



# Ablation de la Fibrillation Atriale

Dr Cyril Durand

**Paroxystique**

Episodes  
spontanément  
résolutifs  
**< 7 jours**

**Persistante**

Episodes  
spontanément  
résolutifs ou après  
cardioversion  
entre **7 jours et 1 an**

**Persistante  
de longue durée**

Episodes résolutifs  
après cardioversion  
**> 1 an**

**Permanente**

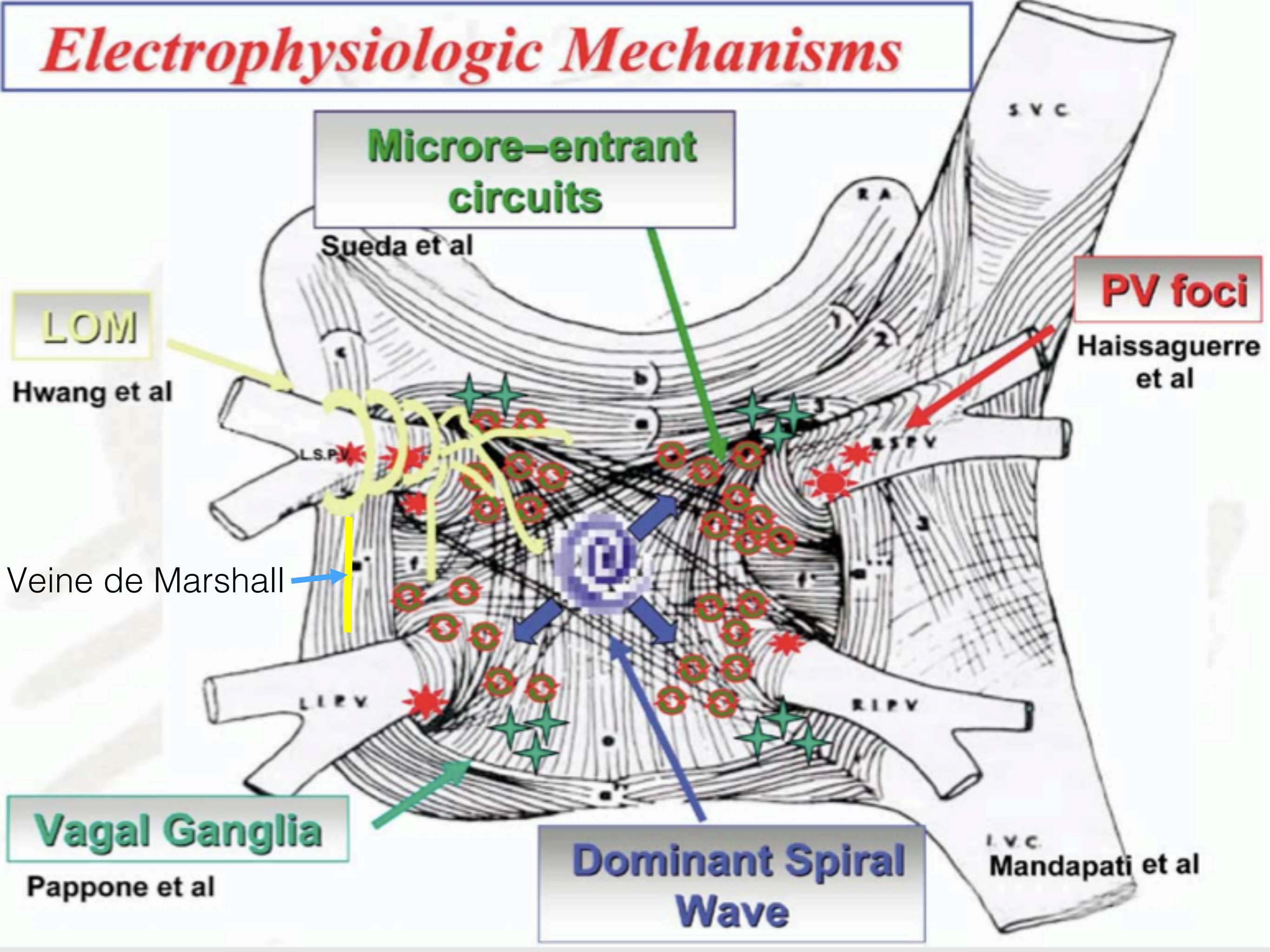
Echec ou absence de  
stratégie de contrôle  
du rythme

Remodelage atrial  
Fibrose

**Triggers  
des Veines Pulmonaires**

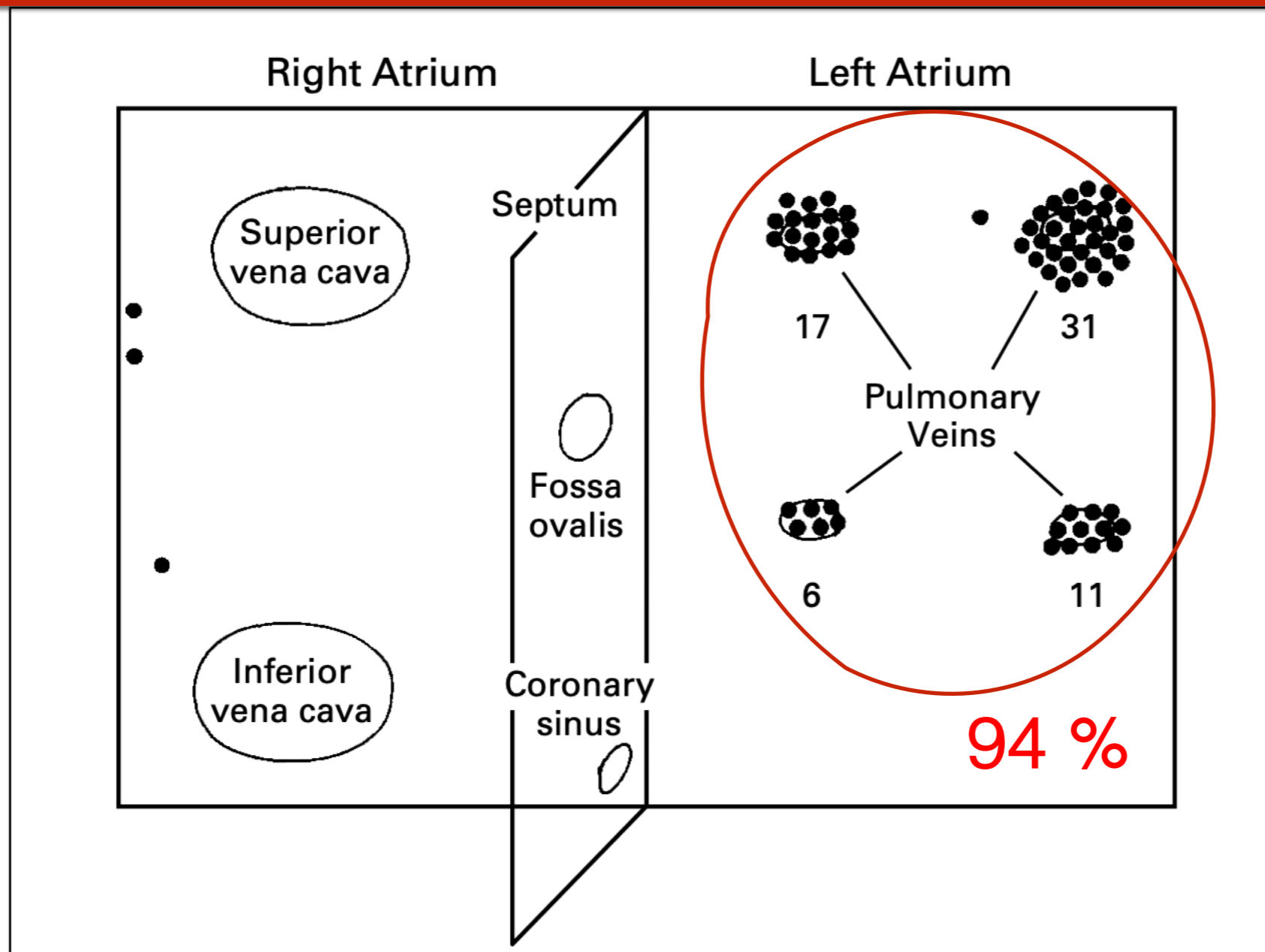
**Triggers et substrat  
extra veineux**

# Electrophysiologic Mechanisms



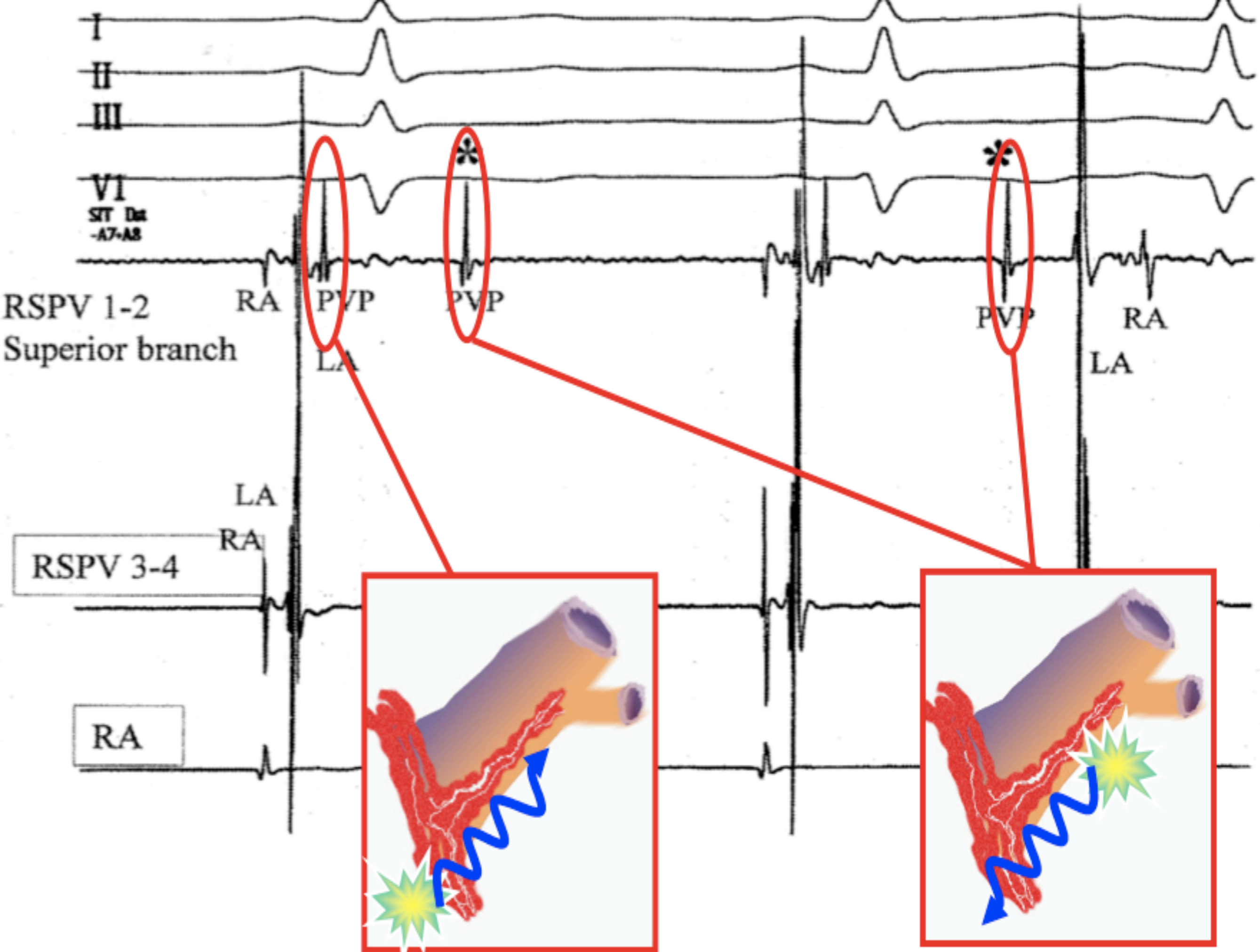
# SPONTANEOUS INITIATION OF ATRIAL FIBRILLATION BY ECTOPIC BEATS ORIGINATING IN THE PULMONARY VEINS

