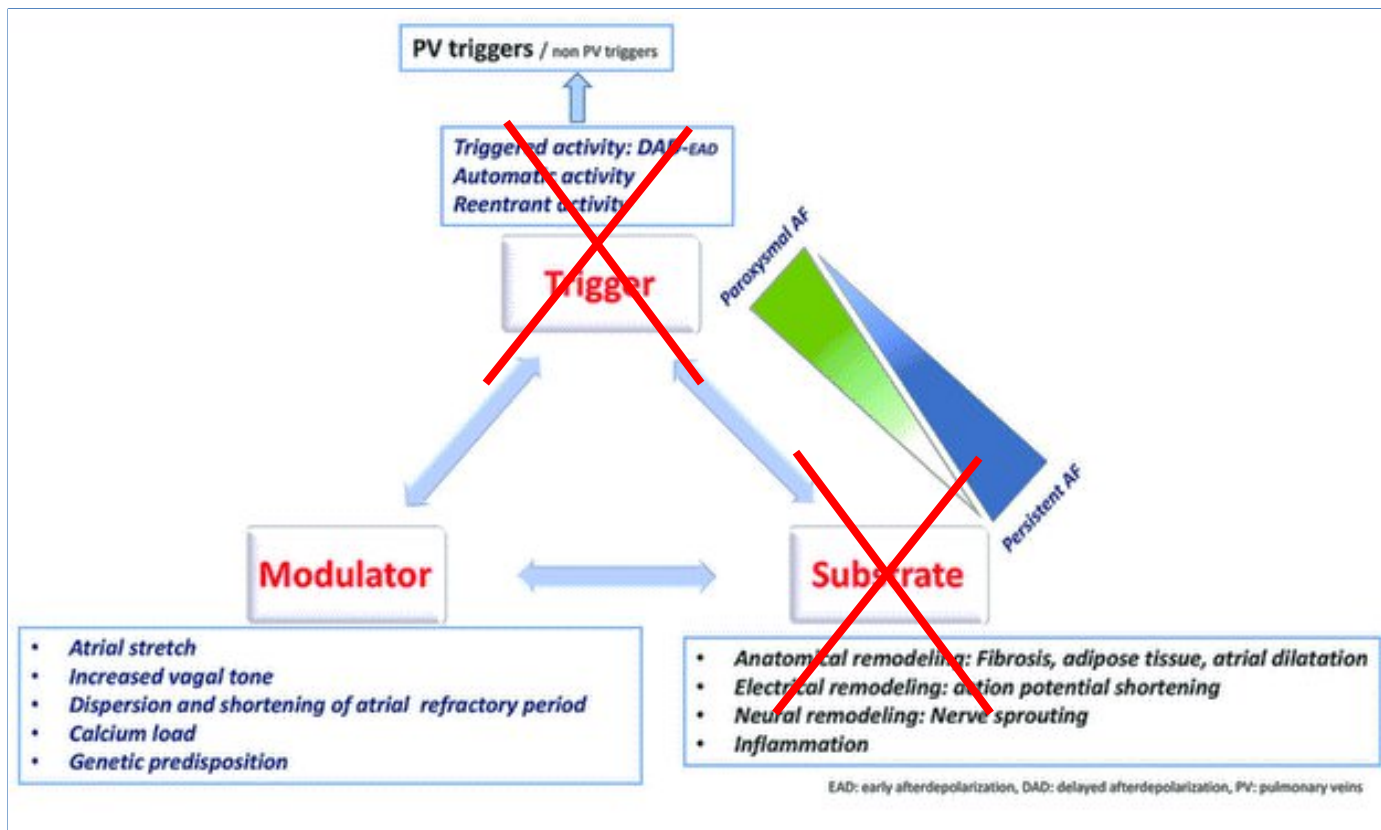
Carola Gianni<sup>1,2</sup>, Sanghamitra Mohanty<sup>1,3</sup>, Chintan Trivedi<sup>1</sup>, Luigi Di Biase<sup>1,4,5,6</sup>, and Andrea Natale<sup>1,3,4,7,8,9,\*</sup>

**“Ablation of non-PV triggers is an important step to improve outcomes in AF ablation”**



# HOW TO IMPROVE OUTCOME?

## Coumel's Triangle neutralization: **Substrate**

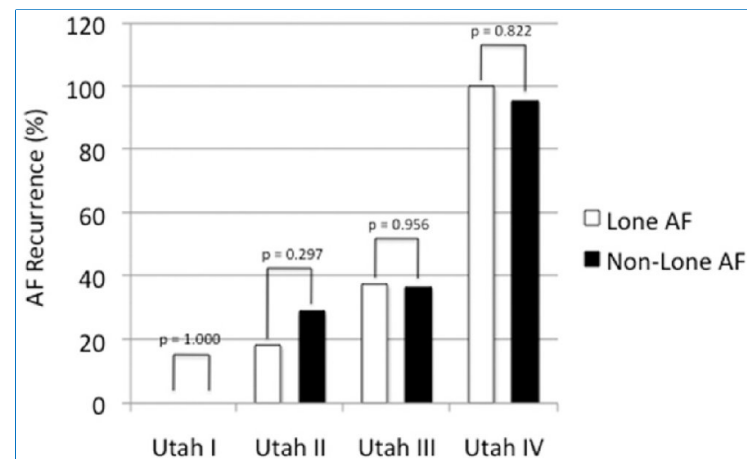
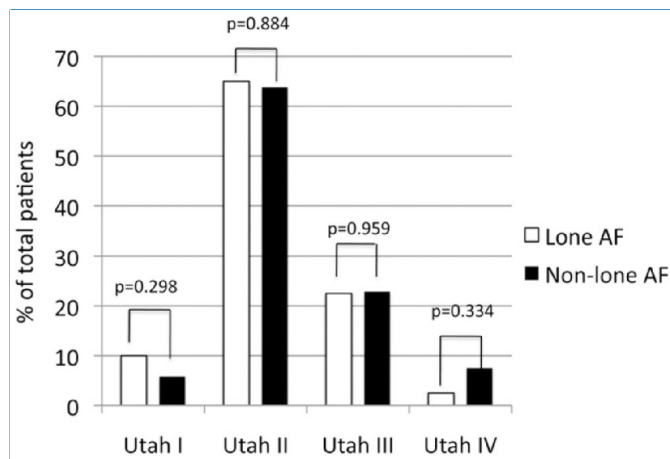
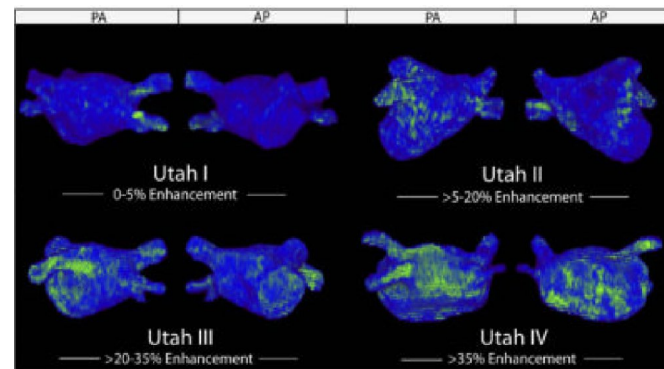




## Evaluation of the left atrial substrate in patients with lone atrial fibrillation using delayed-enhanced MRI: Implications for disease progression and response to catheter ablation

Christian Mahnkopf, MD, Troy J. Badger, MD, Nathan S. Burgon, BSc, Marcos Daccarett, MD, Thomas S. Haslam, Christopher T. Badger, Christopher J. McGann, MD, Nazem Akoum, MD, Eugene Kholmovski, PhD, Rob S. Macleod, PhD, and Nassir F. Marrouche, MD, FHRS

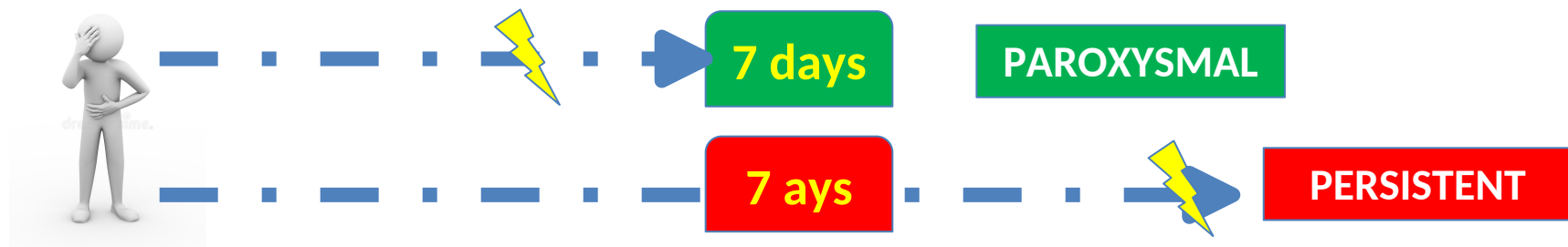
Comprehensive Arrhythmia and Research Management (CARMA) Center, University of Utah School of Medicine, Salt Lake City, Utah