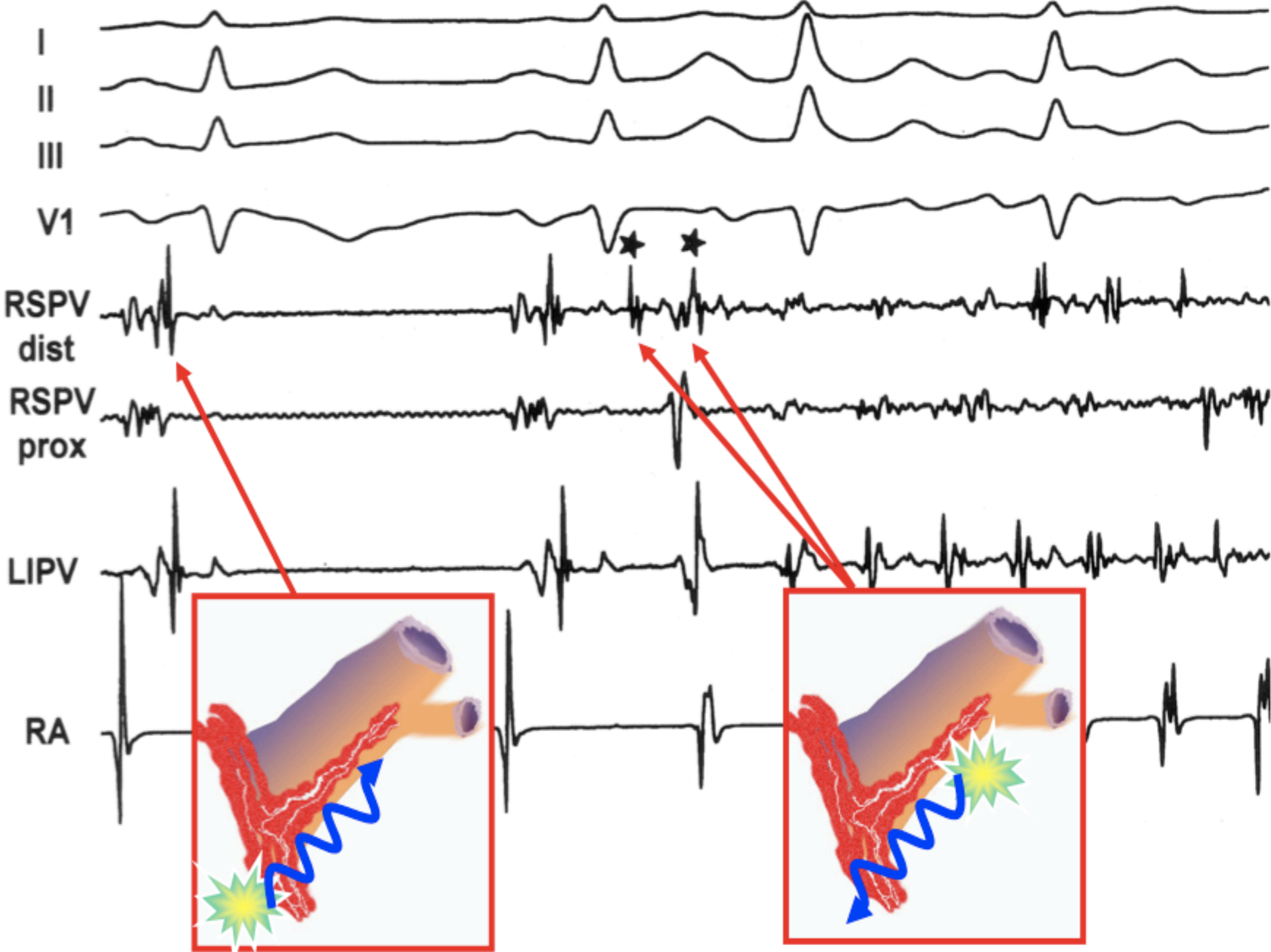
Haïssaguerre Nejm 1998

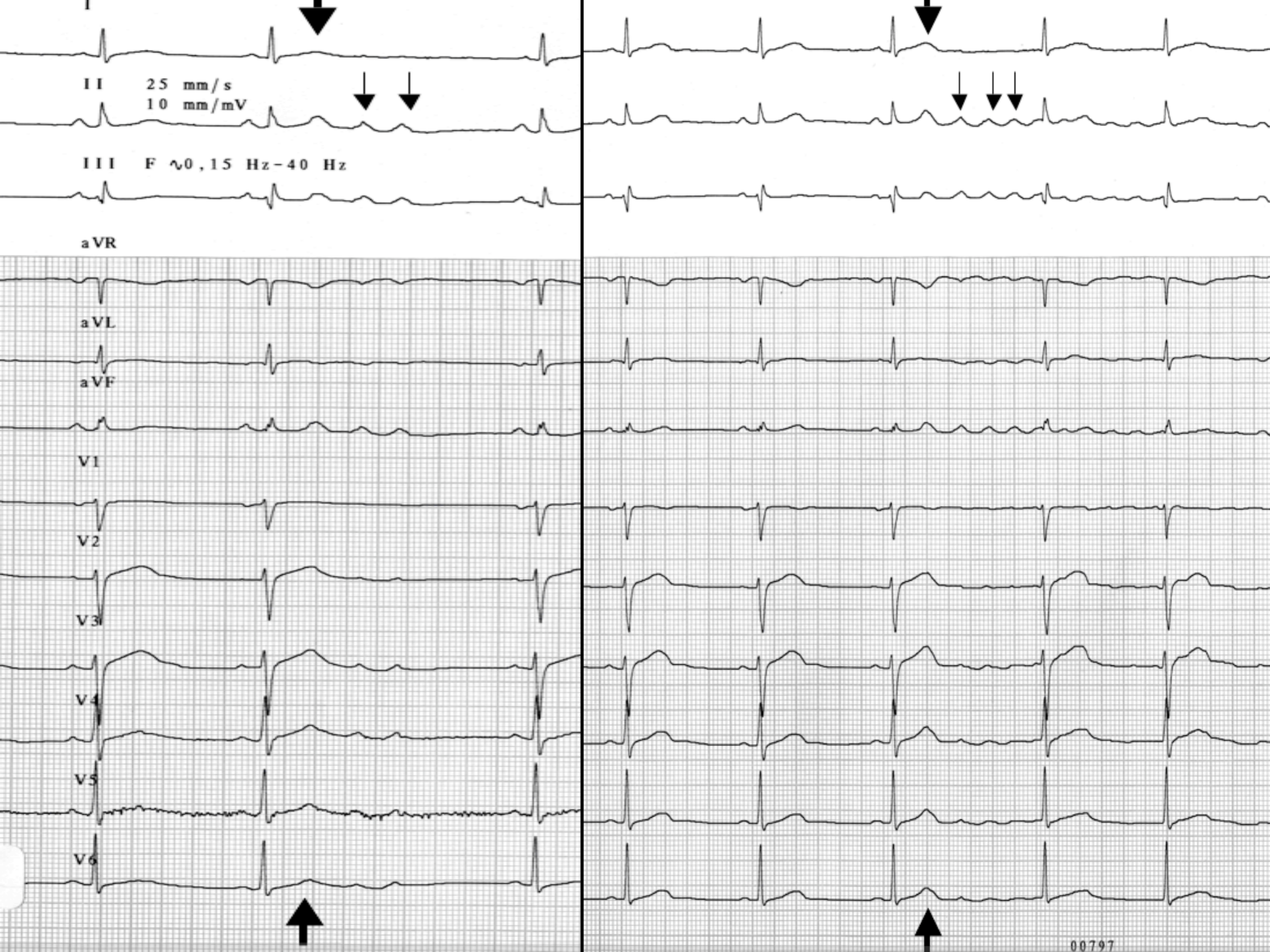


**Figure 1.** Diagram of the Sites of 69 Foci Triggering Atrial Fibrillation in 45 Patients.

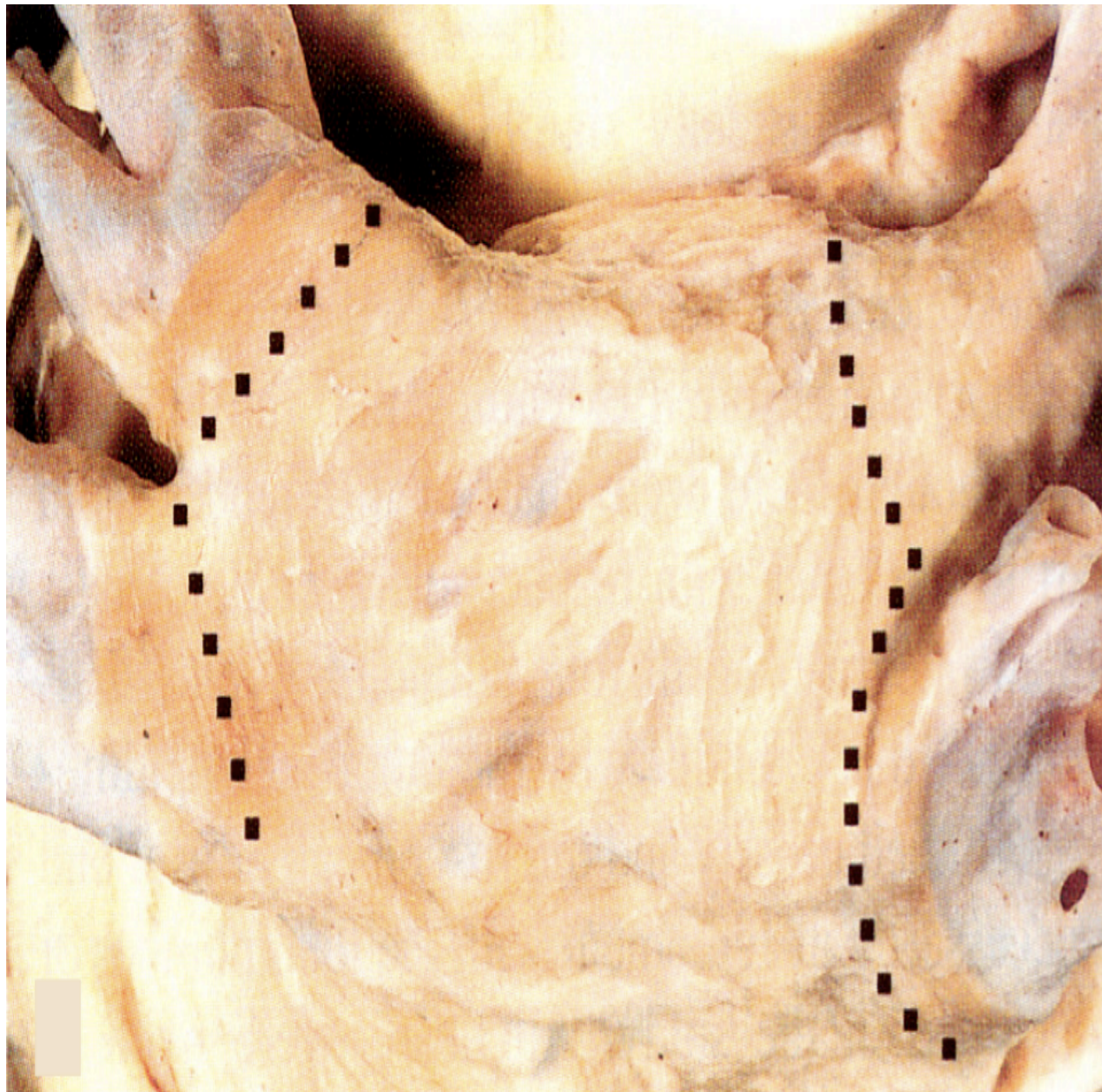
Note the clustering in the pulmonary veins, particularly in both superior pulmonary veins. Numbers indicate the distribution of foci in the pulmonary veins.







# Pourquoi les VP??



- La musculature des VP a des propriétés EP particulières (ectopie, PRE courte, anisotropie) chez les patients faisant de la FA, probablement en partie en lien avec son architecture complexe

Jaïs circ 2008



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

<b>C</b>	<b>Congestive heart failure</b> Clinical HF, or objective evidence of moderate to severe LV dysfunction, or HCM	1	Recent decompensated HF irrespective of LVEF (thus incorporating HFrEF or HFpEF), or the presence (even if asymptomatic) of moderate-severe LV systolic impairment on cardiac imaging <sup>335</sup> ; HCM confers a high stroke risk <sup>336</sup> and OAC is beneficial for stroke reduction. <sup>337</sup>
<b>H</b>	<b>Hypertension</b> or on antihypertensive therapy	1	History of hypertension may result in vascular changes that predispose to stroke, and a well-controlled BP today may not be well-controlled over time. <sup>324</sup> Uncontrolled BP - the optimal BP target associated with the lowest risk of ischaemic stroke, death, and other cardiovascular outcomes is 120 - 129/<80 mmHg. <sup>338</sup>
<b>A</b>	<b>Age 75 years or older</b>	2	Age is a powerful driver of stroke risk, and most population cohorts show that the risk rises from age 65 years upwards. <sup>339</sup> Age-related risk is a continuum, but for reasons of simplicity and practicality, 1 point is given for age 65 - 74 years and 2 points for age $\geq 75$ years.
<b>D</b>	<b>Diabetes mellitus</b> Treatment with oral hypoglycaemic drugs and/or insulin or fasting blood glucose >125 mg/dL (7 mmol/L)	1	Diabetes mellitus is a well-established risk factor for stroke, and more recently stroke risk has been related to duration of diabetes mellitus (the longer the duration of diabetes mellitus, the higher the risk of thromboembolism <sup>340</sup> ) and presence of diabetic target organ damage, e.g. retinopathy. <sup>341</sup> Both type 1 and type 2 diabetes mellitus confer broadly similar thromboembolic risk in AF, although the risk may be slightly higher in patients aged <65 years with type 2 diabetes mellitus compared to patients with type 1 diabetes mellitus. <sup>342</sup>
<b>S</b>	<b>Stroke</b> Previous stroke, TIA, or thromboembolism	2	Previous stroke, systemic embolism, or TIA confers a particularly high risk of ischaemic stroke, hence weighted 2 points. Although excluded from RCTs, AF patients with ICH (including haemorrhagic stroke) are at very high risk of subsequent ischaemic stroke, and recent observational studies suggest that such patients would benefit from oral anticoagulation. <sup>343–345</sup>
<b>V</b>	<b>Vascular disease</b> Angiographically significant CAD, previous myocardial infarction, PAD, or aortic plaque	1	Vascular disease (PAD or myocardial infarction) confers a 17 - 22% excess risk, particularly in Asian patients. <sup>346–348</sup> Angiographically significant CAD is also an independent risk factor for ischaemic stroke among AF patients (adjusted incidence rate ratio 1.29, 95% CI 1.08 - 1.53). <sup>349</sup> Complex aortic plaque on the descending aorta, as an indicator of significant vascular disease, is also a strong predictor of ischaemic stroke. <sup>350</sup>
<b>A</b>	<b>Age 65 – 74 years</b>	1	See above. Recent data from Asia suggest that the risk of stroke may rise from age 50 - 55 years upwards and that a modified CHA <sub>2</sub> DS <sub>2</sub> -VASc score may be used in Asian patients. <sup>351,352</sup>
<b>Sc</b>	<b>Sex category (female)</b>	1	A stroke risk modifier rather than a risk factor. <sup>353</sup>

Risk factors and definitions		Points awarded
<b>H</b>	<b>Uncontrolled hypertension</b> SBP >160 mmHg	1
<b>A</b>	<b>Abnormal renal and/or hepatic function</b> Dialysis, transplant, serum creatinine >200 µmol/L, cirrhosis, bilirubin > × 2 upper limit of normal, AST/ALT/ALP >3 × upper limit of normal	1 point for each
<b>S</b>	<b>Stroke</b> Previous ischaemic or haemorrhagic <sup>a</sup> stroke	1
<b>B</b>	<b>Bleeding history or predisposition</b> Previous major haemorrhage or anaemia or severe thrombocytopenia	1
<b>L</b>	<b>Labile INR<sup>b</sup></b> TTR <60% in patient receiving VKA	1
<b>E</b>	<b>Elderly</b> Aged >65 years or extreme frailty	1
<b>D</b>	<b>Drugs or excessive alcohol drinking</b> Concomitant use of antiplatelet or NSAID; and/or excessive <sup>c</sup> alcohol per week	1 point for each
<b>Maximum score</b>		<b>9</b>

Patient with Atrial Fibrillation; Eligible for Oral Anticoagulation

AF patients with prosthetic mechanical heart valves or moderate-severe mitral stenosis?

No

**Step 1** Identify low-risk patients

**Low stroke risk?**

(CHA<sub>2</sub>DS<sub>2</sub>-VASc score: 0 in males 1 in females)

No

**Step 2**

Consider stroke prevention (ie. OAC) in all AF patients with  
CHA<sub>2</sub>DS<sub>2</sub>-VASc ≥1 (male) or ≥2 (female)

**Address modifiable bleeding risk factors in all AF patients.**

**Calculate the HAS-BLED score.**

If HAS-BLED ≥3, address the modifiable bleeding risk factors  
and 'flag up' patient for regular review and follow-up.

High bleeding risk scores should not be used  
as a reason to withhold OAC.

CHA<sub>2</sub>DS<sub>2</sub>-VASc

=1 (male) or =2 (female)

≥2 (male) or ≥3 (female)

OAC should be considered  
(Class IIa)

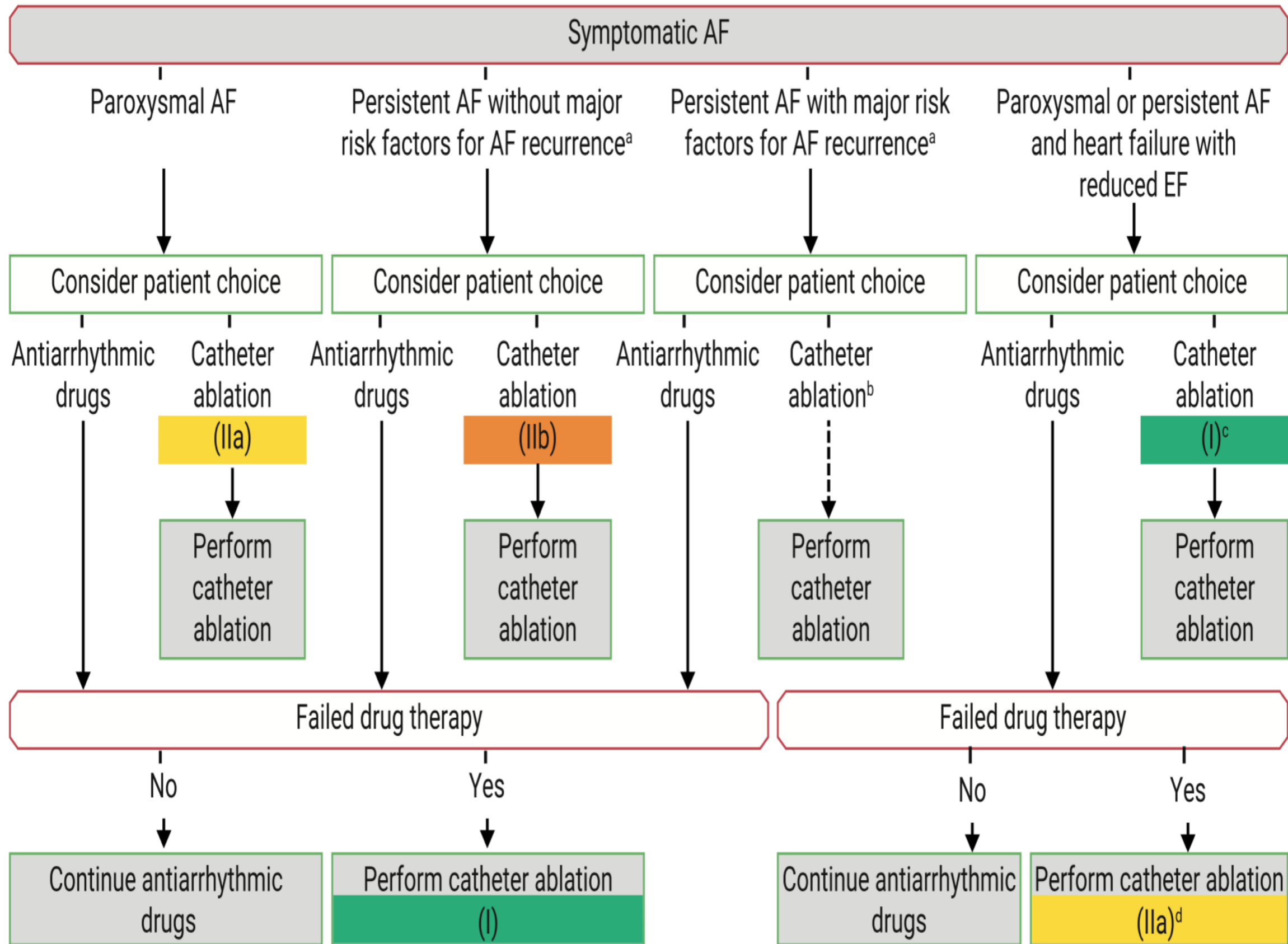
OAC is recommended  
(Class IA)

**Step 3** Begin NOAC (or VKA with high time  
in therapeutic range<sup>a</sup>)  
NOACs generally recommended  
as first line therapy for OAC

Yes

**VKA with high time in  
therapeutic range**  
(target INR range depends  
on type of  
valve lesion or prosthesis)

No antithrombotic  
treatment



a : age, taille OG, Fa ancienne, IRC, FR cv

# Catheter Ablation for Atrial Fibrillation with Heart Failure

## Castle AF

Nejm fev 2018

Etude randomisée multicentrique

- FA parox ou persistante
  - NYHA 2-4
  - FEVG <35%
  - DAI +/-CRT
- 
- Critères primaire : décès aggravation IC

R  
1:1

Ablation (179p)

- PVI +/- complément

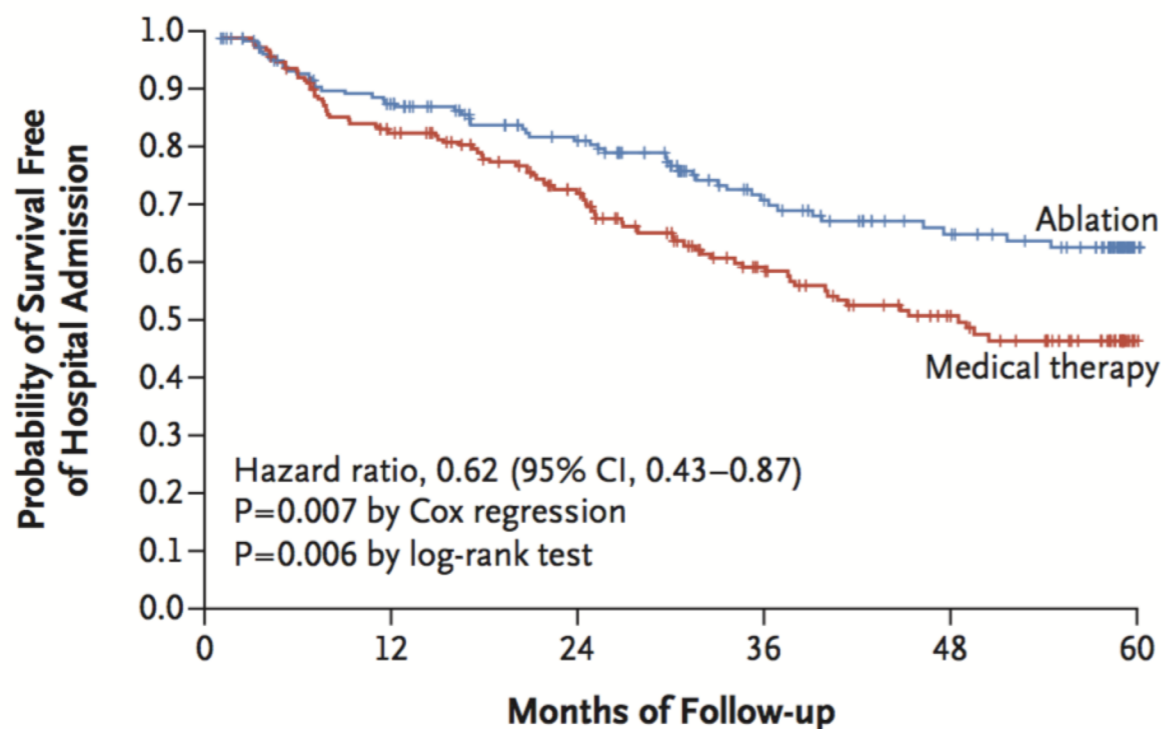
Médical (184p)

- Tentative de maintien RS
- Contrôle de fréquence
  - 60-80/min repos
  - 90-115/min effort

**Table 2. Primary and Secondary Clinical End Points.\***

End Point	Ablation (N = 179)	Medical Therapy (N = 184)	Hazard Ratio (95% CI)	P Value	
				Cox Regression	Log-Rank Test
	<i>number (percent)</i>				
Primary†	51 (28.5)	82 (44.6)	0.62 (0.43–0.87)	0.007	0.006
Secondary					
Death from any cause	24 (13.4)	46 (25.0)	0.53 (0.32–0.86)	0.01	0.009
Heart-failure hospitalization	37 (20.7)	66 (35.9)	0.56 (0.37–0.83)	0.004	0.004
Cardiovascular death	20 (11.2)	41 (22.3)	0.49 (0.29–0.84)	0.009	0.008
Cardiovascular hospitalization	64 (35.8)	89 (48.4)	0.72 (0.52–0.99)	0.04	0.04
Hospitalization for any cause	114 (63.7)	122 (66.3)	0.99 (0.77–1.28)	0.96	0.96
Cerebrovascular accident	5 (2.8)	11 (6.0)	0.46 (0.16–1.33)	0.15	0.14

**A Death or Hospitalization for Worsening Heart Failure**



**No. at Risk**

Ablation	179	141	114	76	58	22
Medical therapy	184	145	111	70	48	12

- Diminution de 38% du critère primaire
- 8 patients à traiter pour éviter un évènement
- NB: Entresto (PARADIGM-HF) 21 patients à traiter pour éviter un évènement !

# Résultats secondaires

- 64% des patients sont en rythme sinusal dans le groupe ablation vs 22 % ( $p < 0,001$ ) à 60 mois
- Amélioration de 8% de la FEVG dans le groupe ablation vs 0 ( $p = 0,005$ ) remodelage inverse de la FEVG
- Test de marche de 6 minutes augmentation de 53m vs 7m

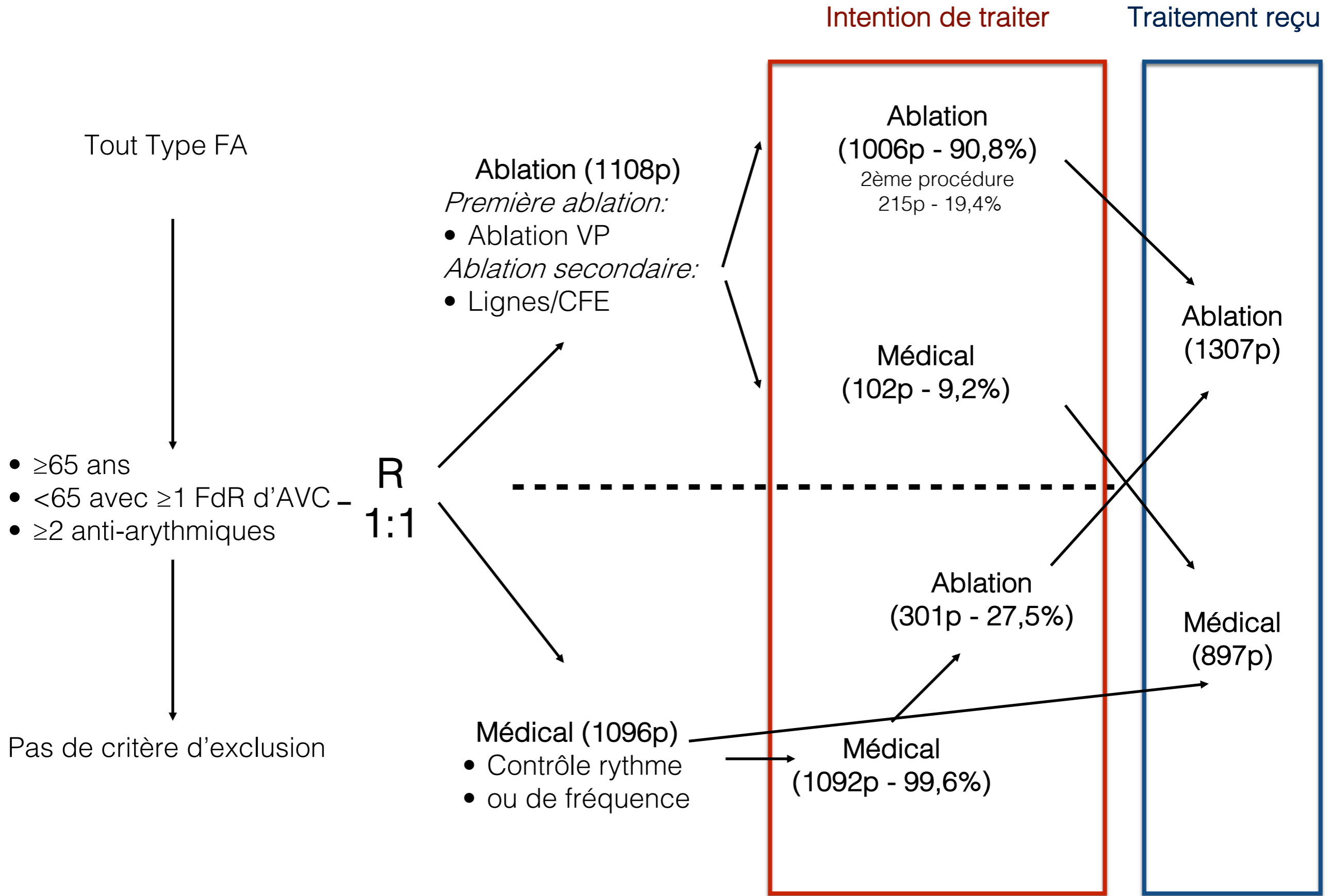


# Effect of Catheter Ablation vs Antiarrhythmic Drug Therapy on Mortality, Stroke, Bleeding, and Cardiac Arrest Among Patients With Atrial Fibrillation

## The CABANA Randomized Clinical Trial

Jama avril 2019

- Etude randomisée multicentrique comparative de l'ablation vs traitement médical optimisé pour nouvelle FA/ancienne FA « sous traité »
- Critère primaire composite : mortalité toute cause, AVC, saignement grave, mort subite
- Critère secondaire majeur :
  - mortalité toute cause
  - mtt ou hospitalisation CV