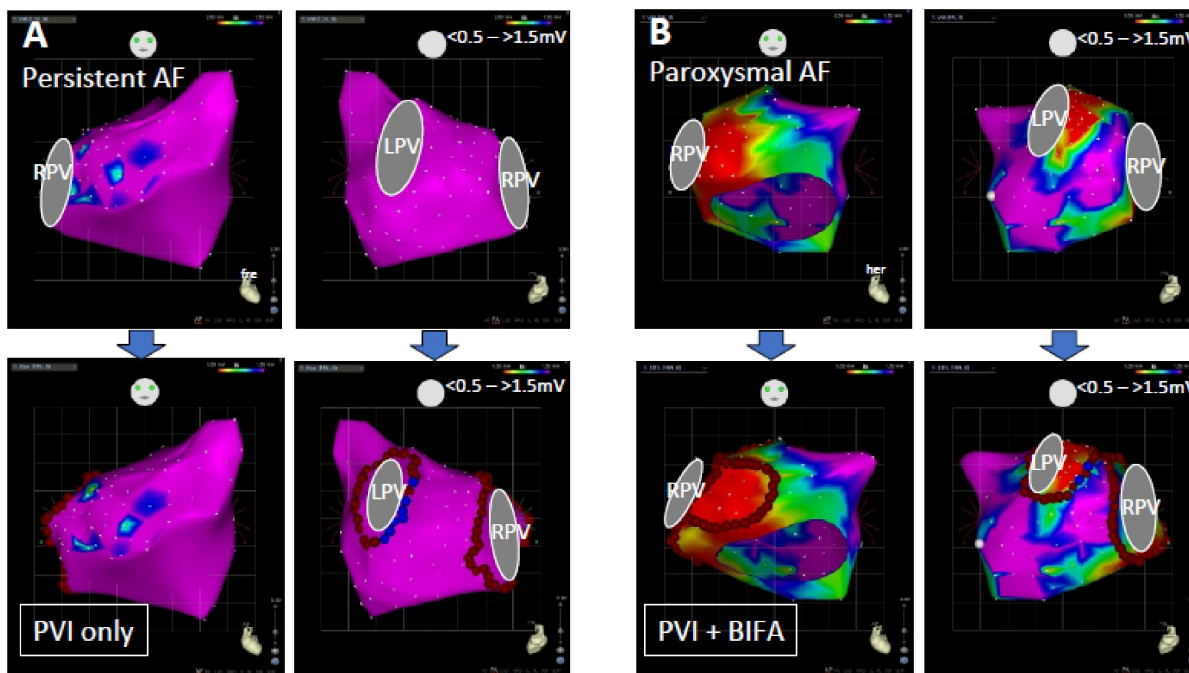
**“The degree of LA structural remodeling as detected using DE-MRI is independent of AF type and associated comorbidities”**

2020 ESC Guidelines for the diagnosis and management of atrial fibrillation developed in collaboration with the European Association for Cardio-Thoracic Surgery (EACTS)

AF pattern	Definition
<b>First diagnosed</b>	AF not diagnosed before, irrespective of its duration or the presence/severity of AF-related symptoms.
<b>Paroxysmal</b>	AF that terminates spontaneously or with intervention within 7 days of onset.
<b>Persistent</b>	AF that is continuously sustained beyond 7 days, including episodes terminated by cardioversion (drugs or electrical cardioversion) after $\geq 7$ days
<b>Long-standing persistent</b>	Continuous AF of >12 months' duration when decided to adopt a rhythm control strategy.
<b>Permanent</b>	AF that is accepted by the patient and physician, and no further attempts to restore/maintain sinus rhythm will be undertaken. Permanent AF represents a therapeutic attitude of the patient and physician rather than an inherent pathophysiological attribute of AF, and the term should not be used in the context of a rhythm control strategy with antiarrhythmic drug therapy or AF ablation. Should a rhythm control strategy be adopted, the arrhythmia would be re-classified as 'long-standing persistent AF'.



References	Population	Ablation technique	Acute results/main findings	Long term outcome
BIFA trial Schreiber et al., 2017	<ul style="list-style-type: none"> <li>PAF= 34</li> <li>PsAF= 49</li> <li>Long lasting PsAF= 9</li> </ul>	<ul style="list-style-type: none"> <li>92 PVI + box isolation of fibrotic area (BIFA) (&lt;0.5 mV bipolar signals in sinus rhythm)</li> <li>49 PVI (no fibrotic area identified during mapping)</li> </ul>	<ul style="list-style-type: none"> <li>Different stages of Fibrotic atrial cardiomyopathy (FACM)                             <ul style="list-style-type: none"> <li>0= no detectable voltage &lt; 1.5 mV</li> <li>I= very limited severe fibrosis</li> <li>II= confluence scar fibrotic areas (&lt; 0.5 mV)</li> <li>III= pronounced <math>\geq 2</math> scar fibrotic areas (&lt;0.5 mV)</li> <li>IV= diffuse fibrosis ("strawberry")</li> </ul> </li> </ul>	<ul style="list-style-type: none"> <li>AF freedom after <math>16 \pm 8</math> months                             <ul style="list-style-type: none"> <li>Single procedure=69%</li> <li>Multiple procedures= 83%</li> </ul> </li> <li>The extent of fibrosis significantly associated to AF recurrence</li> </ul>



Kottkamp H, et al.: J Am Coll Cardiol 2015;65:196-206

Kottkamp H, et al.: JACC EP 2017;3:643-653



Received: 1 April 2019 | Revised: 30 June 2019 | Accepted: 26 July 2019

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PACE 

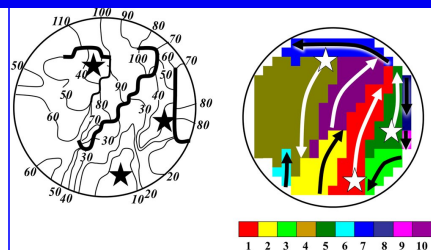
## REVIEW

# Pathophysiology of atrial fibrillation: Focal patterns of activation

Natasja M. S. de Groot MD, PhD  | Maurits A. Allessie MD, PhD



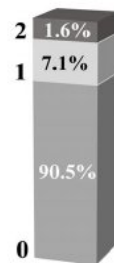
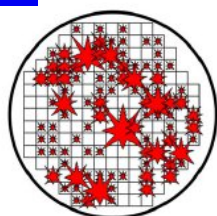
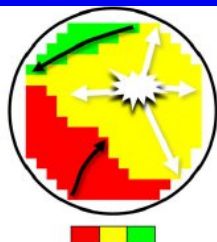
## ROTATIONAL ACTIVITY