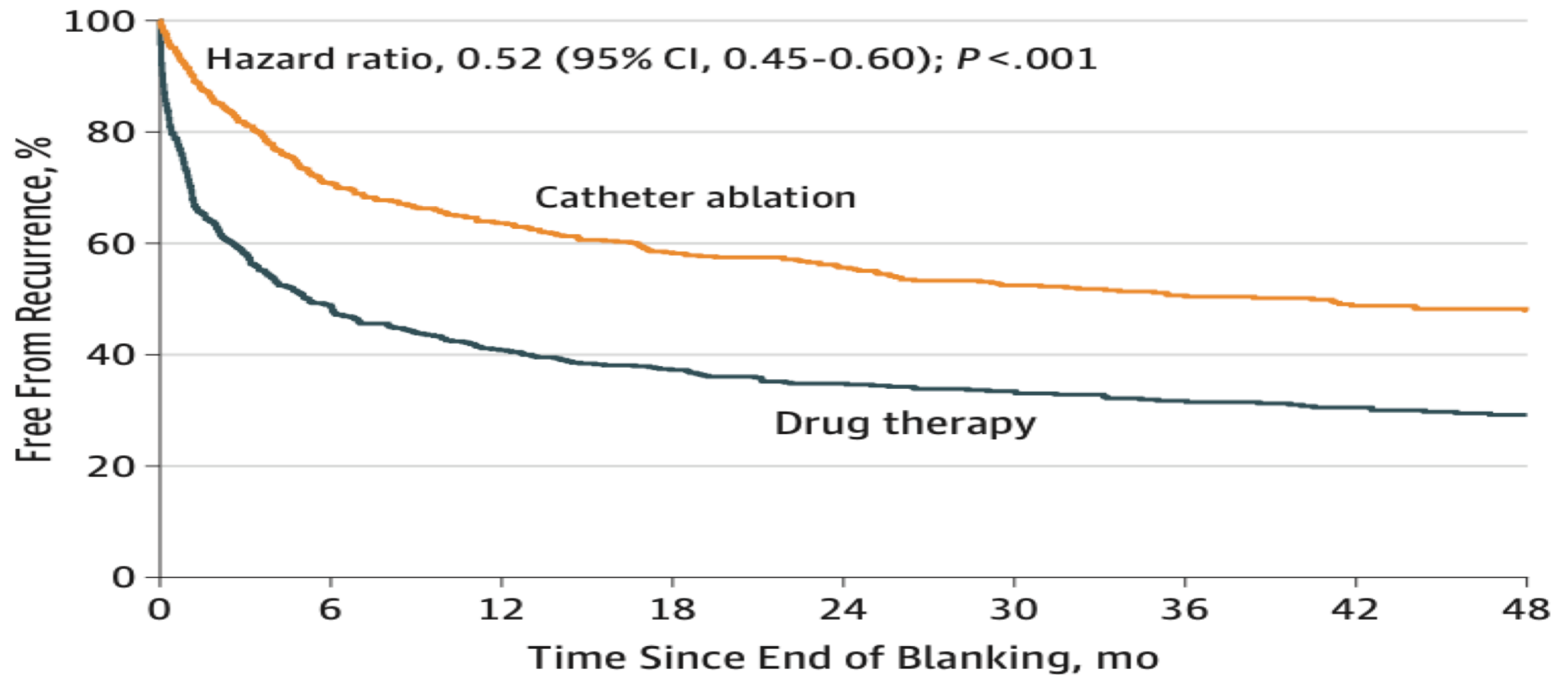




# Primary and Secondary Outcomes as Randomized (ITT)

	<b>Ablation N = 1108</b>	<b>Drug N = 1096</b>	<b>Hazard Ratio (95% CI)</b>	<b>P- Value</b>
<b><i>Primary Outcome</i></b>				
<b>Composite:</b>	<b>89 (8.0%)</b>	<b>101 (9.2%)</b>	<b>0.86 (0.65, 1.15)</b>	<b>0.30</b>
<b>Death</b>	<b>58 (5.2%)</b>	<b>67 (6.1%)</b>	<b>0.85 (0.60, 1.21)</b>	<b>0.38</b>
<b>Disabling stroke</b>	<b>3 (0.3%)</b>	<b>7 (0.6%)</b>	<b>0.42 (0.11, 1.62)</b>	<b>0.19</b>
<b>Serious bleeding</b>	<b>36 (3.2%)</b>	<b>36 (3.3%)</b>	<b>0.98 (0.62, 1.56)</b>	<b>0.93</b>
<b>Cardiac arrest</b>	<b>7 (0.6%)</b>	<b>11 (1.0%)</b>	<b>0.62 (0.24, 1.61)</b>	<b>0.33</b>
<b><i>Secondary Outcomes</i></b>				
<b>All-cause mortality</b>	<b>58 (5.2%)</b>	<b>67 (6.1%)</b>	<b>0.85 (0.60, 1.21)</b>	<b>0.38</b>
<b>Death or CV hospitalization</b>	<b>573 (51.7%)</b>	<b>637 (58.1%)</b>	<b>0.83 (0.74, 0.93)</b>	<b>0.001</b>

**Figure 6. Recurrent Atrial Fibrillation After Blanking by Intention-to-Treat Analysis**



No. at risk	0	6	12	18	24	30	36	42	48
Drug therapy	629	304	252	212	181	157	131	115	94
Catheter ablation	611	432	381	328	291	241	201	163	134

Freedom from recurrence of atrial fibrillation following the blanking period in 1240 patients who used the study electrocardiogram event recorders (intention-to-treat analysis with death as a competing risk). The median (25th, 75th percentiles) length of patient follow-up was 4.3 years (2.8, 5.0) in the catheter ablation group and 4.3 years (2.7, 5.3) in the drug therapy group.



# Primary and Secondary Outcomes (Treatment Received)\*

	<b>Ablation (N = 1307)</b>	<b>Drug (N = 897)</b>	<b>Hazard Ratio (95% CI)</b>	<b>P- Value</b>
<b>Primary Outcome</b>	<b>92 (7.0%)</b>	<b>98 (10.9%)</b>	<b>0.67 (0.50, 0.89)</b>	<b>0.006</b>
<b>Secondary Outcomes</b>				
<b>All-cause mortality</b>	<b>58 (4.4%)</b>	<b>67 (7.5%)</b>	<b>0.60 (0.42, 0.86)</b>	<b>0.005</b>
<b>Death or CV hospitalization</b>	<b>538 (41.2%)</b>	<b>672 (74.9%)</b>	<b>0.83 (0.74, 0.94)</b>	<b>0.002</b>

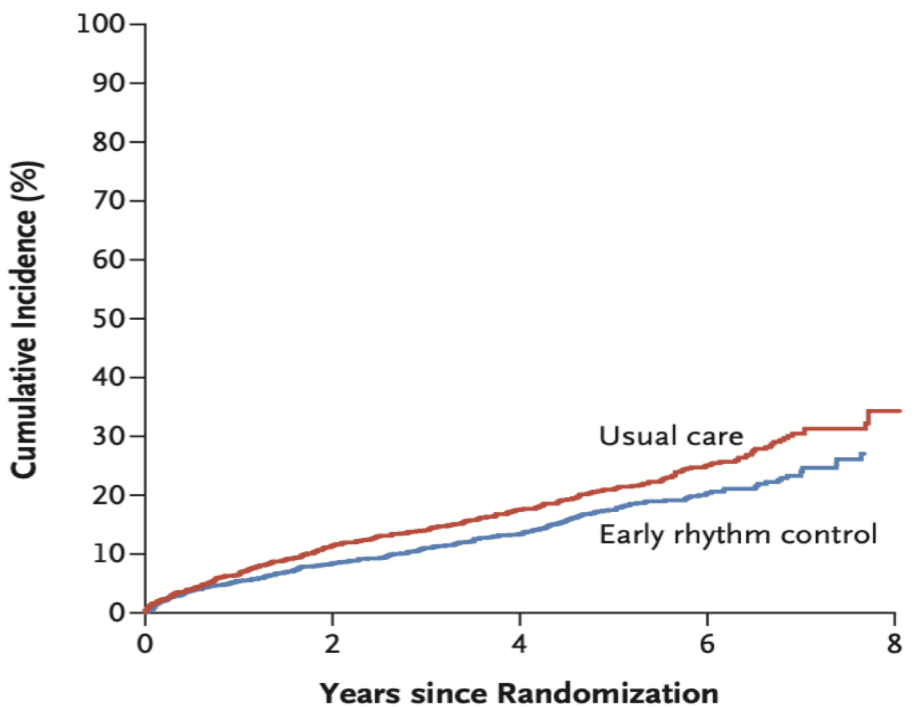
# Early Rhythm-Control Therapy in Patients with Atrial Fibrillation

## EAST AFNET 4

Nejm oct 2020

- 2789 patients FA précoce (moins d'un an, moyenne 36 jours) et plus de 75 ans ou atcd ait/avc ou 2 critères parmi plus de 65 ans, sexe F, IC, HTA, diabète, IRC, CMI sévère, HVG (septum sup 15mm)
- Randomisé en 2 groupes rhythm control (AA et/ou ablation) ou traitement usuel(!)
- Critère Primaire composite : décès cv, AVC, SCA, hospitalisation pour IC
- Arrêt à 5 ans de suivi car efficacité du rhythm control

- Supériorité du groupe rhythm control sur le critère primaire, sur décès cv, AVC, hospit CV



No. at Risk		0	2	4	6	8
Usual care		1394	1169	888	405	34
Early rhythm control		1395	1193	913	404	26

Outcome	Early Rhythm Control	Usual Care	Treatment Effect
First primary outcome — events/person-yr (incidence/100 person-yr)	249/6399 (3.9)	316/6332 (5.0)	0.79 (0.66 to 0.94) <sup>†</sup>
Components of first primary outcome — events/person-yr (incidence/100 person-yr)			
Death from cardiovascular causes	67/6915 (1.0)	94/6988 (1.3)	0.72 (0.52 to 0.98) <sup>‡</sup>
Stroke	40/6813 (0.6)	62/6856 (0.9)	0.65 (0.44 to 0.97) <sup>‡</sup>
Hospitalization with worsening of heart failure	139/6620 (2.1)	169/6558 (2.6)	0.81 (0.65 to 1.02) <sup>‡</sup>
Hospitalization with acute coronary syndrome	53/6762 (0.8)	65/6816 (1.0)	0.83 (0.58 to 1.19) <sup>‡</sup>
Second primary outcome — nights spent in hospital/yr	5.8±21.9	5.1±15.5	1.08 (0.92 to 1.28) <sup>§</sup>

# Technique d'ablation

## Techniques and technologies

Complete electrical isolation of the pulmonary veins is recommended during all AF catheter-ablation procedures. [235–237,239,606,608–610,613,614,678,679,681,683,684,686,713,731,759,780](#)

I

- FA Paroxystique (et Persistante!!)  
isolation électrique « large » des veines pulmonaires soit en cartographie 3D par ablation soit en cryoablation.
- Permet d'éliminer les foyers initiateurs des veines pulmonaires, dénervation para-sympathique cardiaque

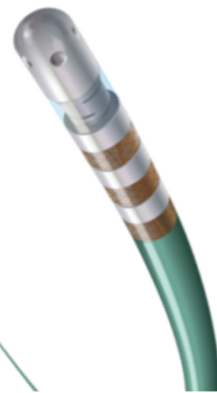


# Isolation électrique des VP par ablation (courant de radiofréquence) avec un Cathéter irriguée 4mm contact force

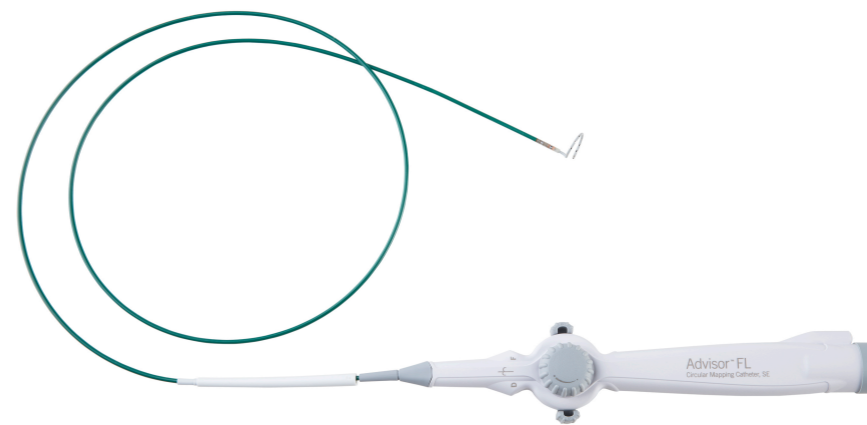
**FlexAbility™**  
Ablation Catheter, Sensor  
Enabled™



**TactiCath™**  
Ablation Catheter,  
Sensor Enabled™



**Advisor™ FL**  
Circular Mapping Catheter,  
Sensor Enabled™



**PRECISION SPRING**

Allow small amount of electrode deflection



**TRANSMITTER**

Coil in the tip sends location reference information

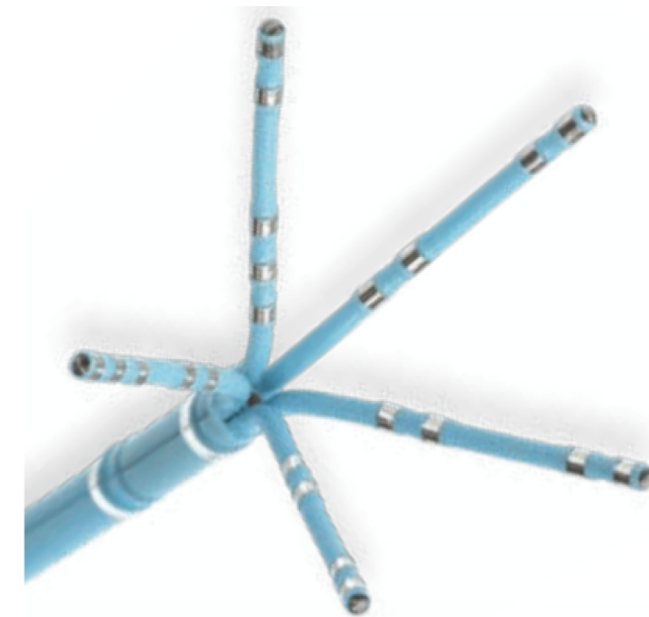
**SENSORS**

Monitor the transmitter coil and record the micro-movements of the spring

**INTEGRATED** with  
CARTO SMARTTOUCH™  
Software Module

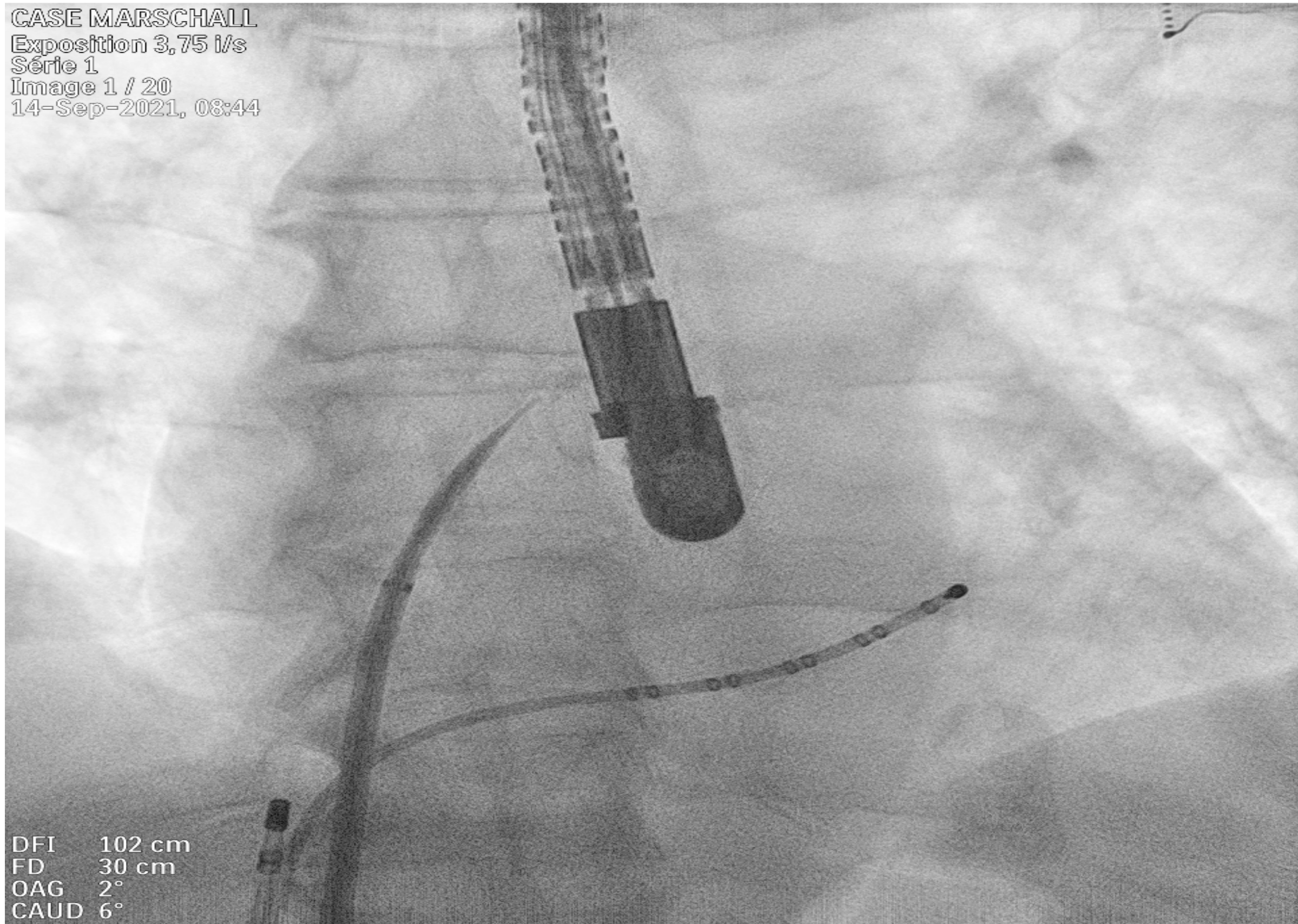
**POROUS TIP**

Efficient cooling with ½ the flow rate of THERMOCOOL SMARTTOUCH® Catheter



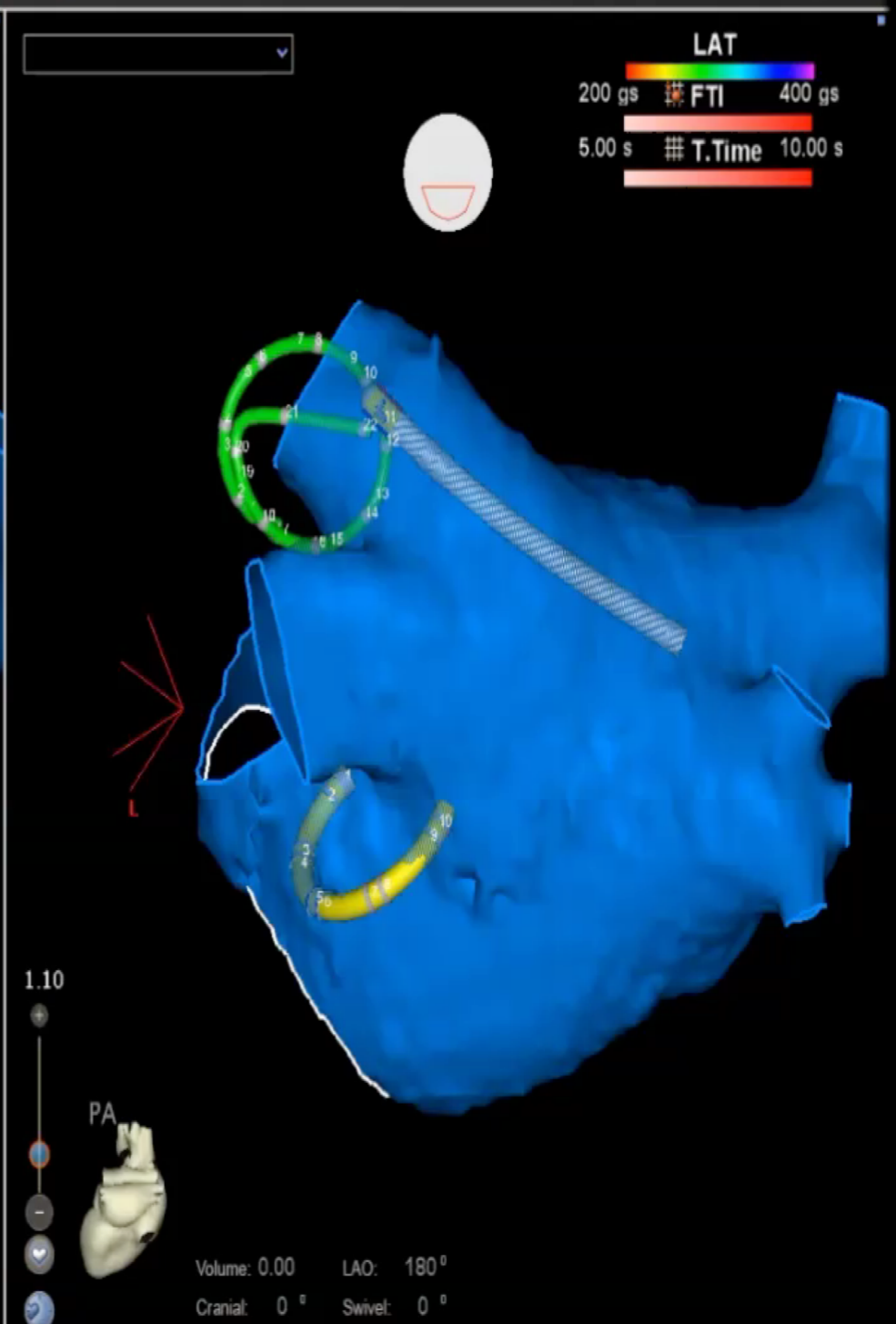
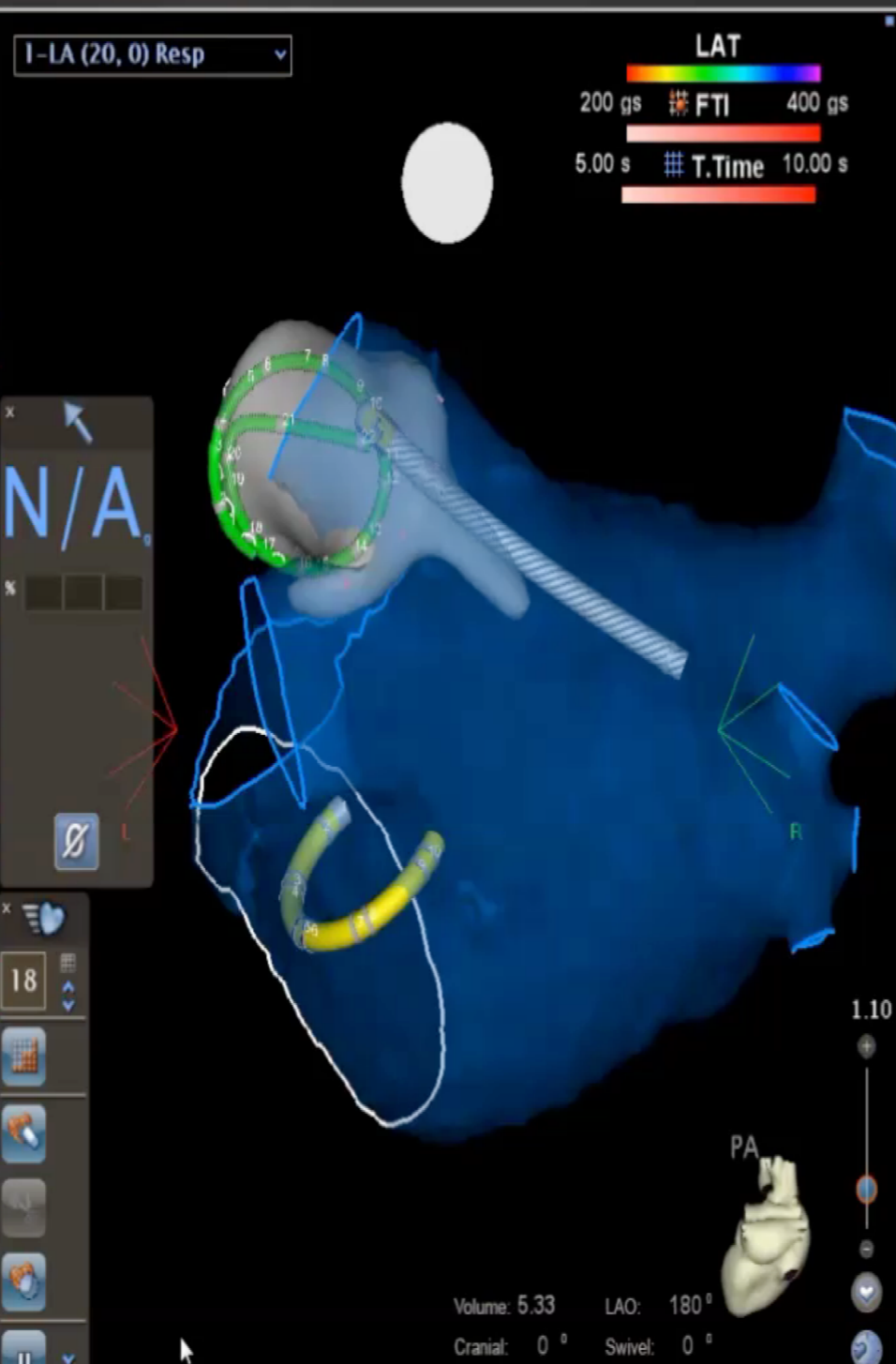
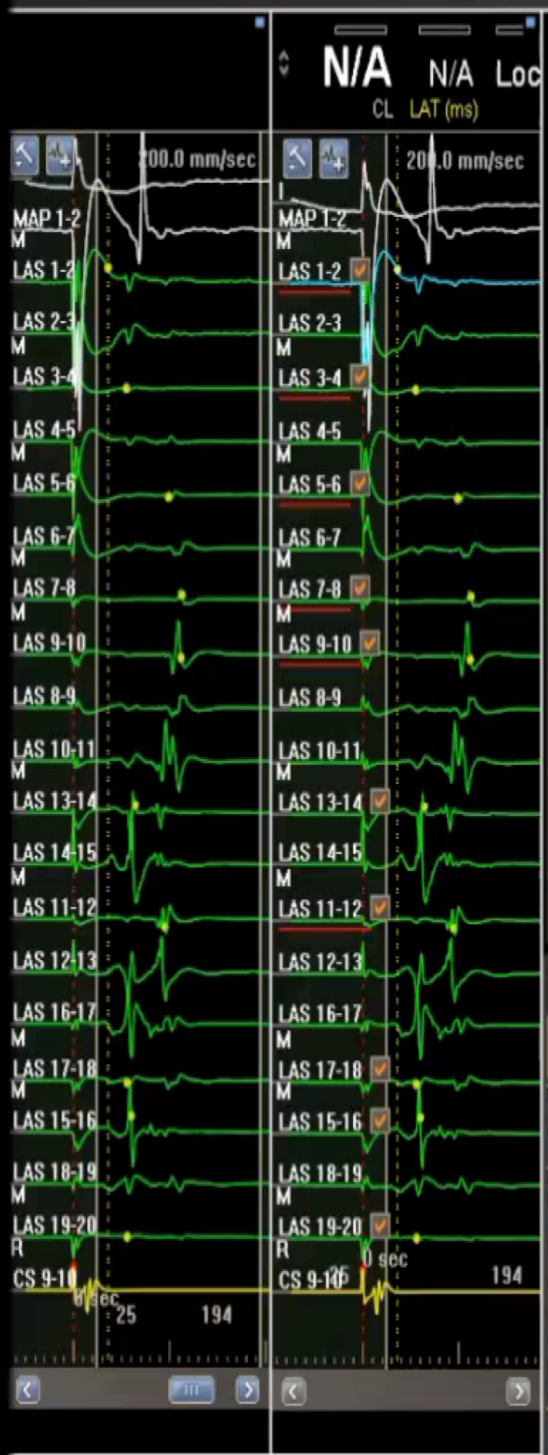
CASE MARSCHALL  
Exposition 3,75 i/s  
Série 1  
Image 1 / 20  
14-Sep-2021, 08:44