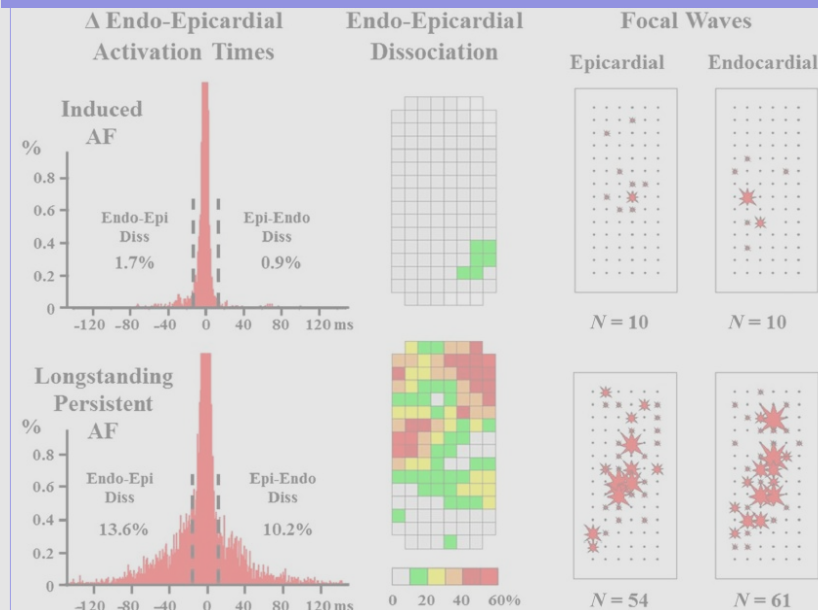
## FOCAL WAVES

patial Distribution

Repetitiveness



## DOUBLE LAYER (ENDO-EPI) HYPOTHESIS

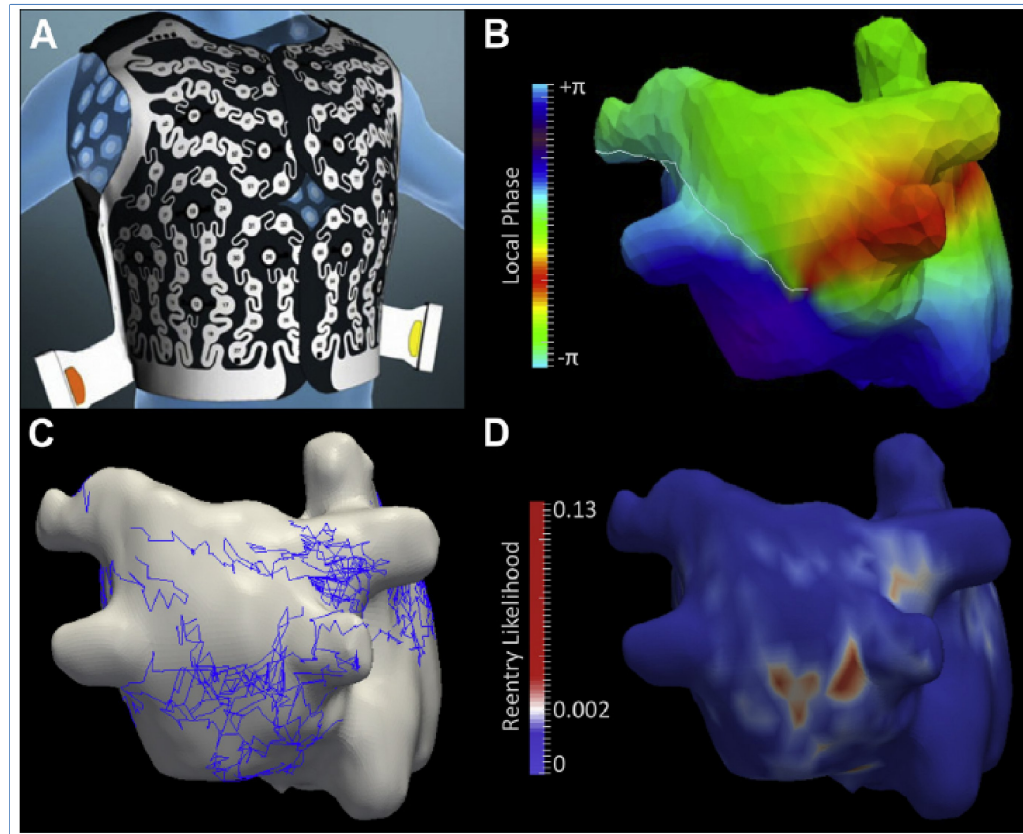
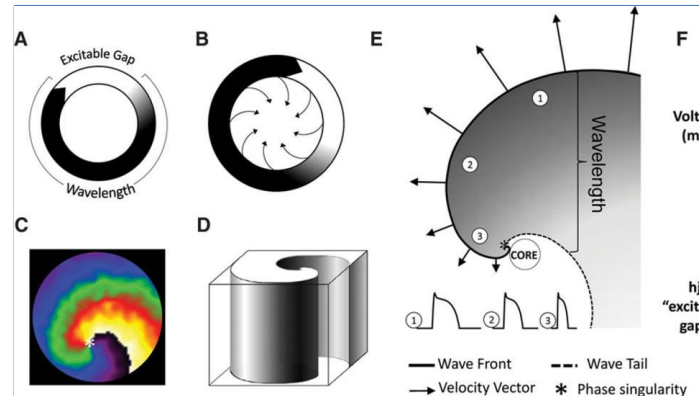




# Relationship Between Fibrosis Detected on Late Gadolinium-Enhanced Cardiac Magnetic Resonance and Re-Entrant Activity Assessed With Electrocardiographic Imaging in Human Persistent Atrial Fibrillation

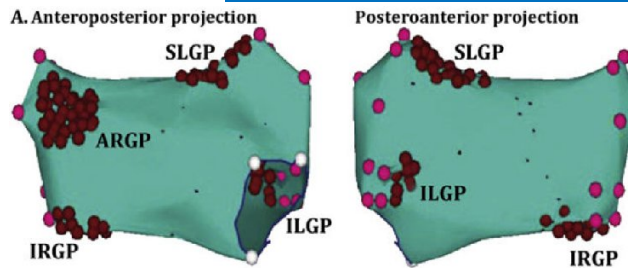
Hubert Cochet, MD, PhD,<sup>a,b</sup> Rémi Dubois, PhD,<sup>c</sup> Seigo Yamashita, MD,<sup>a</sup> Nora Al Jefairi, MD,<sup>a</sup> Benjamin Berte, MD,<sup>a</sup> Jean-Marc Sellal, MD,<sup>a</sup> Darren Hooks, MD,<sup>a</sup> Antonio Frontera, MD,<sup>a</sup> Sana Amraoui, MD,<sup>a,b</sup> Adlane Zemoura, MD,<sup>a,b</sup> Arnaud Denis, MD,<sup>a,b</sup> Nicolas Derval, MD,<sup>a,b</sup> Frederic Sacher, MD, PhD,<sup>a,b</sup> Olivier Cornéloup, MD,<sup>a</sup> Valérie Latrabe, MD,<sup>a</sup> Stéphanie Clément-Guinaudeau, MD,<sup>a</sup> Jatin Relan, PhD,<sup>c</sup> Sohail Zahid, PhD,<sup>d</sup> Patrick M. Boyle, PhD,<sup>d</sup> Natalia A. Trayanova, PhD,<sup>e</sup> Olivier Bernus, PhD,<sup>b</sup> Michel Montaudon, MD, PhD,<sup>a,b</sup> François Laurent, MD,<sup>a,b</sup> Méléze Hocini, MD,<sup>a,b</sup> Michel Haissaguerre, MD,<sup>a,b</sup> Pierre Jaïs, MD,<sup>a,b</sup>

J Am Coll Cardiol EP 2018;4:17-29



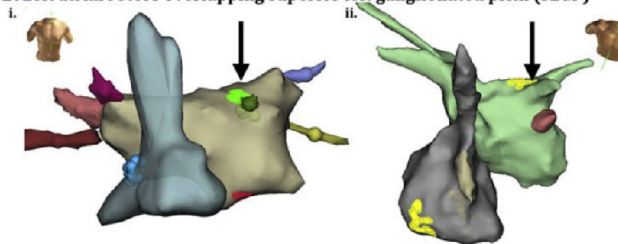
The number of re-entrant regions during AF **relates** to the extent of LGE on CMR, with the location of these regions **clustering** to LGE areas.

Clinically detected AF focal and rotational sources in the left atrium often **colocalize** with regions of autonomic innervation.

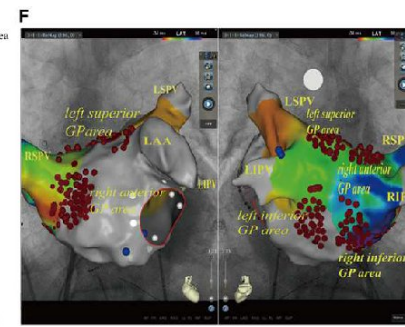
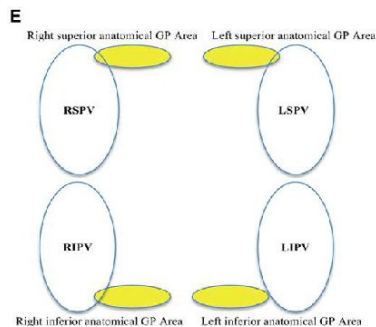
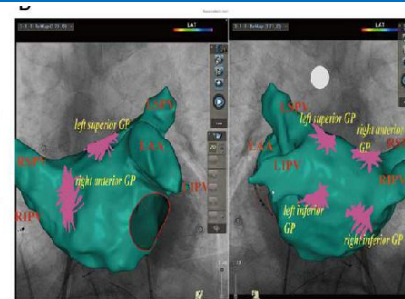
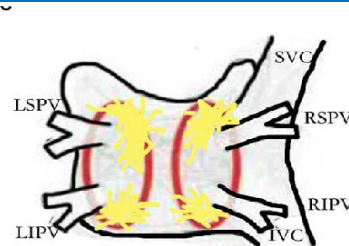
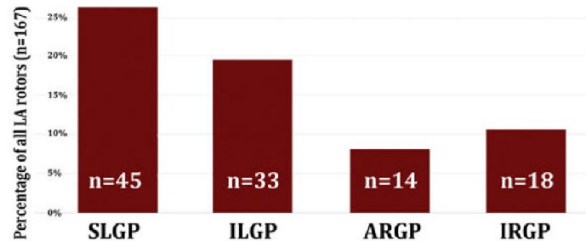