DFI 102 cm  
FD 30 cm  
OAG 2°  
CAUD 6°



Setup Mapping Ablation Verification IS Routed channel: None

MAP 1-2 OS 1-2 Q-A1-2 None



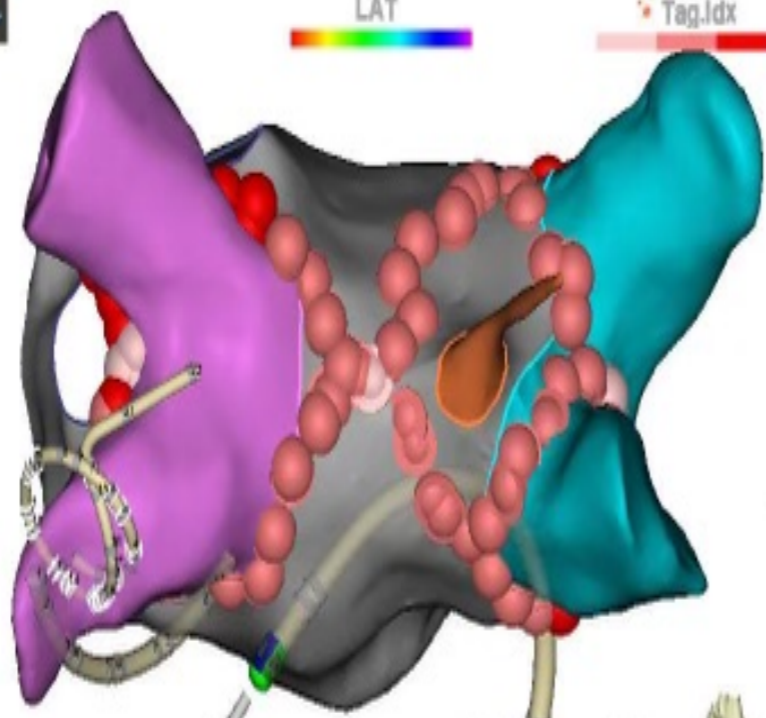
#	LAT	Elect.	Frc	PASO
021	36	LAS 1-2	N/A	
022	55	LAS 2-3	N/A	
028	60	LAS 15-16	N/A	
029	56	LAS 17-18	N/A	
030	55	LAS 19-20	N/A	