Pokushalov et al. Europace

**B. Left atrial rotors overlapping superior left ganglionated plexi (SLGP)**

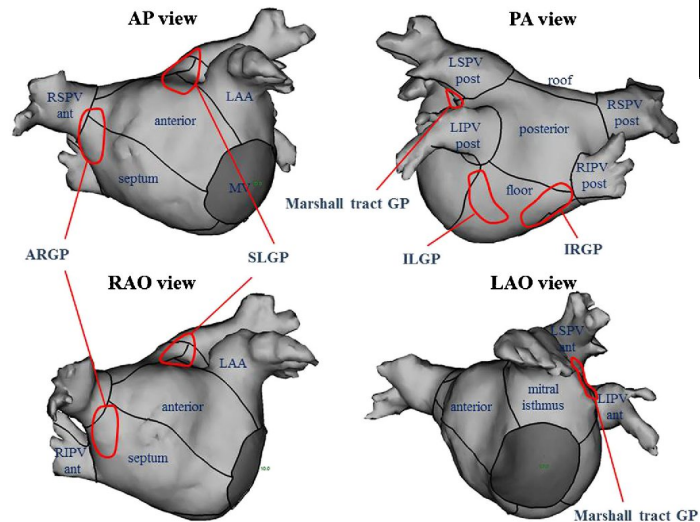


**C. Distribution of left atrial rotors overlapping at ganglionated plexi sites**



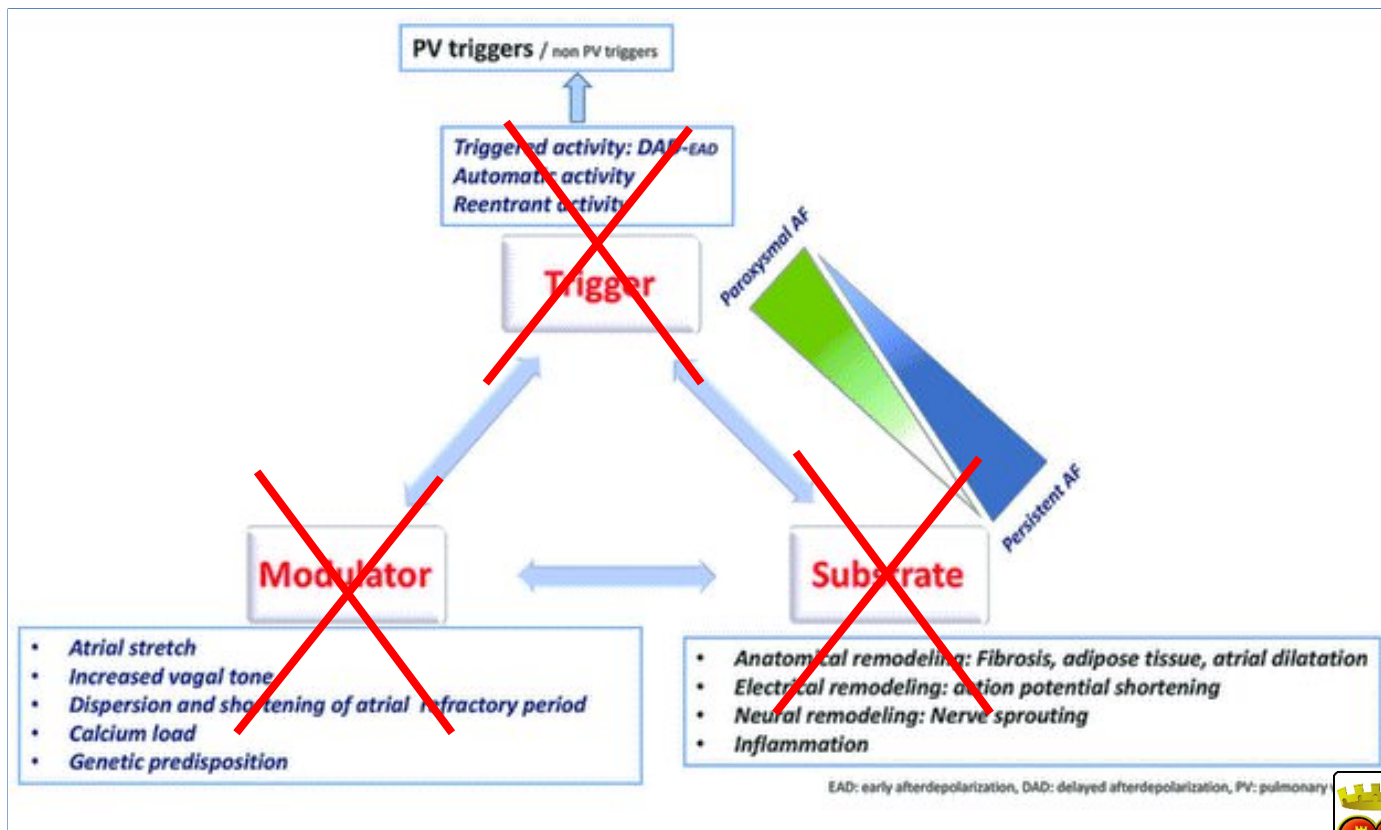
GPA conferred **incremental** benefit when performed in addition to re-PVI in patients with PAF recurrence; the GPA group yielded **higher success rates** than the re-PVI group

# Reproducible Bradycardia during RF LCO h 10 (GPA)



# NEW WAY TO THINK ABOUT AF ABLATION

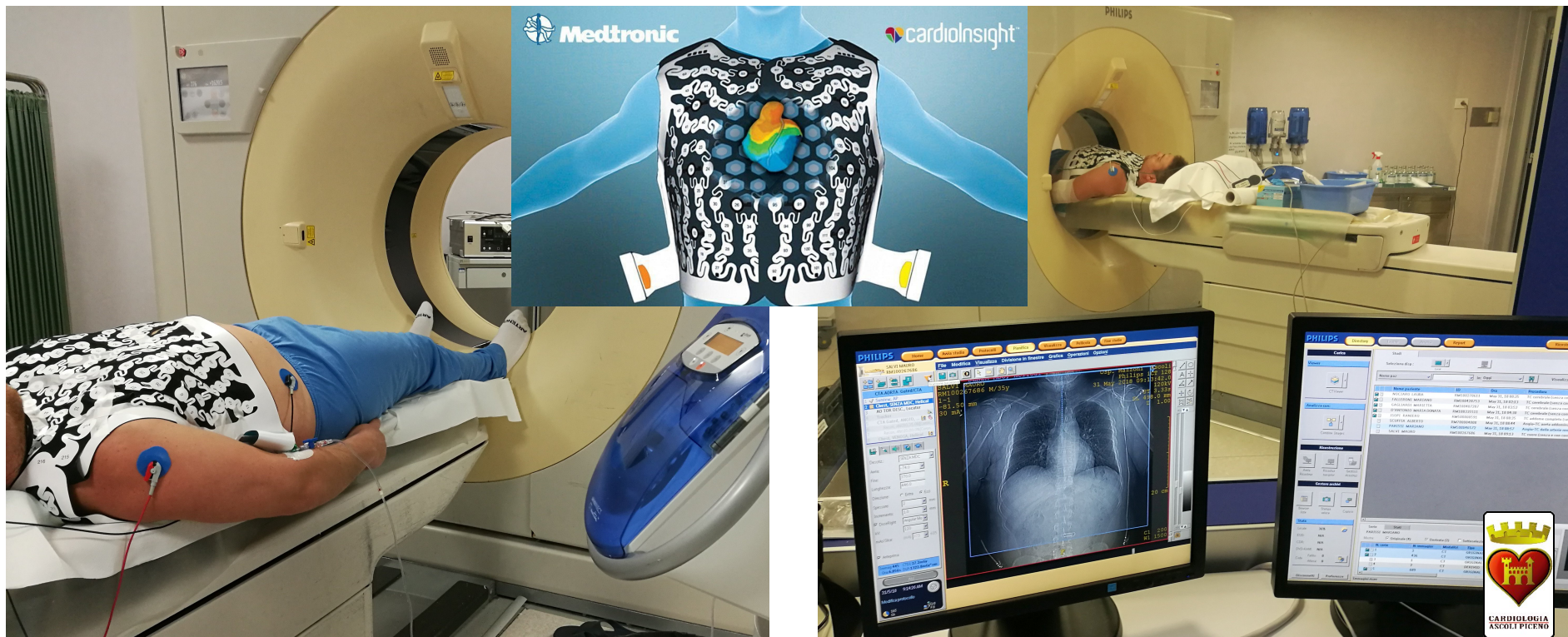
## Coumel's Triangle neutralization: **Modulator (s)**



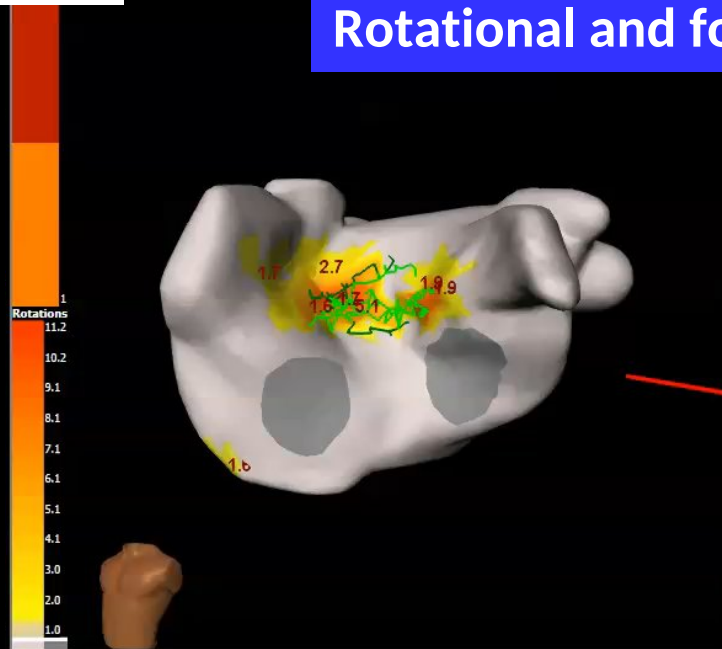


# Our experience

## Rotational and focal activity mapping

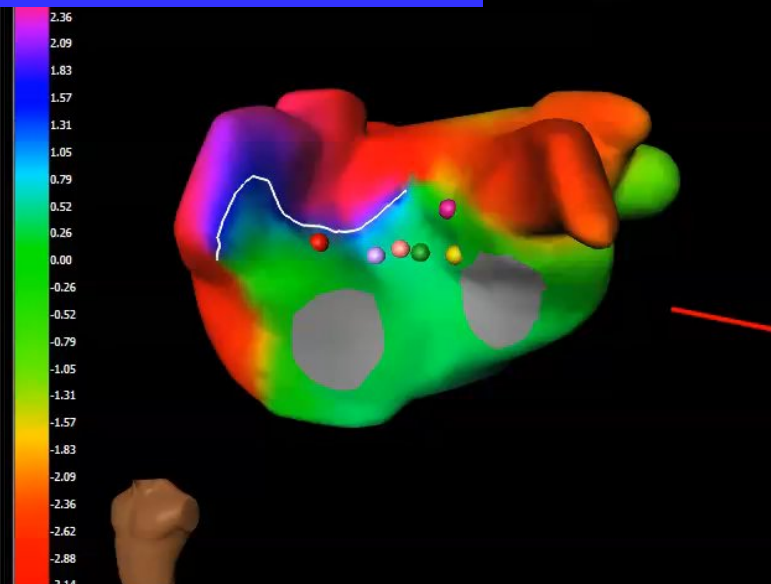


# Non invasive Rotational and focal activity mapping



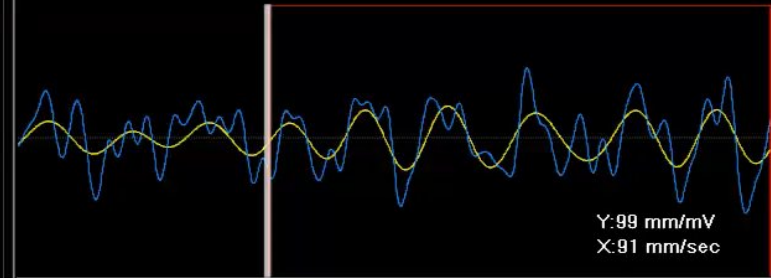
Display: ☐ Unreviewed ☒ Updated ☐ All

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Rotation	Phase Map 18	1.68	<input type="checkbox"/>	<input checked="" type="checkbox"/>



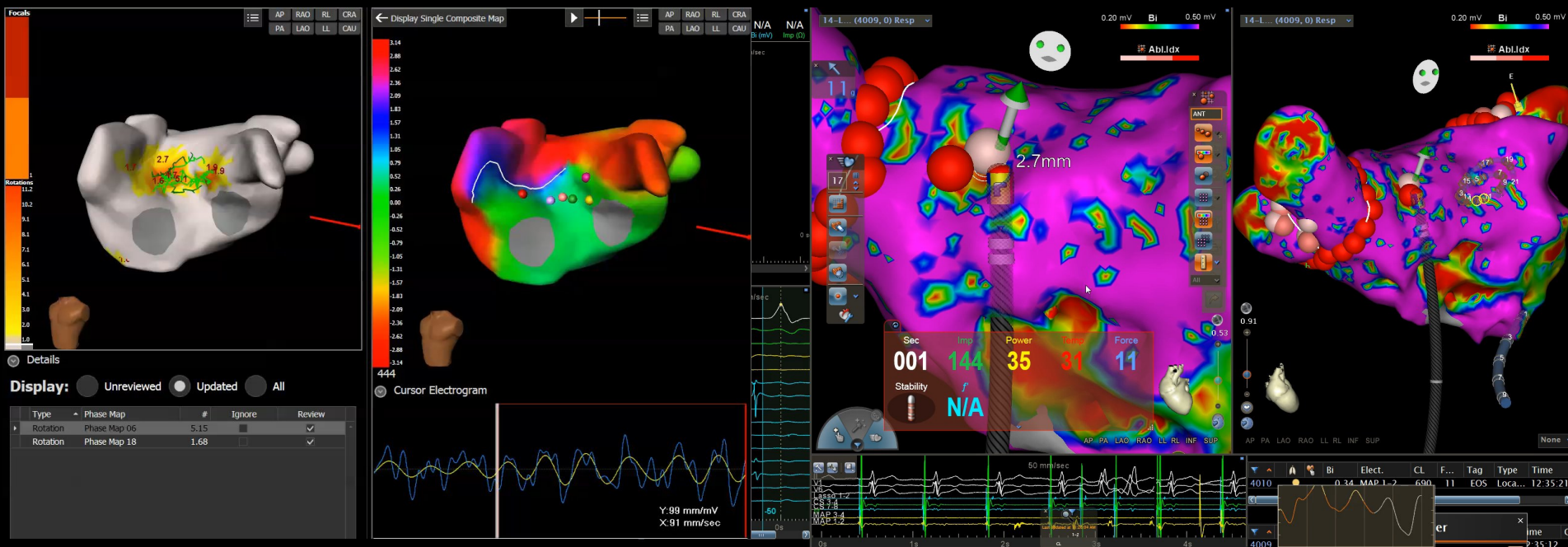
444

☒ Cursor Electrogram



# Which rotor/focal activity is THE CHOSEN ONE?

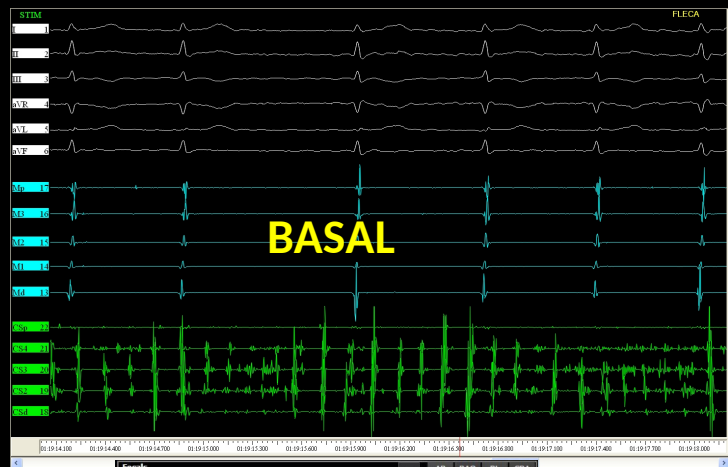
## Rotors-scar colocalized area ablation



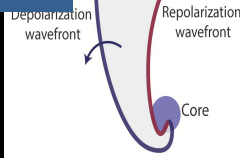


# Which rotor/focal activity is THE CHOSEN ONE?

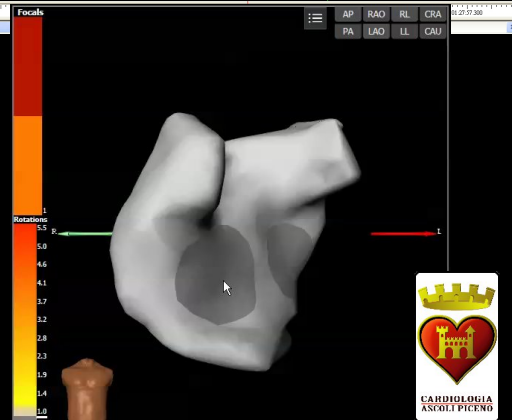
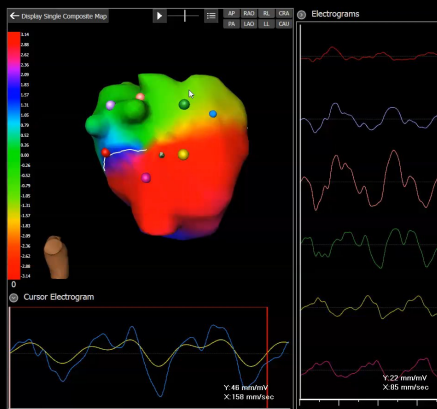
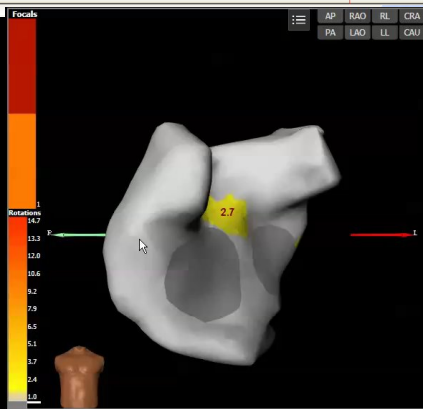
## «Mother Rotor» selection



⚡ Conduction velocity



🎵 RP  
⚡ Excitability









Received: 1 April 2019 | Revised: 30 June 2019 | Accepted: 26 July 2019

DOI: 10.1111/pace.13777

# REVIEW

PACE 

## Pathophysiology of atrial fibrillation: Focal patterns of activation

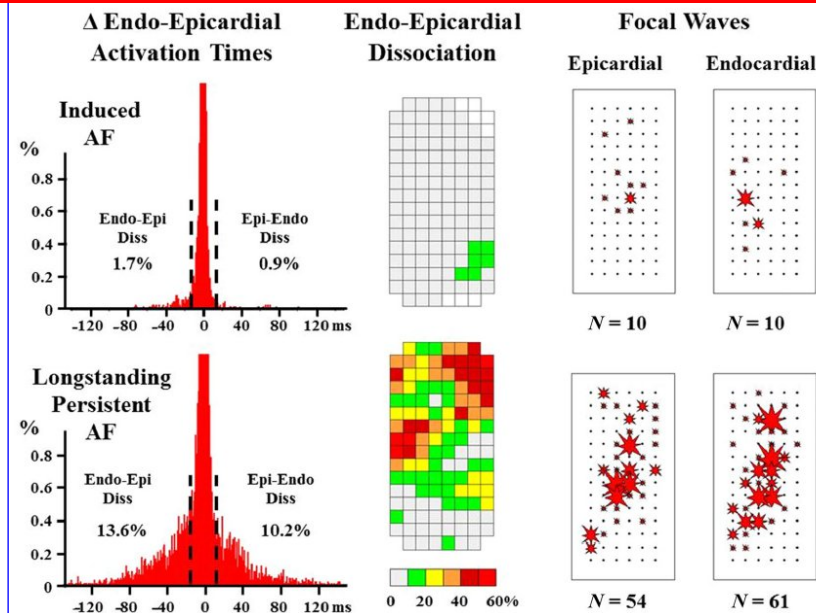
Natasja M. S. de Groot MD, PhD  | Maurits A. Allesie MD, PhD



# THE DOUBLE-LAYER HYPOTHESIS: don't forget the EPICARDIUM

Key element of the substrate underlying AF is electrical asynchrony giving rise to transmurally propagating waves and hence “new” focal waves in the opposite layer.