1-1-1-Re\_ (11, 0) Resp

LAT

Tag.Idx



Volume: 132.41  
Cranial: 38°

LAO: 178°  
Swivel: 5°

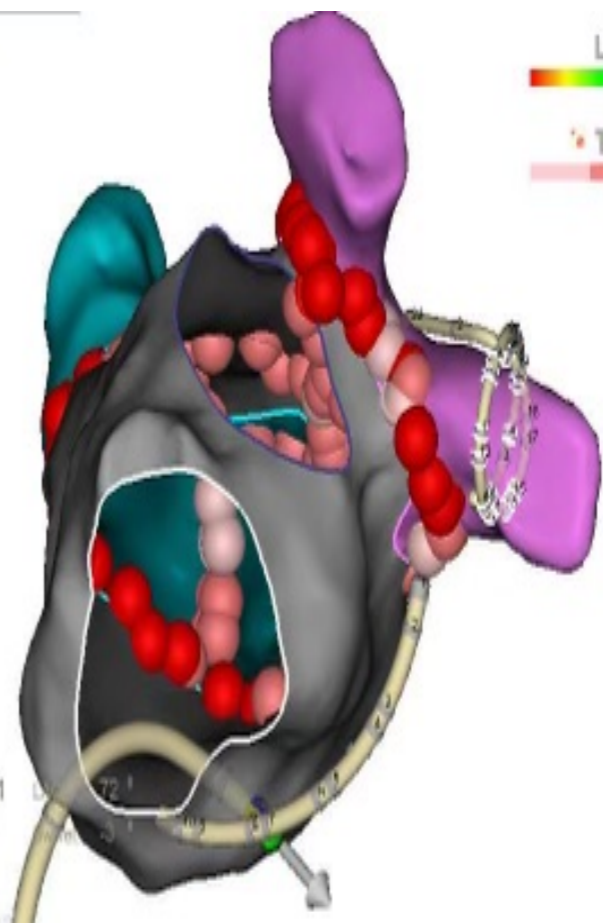


AP PA LAO RAO LL RL BP BUP

1-1-1-Re\_ (11, 0) Resp

LAT

Tag.Idx



Volume: 132.41  
Caudal: 1°

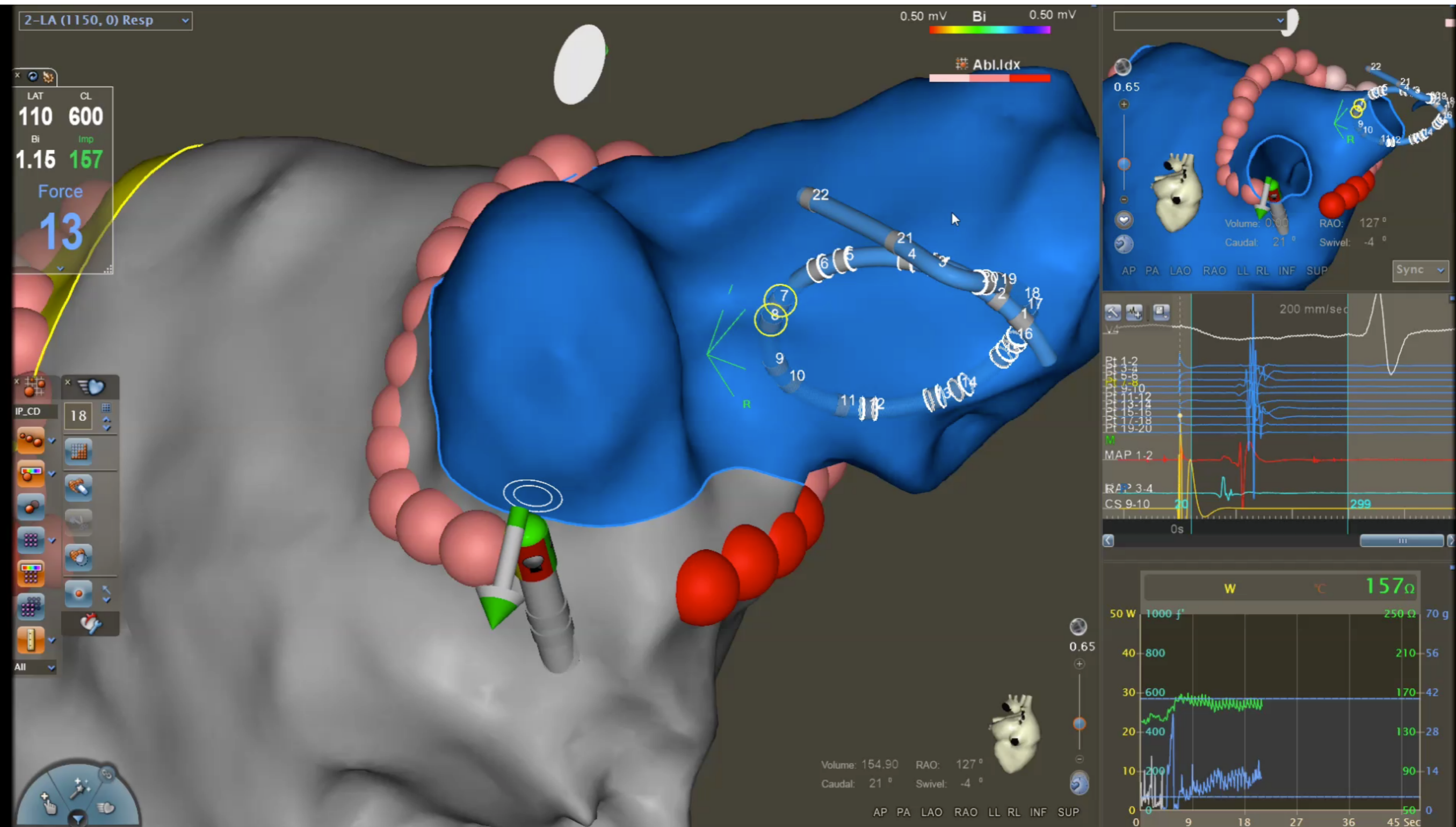


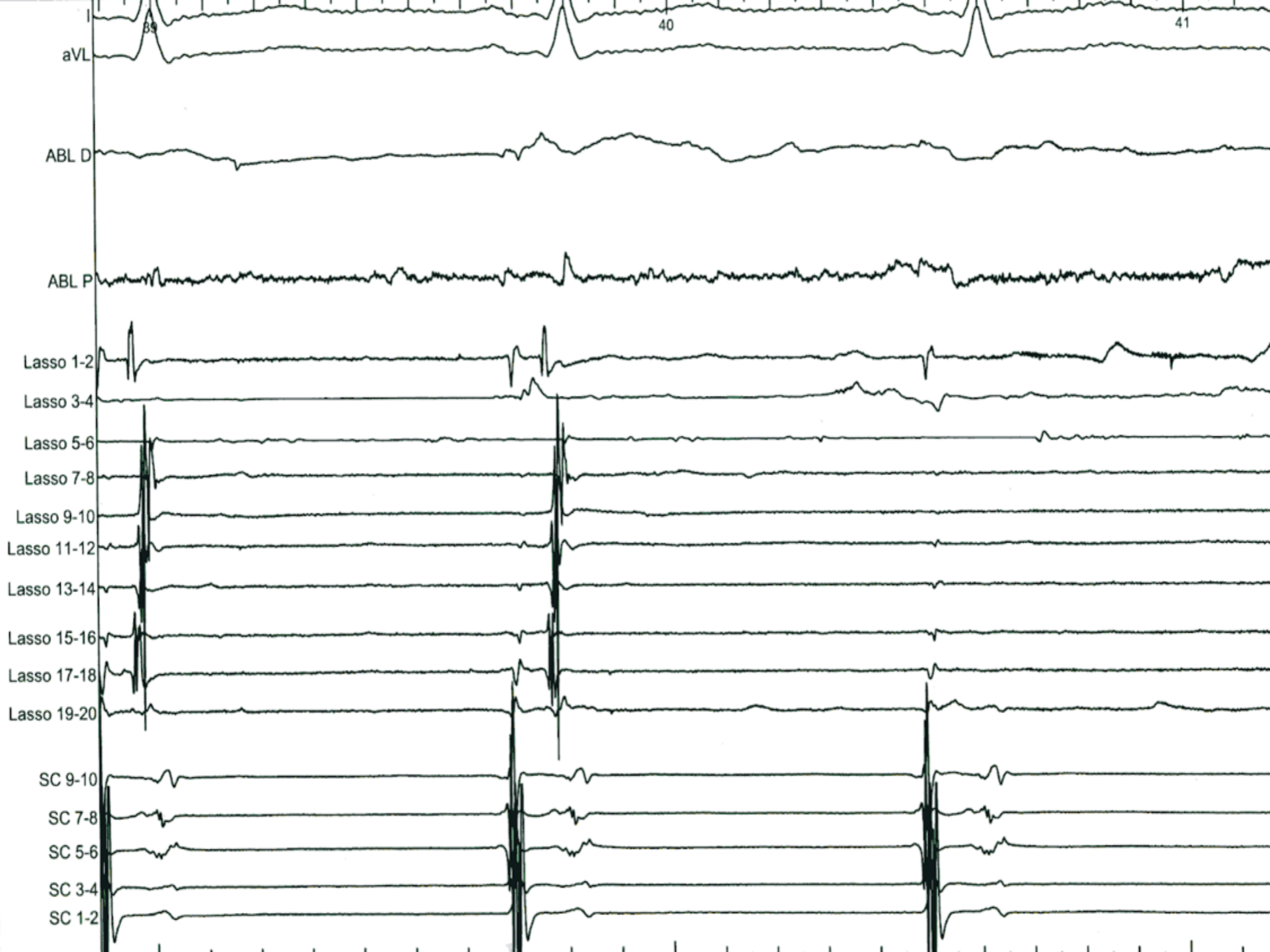
AP PA LAO RAO LL RL BP BUP

None



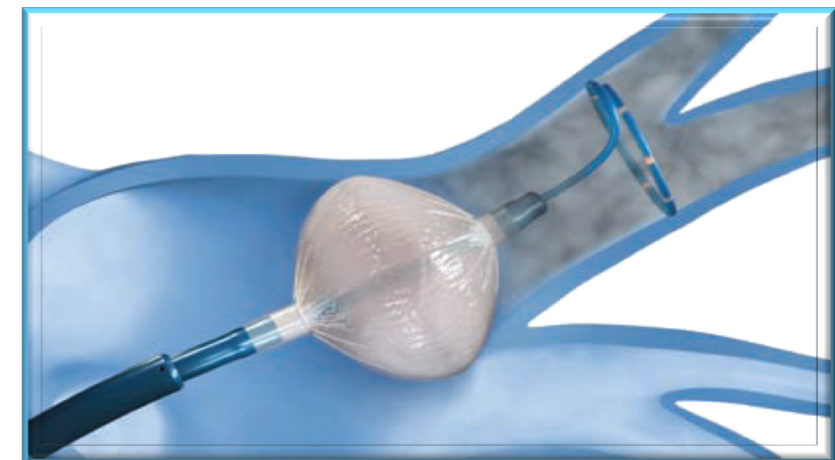
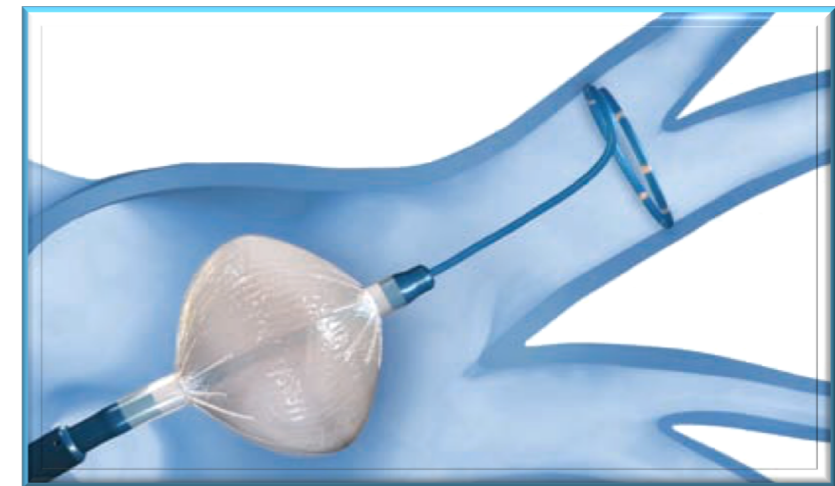
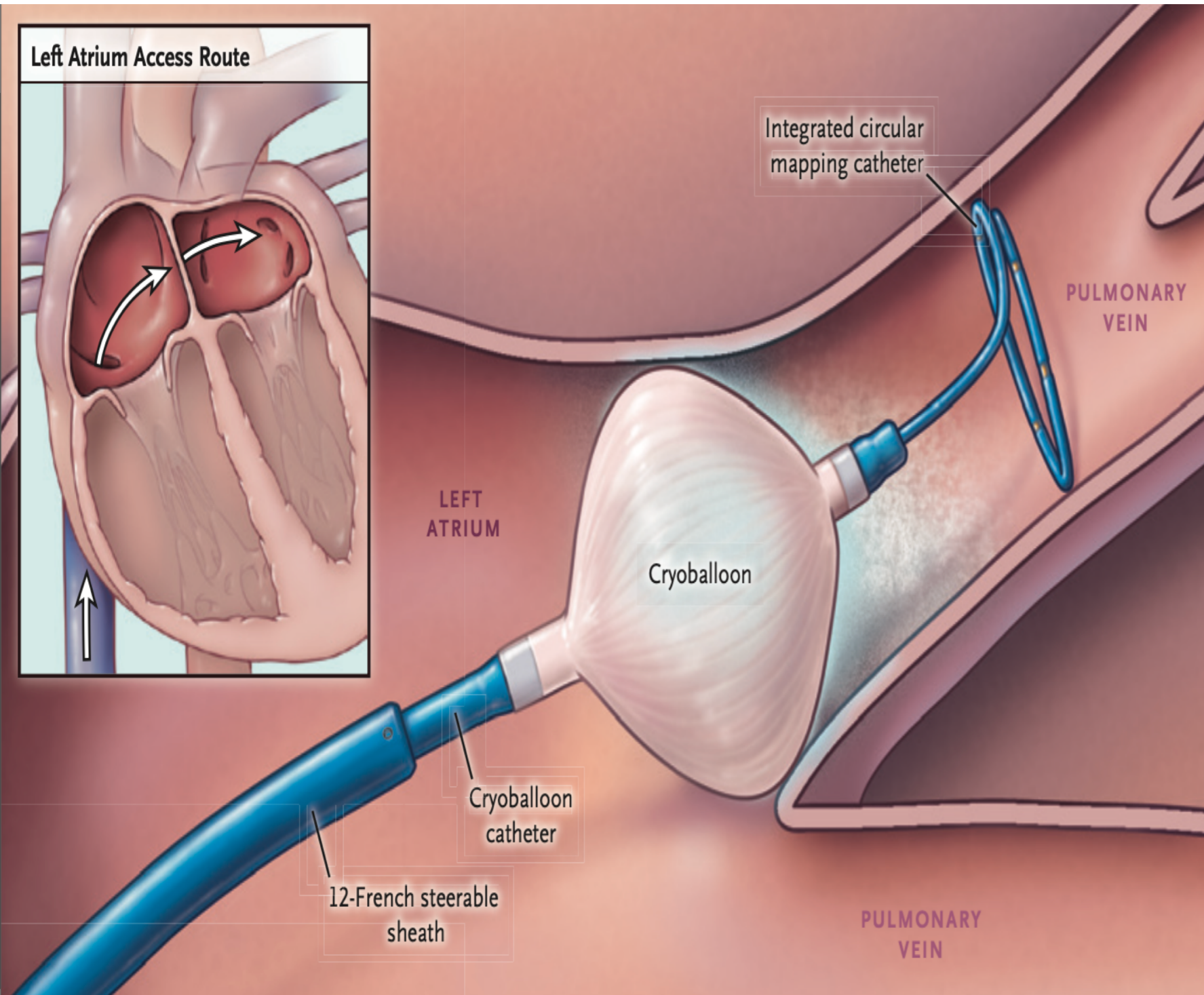
# Isolation anatomique large des VP







# Isolation VP par Cryoablation

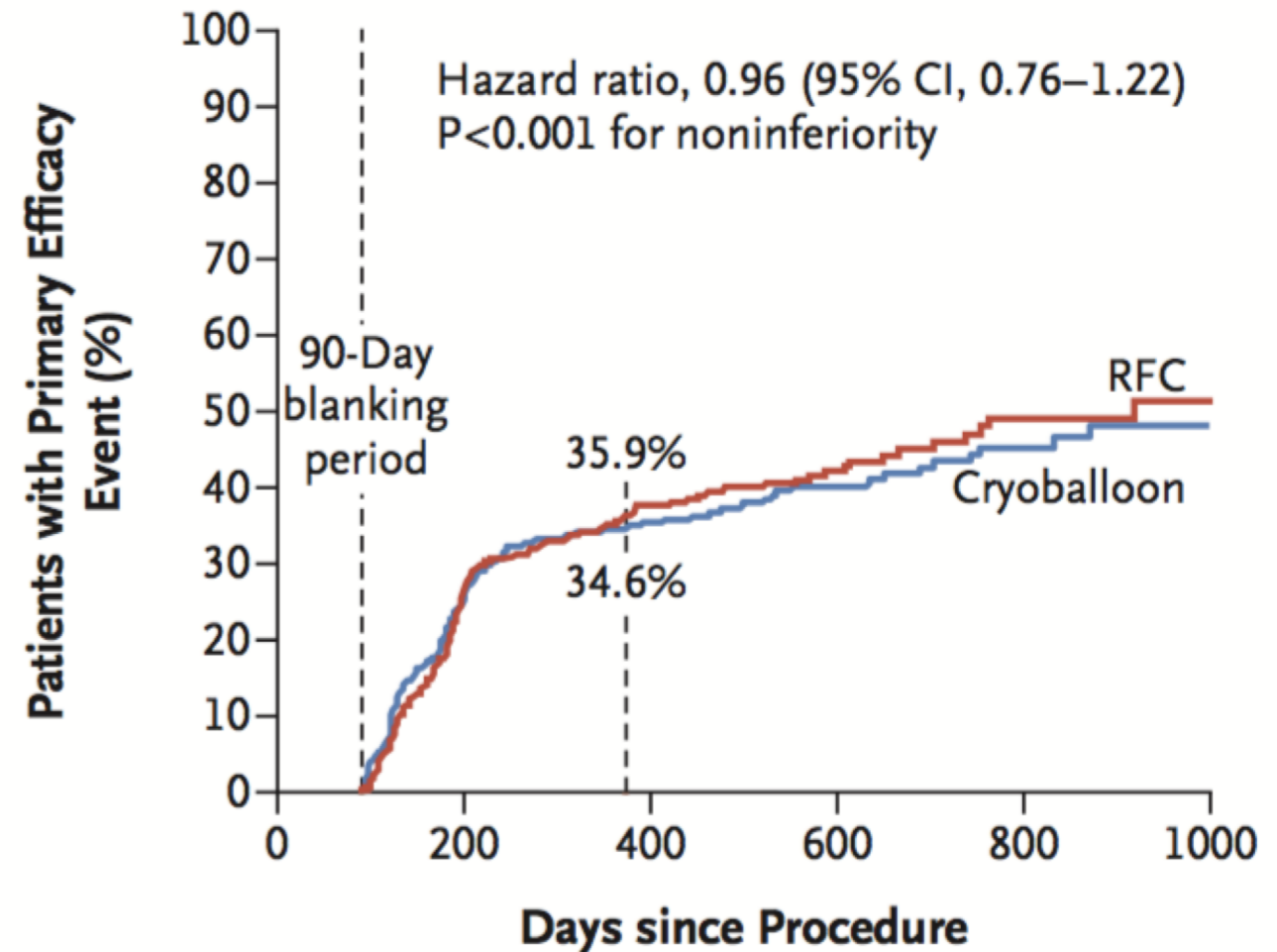




# Cryoballoon or Radiofréquence ablation for paroxysmal AF (Fire and Ice Study)

Kuck Nejm 2016

1. Etude randomisée de non infériorité Isolation VP pour FA paroxystique Cryo vs RF
2. Inclusion de 762 patients (378 Cryo et 384 RF)
3. Critère de jugement principal :
  - Recidive FA, Flutter, TA
  - Prescription anti arythmique
  - Nouvelle ablation
4. Tx de complication idem

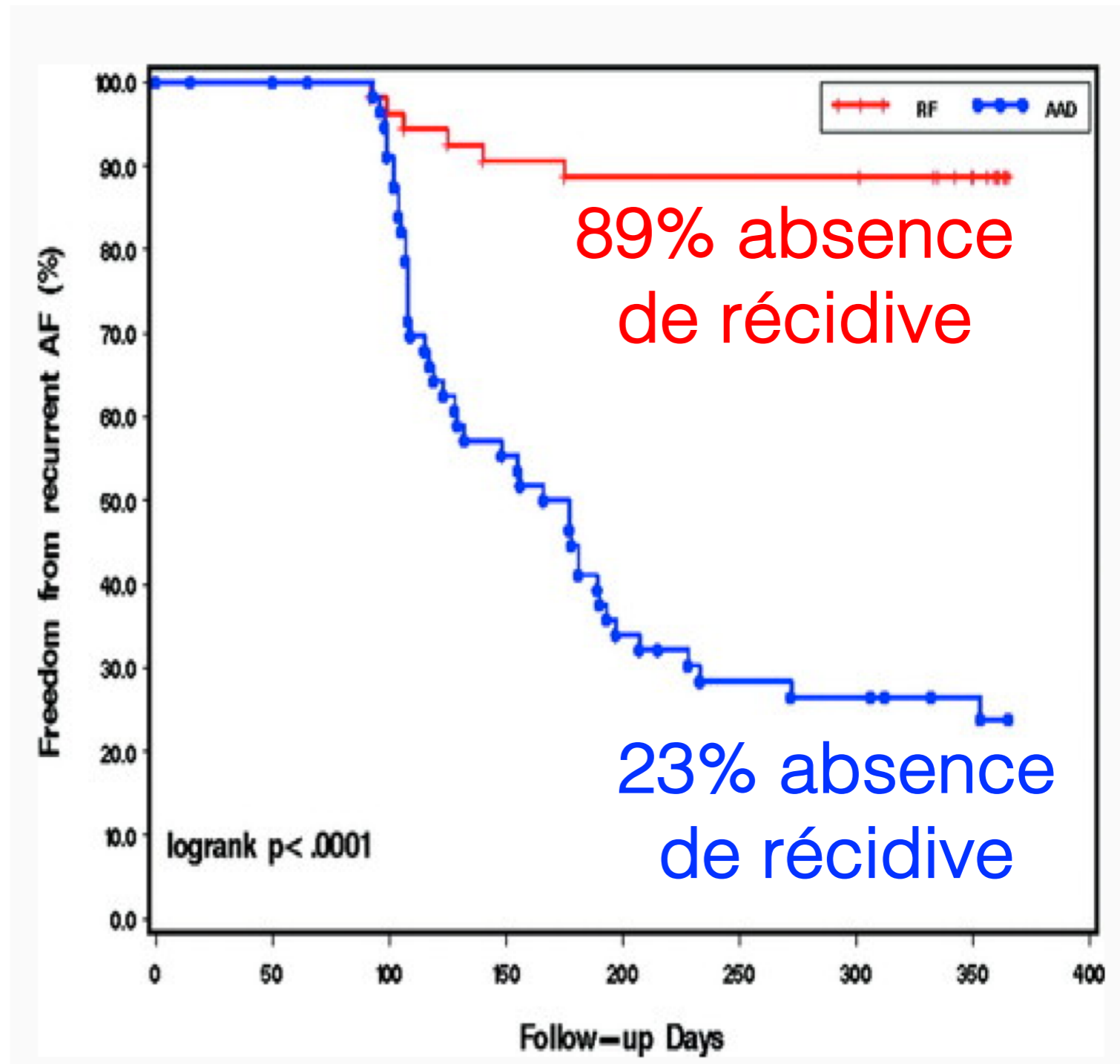


# Cathéter Ablation versus Antiarrhythmic drugs for AF

## A4 study

Jaïs Circ 2008

- Etude randomisée 112 pts ablation (53) vs AA (59)
- FA parox résistante à 1 AAR PVI +/- autres foyers
- Une ou 2 procédures d'ablation

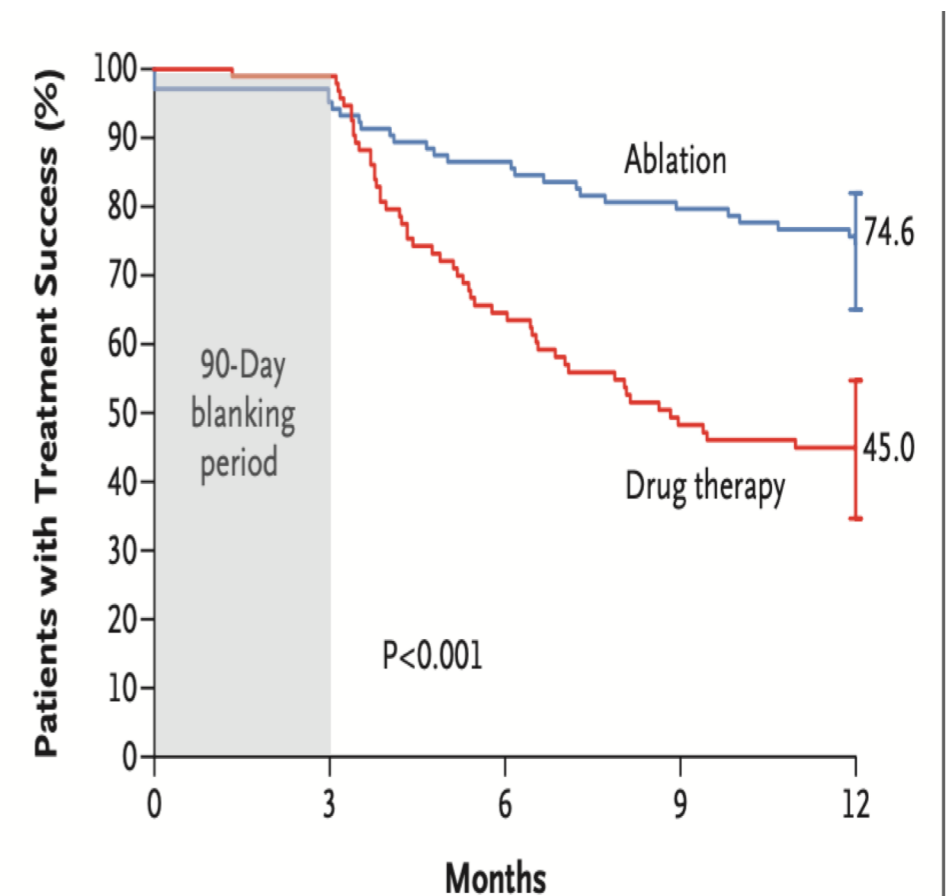


# Cryoablation as initial therapy for AF

Stop AF trial

Nejm janvier 2021

- Etude prospective randomisée cryoablation FA (104 pts) vs traitement antiarythmique (99pts)
- Meilleure efficacité de l'ablation
- Taux de complications idem