In theory, the continuous generation of a huge amount of new fibrillation waves on both sides of the atrial wall explains the stability of AF persistence



# VEIN OF MARSHALL: A BACKDOOR TO THE

Received: 13 November 2019 | Accepted: 14 November 2019  
DOI: 10.1111/jce.14297

EDITORIAL-INVITED

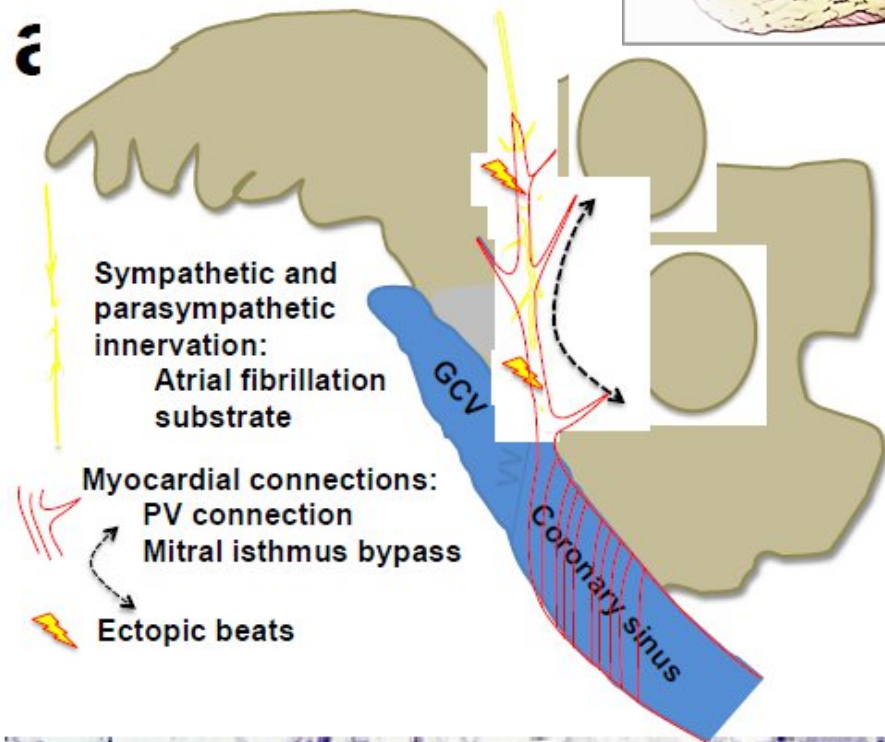
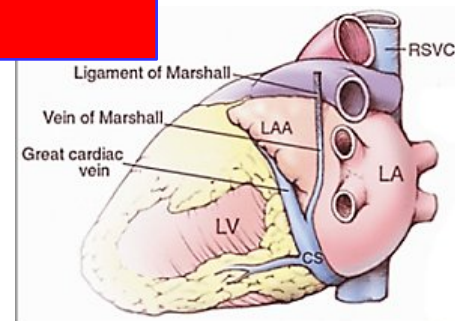
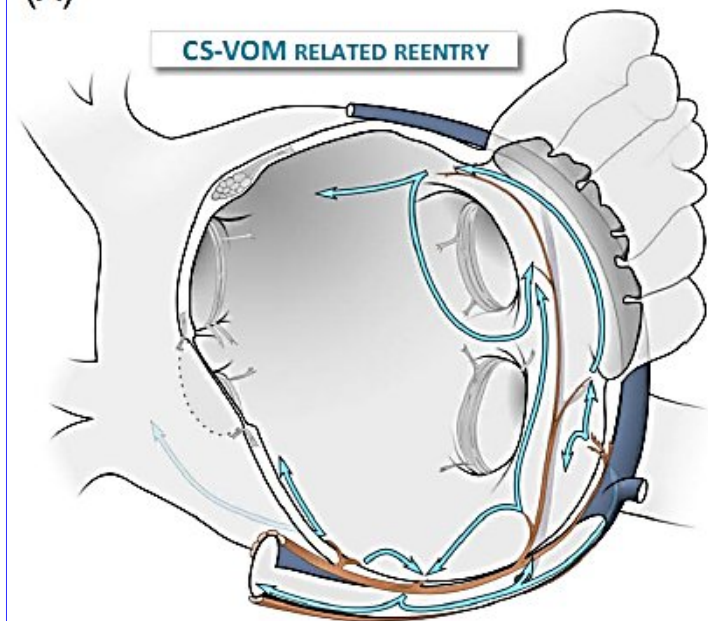
WILEY

## Beyond pulmonary veins... The new horizon remains atrial anatomy

Thomas Pambrun MD  | Nicolas Derval MD | Josselin Duchateau MD, PhD

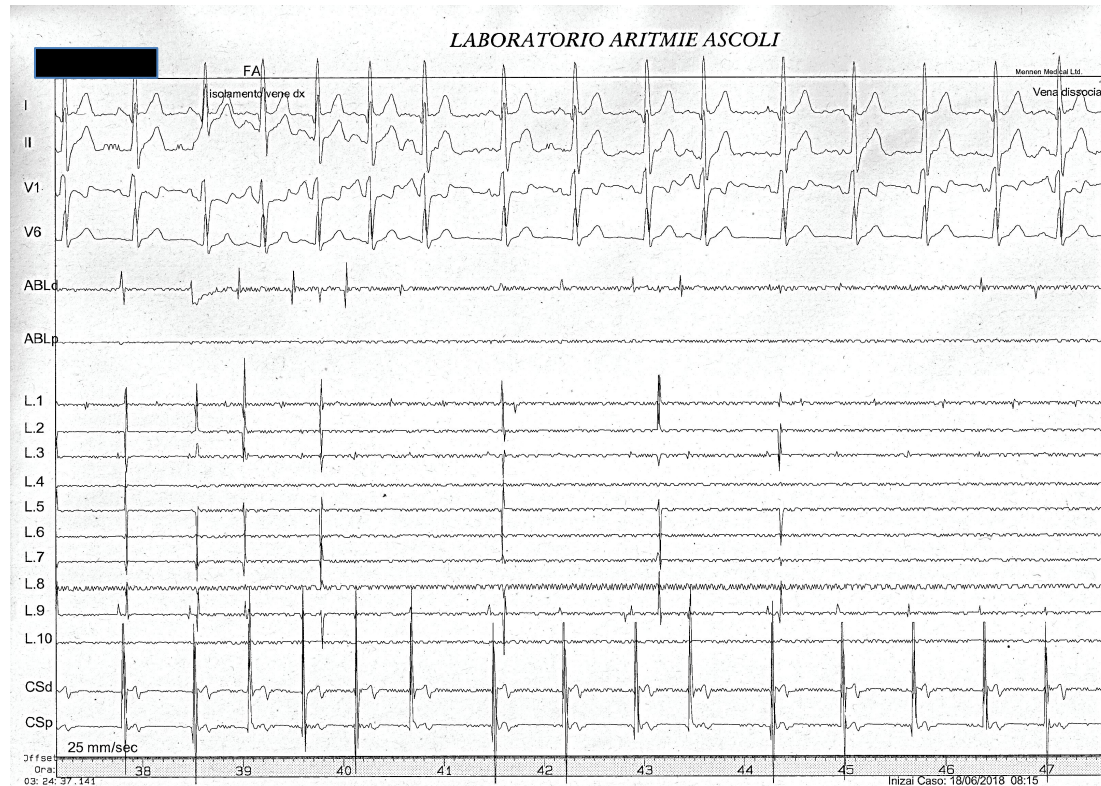
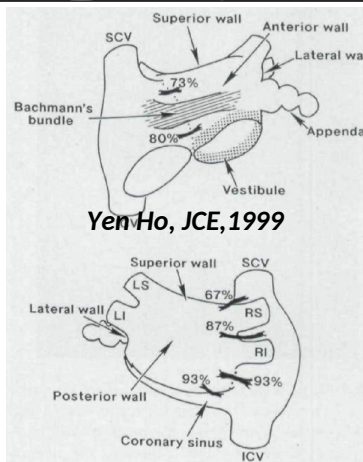
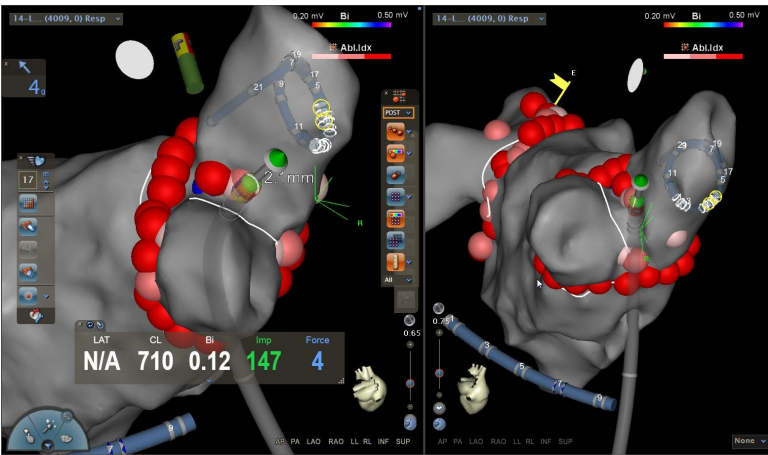
Hôpital Cardiologique du Haut-Lévêque, CHU Bordeaux, L'Institut de Rythmologie et modélisation Cardiaque (LIRYC), Université Bordeaux, Bordeaux, France

### CS-VOM RELATED REENTRY





# WACA but PV isolation during RF in right PVs carena



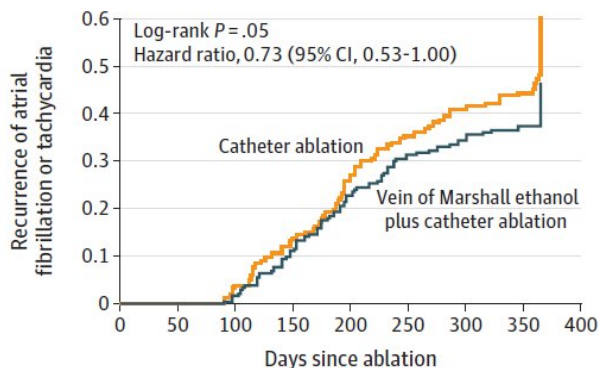


# Effect of Catheter Ablation With Vein of Marshall Ethanol Infusion vs Catheter Ablation Alone on Persistent Atrial Fibrillation The VENUS Randomized Clinical Trial

Miguel Valderrábano, MD; Leif E. Peterson, PhD; Vijay Swarup, MD; Paul A. Schurmann, MD; Akash Makkar, MD; Rahul N. Doshi, MD; David DeLurgio, MD; Charles A. Athill, MD; Kenneth A. Ellenbogen, MD; Andrea Natale, MD; Jayanthi Koneru, MD; Amish S. Dave, MD, PhD; Irakli Giorgberidze, MD; Hamid Afshar, MD; Michelle L. Guthrie, RN; Raquel Bunge, RN; Carlos A. Morillo, MD; Neal S. Kleiman, MD

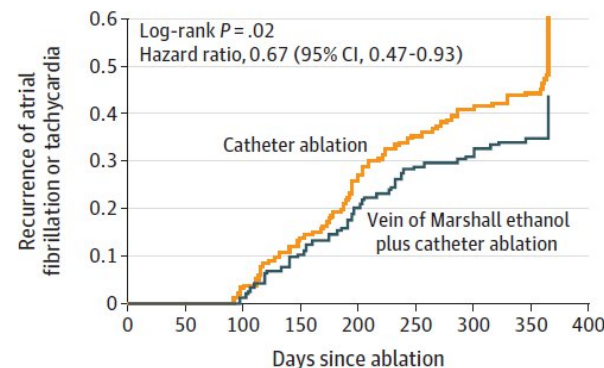
JAMA

**A** Atrial fibrillation or tachycardia occurrence after single procedure in as-randomized analysis



No. at risk									
Vein of Marshall ethanol plus catheter ablation	185	180	174	153	129	116	108	89	68
Catheter ablation	158	157	148	132	110	95	86	69	54

**B** Atrial fibrillation or tachycardia occurrence after single procedure in as-treated analysis



No. at risk									
Vein of Marshall ethanol plus catheter ablation	155	151	145	129	111	100	95	77	58
Catheter ablation	158	157	148	132	110	95	86	69	54

# Marshall bundle elimination, Pulmonary vein isolation, and Line completion for ANatomical ablation of persistent atrial fibrillation (Marshall-PLAN): Prospective, single-center study <sup>e</sup>

Nicolas Derval, MD,<sup>\*†</sup> Josselin Duchateau, MD, PhD,<sup>\*††</sup> Arnaud Denis, MD,<sup>\*†</sup> F. Daniel Ramirez, MD,<sup>\*†</sup> Saagar Mahida, MD,<sup>‡</sup> Clémentine André, MD,<sup>\*†</sup> Philipp Krisai, MD,<sup>\*†</sup> Yosuke Nakatani, MD,<sup>\*†</sup> Takeshi Kitamura, MD,<sup>\*†</sup> Masateru Takigawa, MD,<sup>\*†</sup> Remi Chauvel, MD,<sup>\*†</sup> Romain Tixier, MD,<sup>\*†</sup> Xavier Pillois, PhD,<sup>\*††</sup> Frédéric Sacher, MD, PhD,<sup>\*††</sup> Mèlèze Hocini, MD,<sup>\*††</sup> Michel Haïssaguerre, MD,<sup>\*††</sup> Pierre Jaïs, MD, PhD,<sup>\*††</sup> Thomas Pambrun, MD<sup>\*†</sup>

From the <sup>\*</sup>IHU Liryc, Electrophysiology and Heart Modeling Institute, Fondation Bordeaux Université, Pessac-Bordeaux, France, <sup>†</sup>Bordeaux University Hospital (CHU), Cardio-Thoracic Unit, Pessac, France, <sup>‡</sup>Université de Bordeaux, Centre de Recherche Cardio-Thoracique de Bordeaux, Bordeaux, France, and <sup>§</sup>Liverpool Centre for Cardiovascular Science and Liverpool Heart & Chest Hospital, Liverpool, United Kingdom.

**BACKGROUND** Beyond pulmonary vein isolation (PVI), the optimal ablation strategy for persistent atrial fibrillation (AF) remains poorly defined.

**OBJECTIVE** The purpose of this study was to examine a novel comprehensive ablation strategy (Marshall bundle elimination, Pulmonary vein isolation, and Line completion for ANatomical ablation of persistent atrial fibrillation [Marshall-PLAN]) strictly based on anatomical considerations.

**METHODS** Left atrial (LA) sites were sequentially targeted as follows: (1) coronary sinus and vein of Marshall (CS-VOM) musculature; (2) PVI; and (3) anatomical isthmuses (mitral, roof, and cavotricuspid isthmus [CTI]). The primary endpoint was 12-month freedom from AF/atrial tachycardia (AT).

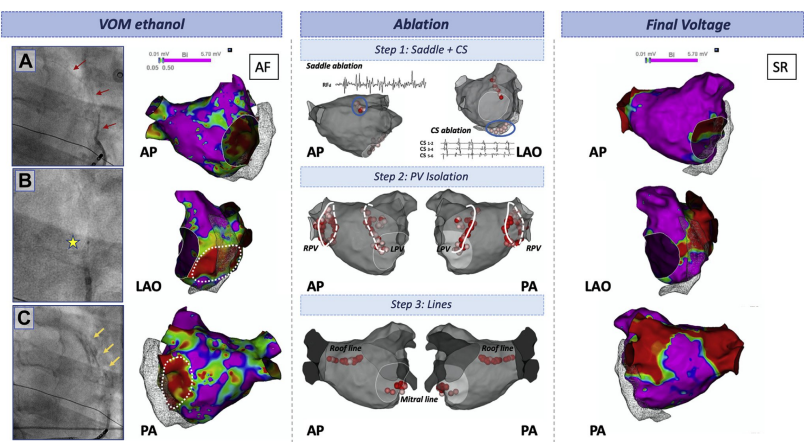
**RESULTS** Seventy-five consecutive patients were included (age 61 ± 9 years; 10 women; AF duration 9 ± 11 months; mean LA volume 197 ± 43 mL). VOM ethanol infusion was completed in 69 patients (92%). The full Marshall-PLAN lesion set (VOM, PVI, mitral, roof, and

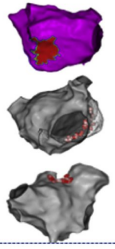
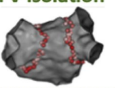
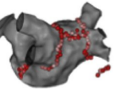
CTI with block) was successfully completed in 68 patients (91%). At 12 months, 54 of 75 patients (72%) were free from AF/AT after a single procedure (no antiarrhythmic drugs) in the overall cohort. In the subset of patients with a complete Marshall-PLAN lesion set (n = 68), the single procedure success rate was 79%. After 1 or 2 procedures, 67 of 75 patients (89%) remained free from AF/AT (no antiarrhythmic drugs). After 1 or 2 procedures, VOM ethanol infusion was complete in 72 of 75 patients (96%).

**CONCLUSION** A novel ablation strategy that systematically targets anatomical atrial structures (VOM ethanol infusion, PVI, and prespecified linear lesions) is feasible, safe, and associated with a high rate of freedom from arrhythmia recurrence at 12 months in patients with persistent AF.

**KEYWORDS** Anatomical approach; Catheter ablation; Ethanol infusion; Persistent atrial fibrillation; Vein of Marshall

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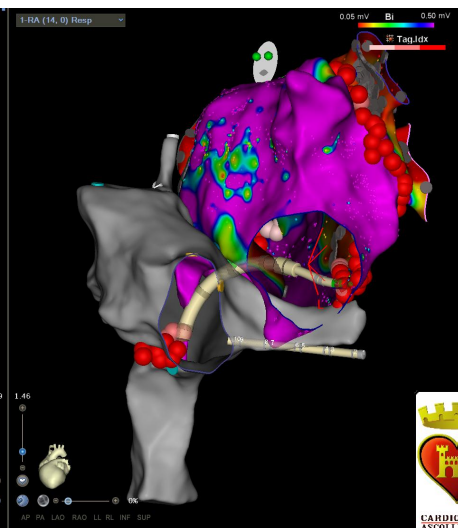
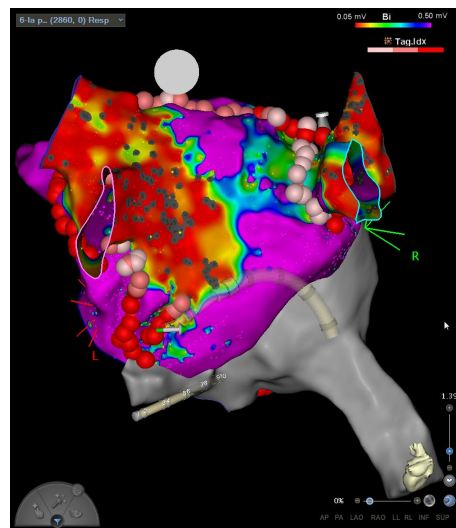
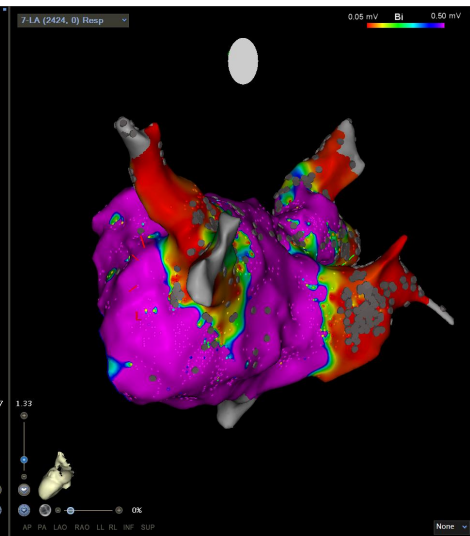
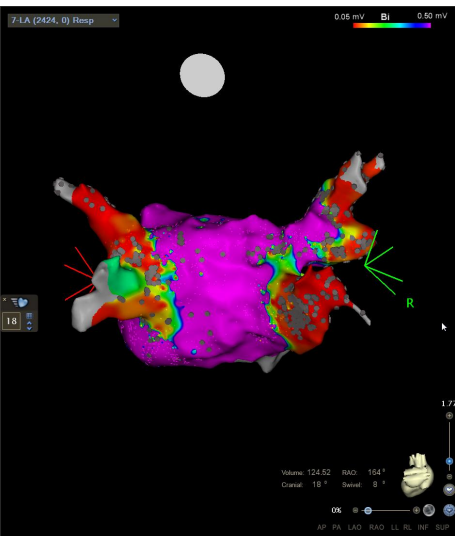
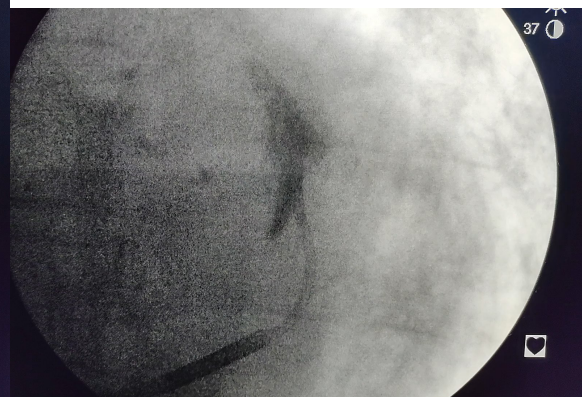
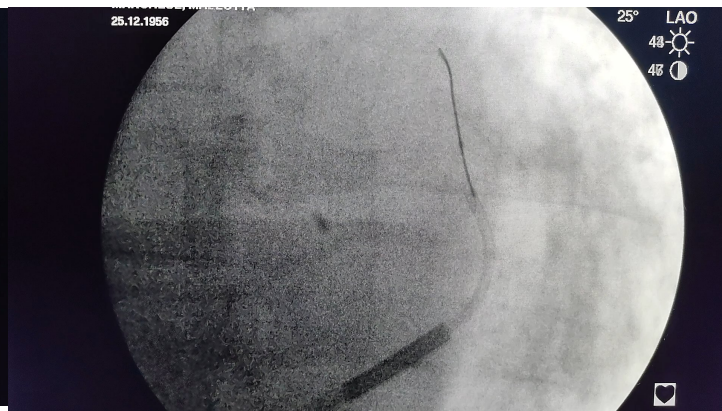
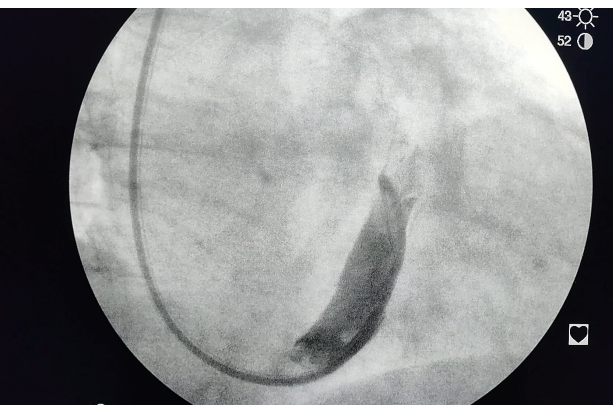
VOM + CS	Success	Failure	Duration
	69 pts (92%)	6 pts 1 LAA 2 VOM dissection 3 VOM not found	OH infusion: 30±11min  CS: RF=5.9±3min  Ridge: RF= 7.0±3.5min
	75 pts (100%)	0 pts (0%)	LPV: RF=7.1±4.4min RPV: RF=15.2±7.5min
	<b>Mitral line</b> 71 pts (95%) <b>Roof line</b> 74 pts (99%) <b>CTI line</b> 74 pts (99%)	4 pts, <b>All</b> failed VOM OH infusion  1 pt	RF=7.9±7.2min RF=7.6±5.0min RF=8.3±5.7min

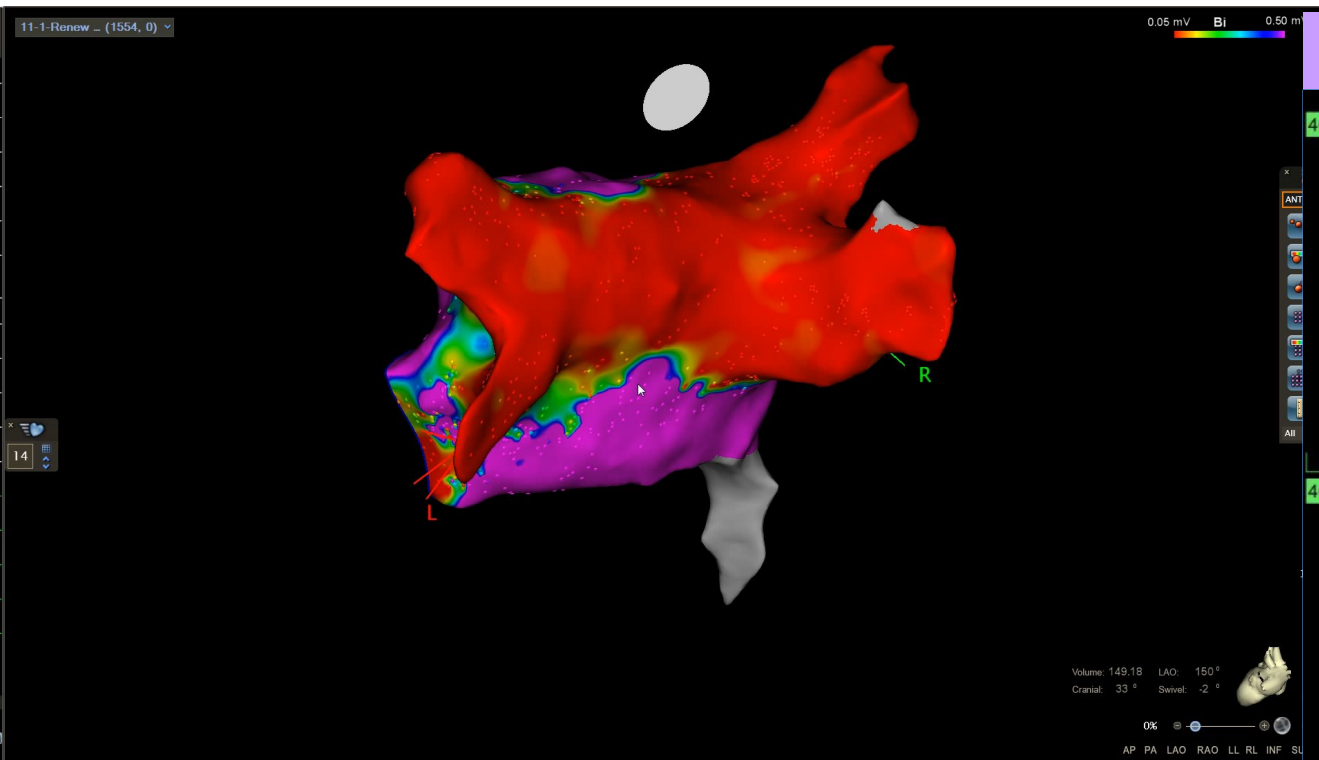
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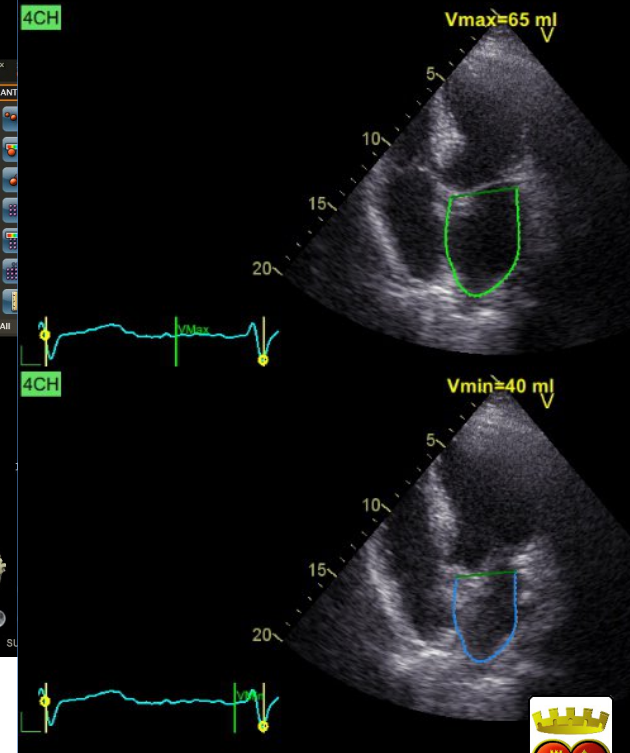


# Our Experience **MARSHALL VEIN ETHANOL INFUSION ABLATION**





**NO EFFECT ON LA FUNCTION**





## CONCLUSIVE REMARKS

We should aim for a **STANDARDIZED/TAILORED** approach

**PRE-ABLATION**

Evaluate AFib (triggers, burden, risk factor management, LA evaluation)

**ABLATION**

- ☐ Lesion control (safety, reproducibility)
- ☐ ***Coumel's Triangle neutralization***
  - Triggers evaluation
  - Substrate evaluation (high definition mapping, rotors/focal area, epicardium backdoors)

**POST ABLATION**

- ☐ Evaluate AFib (triggers, burden, risk factor management, LA evaluation)

# Saluti da Ascoli