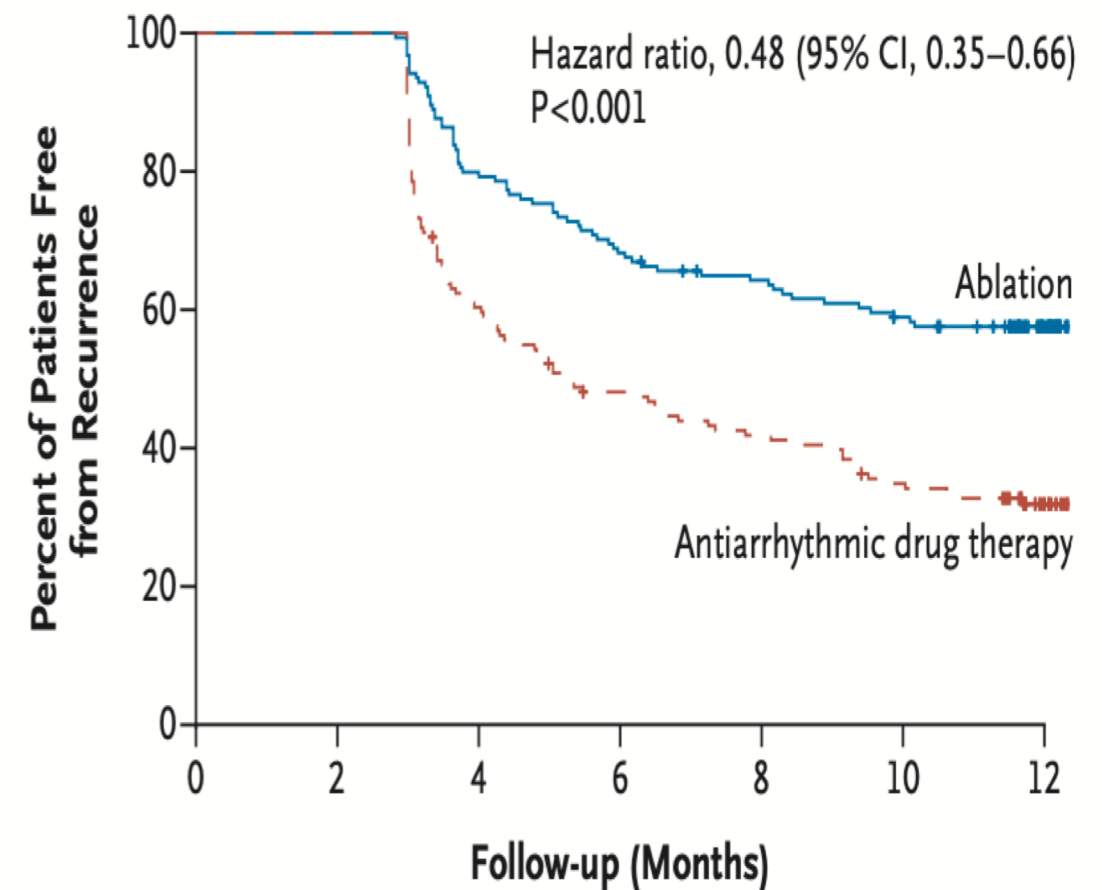
No. at Risk	0	3	6	9	12
Ablation	104	99	88	81	70
Drug therapy	99	93	60	44	39

# Cryoablation or drug Therapy for initial treatment of AF

## EARLY AF

Nejm janv 2021

- Etude prospective randomisée cryoablation FA (154 pts) vs traitement antiarythmique (143pts)
- Holter sous cutané
- Meilleure efficacité de l'ablation
- Complications idem



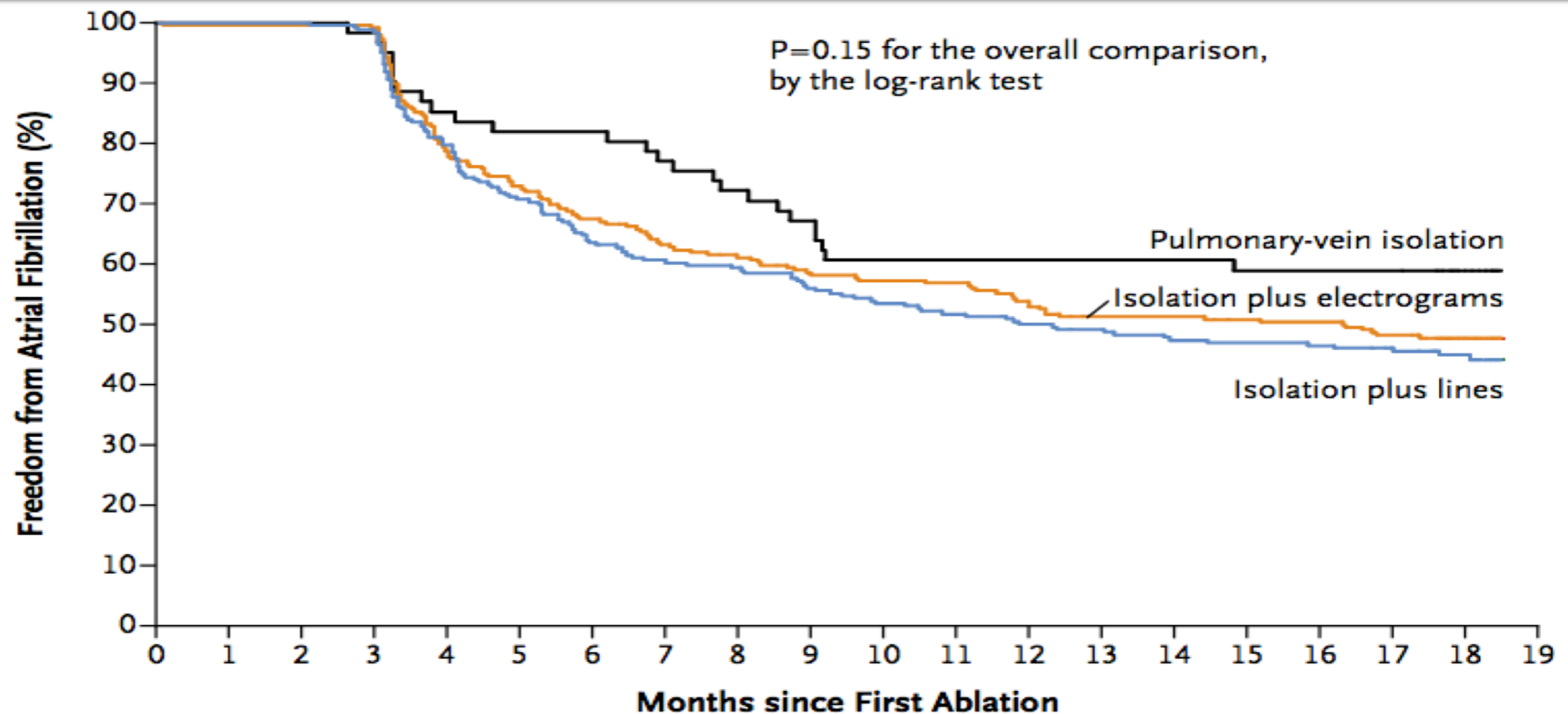
No. at Risk							
Ablation	154	154	123	105	96	86	55
Antiarrhythmic drug therapy	149	149	89	69	60	49	27

# Autres techniques d'ablations pour (essayer) améliorer les résultats dans la FA persistante

- Ablation des potentiels fragmentés complexes (CFE)
- Ablation guidée par l'évaluation de la cicatrice OG en IRM ou en voltage
- Segmentation OG

# Approaches to Catheter Ablation for persistent AF STAR AF 2

Verma Nejm 2015



**No. at Risk**

Pulmonary-vein isolation	61	60	50	41	36	23
Isolation plus electrograms	244	242	161	137	124	72
Isolation plus lines	244	240	152	133	115	57

Use of additional ablation lesions beyond PVI (low voltage areas, lines, fragmented activity, ectopic foci, rotors, and others) may be considered but is not well established. [677,680,708,711-730](#)

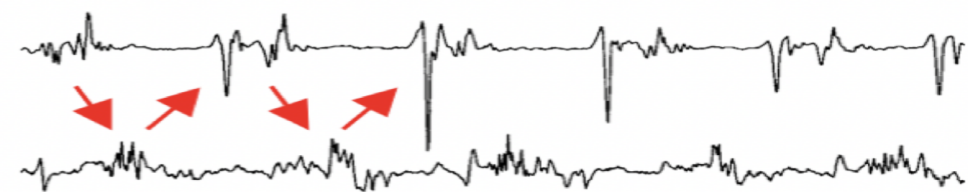
# Ablation CFE

- Endpoint ?
- Procédures plus longues (plus de complication)
- Flutter atypique++
- ablation plus large de l'OG
- Etude randomisée en cours

Fractionation



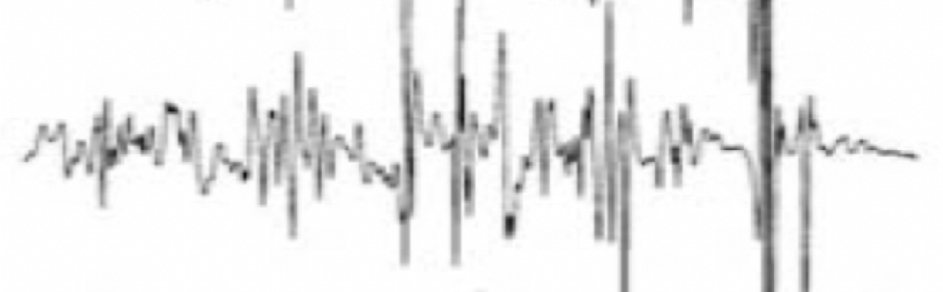
Activation Gradient



RF D



RF P





# Delayed-Enhancement MRI (DE-MRI) Determinant of Successful Radiofrequency Catheter Ablation of Atrial Fibrillation (DECAAF II)

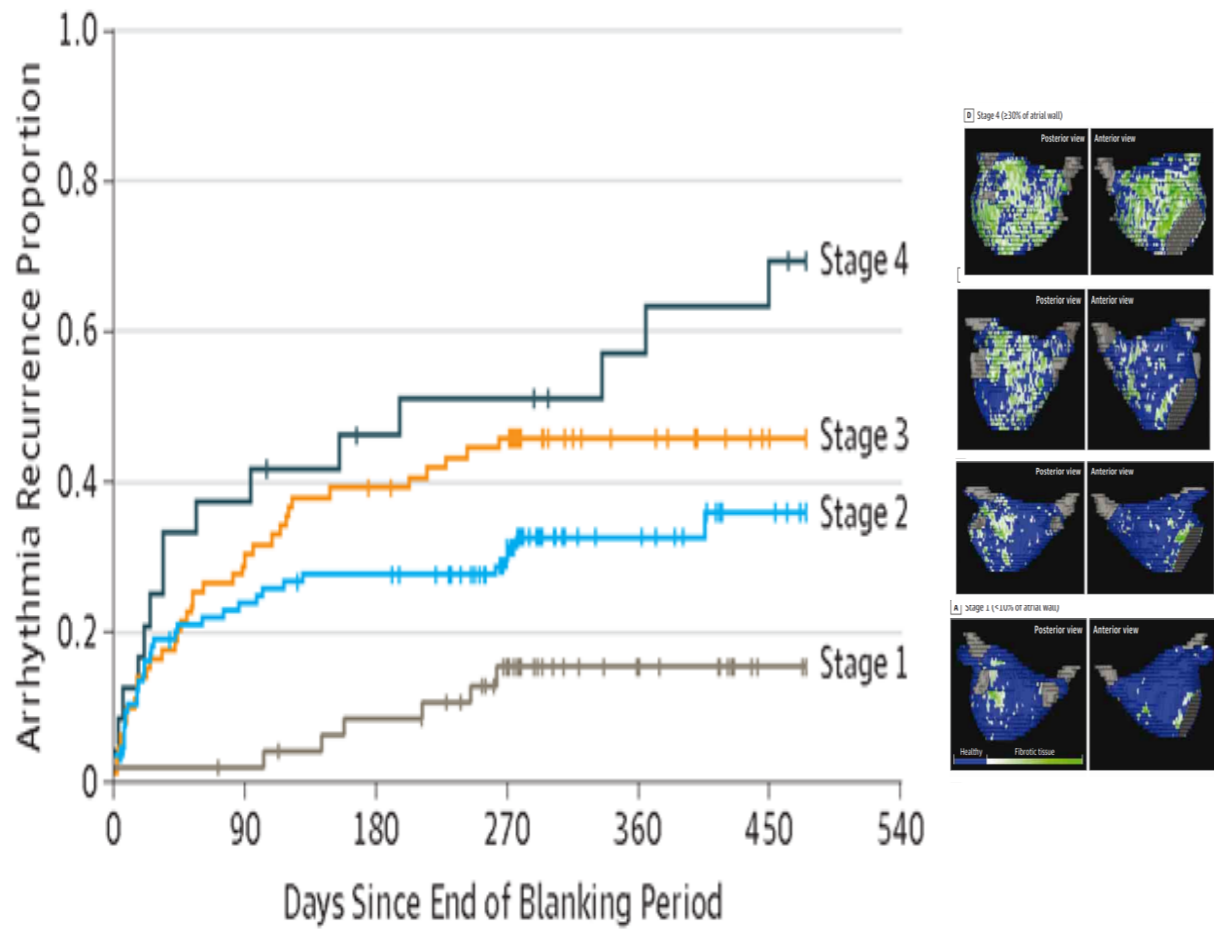
**Nassir F. Marrouche, MD**, Oussama Wazni, MD, Tom Greene, PhD, J Michael Dean, MD, Eugene Kholmovski, PhD, Moussa Mansour, MD, Hugh Calkins, MD, Francis Marchlinski, MD, David Wilber, MD, Gerhard Hindricks, MD, Christian Mahnkopf, MD, Pierre Jais, MD, Prashanthan Sanders, MD, Johannes Brachmann, MD, Jereon Bax, MD, Lilas Dagher, MD, Nazem Akoum, MD;

On Behalf of The DECAAF II Investigators



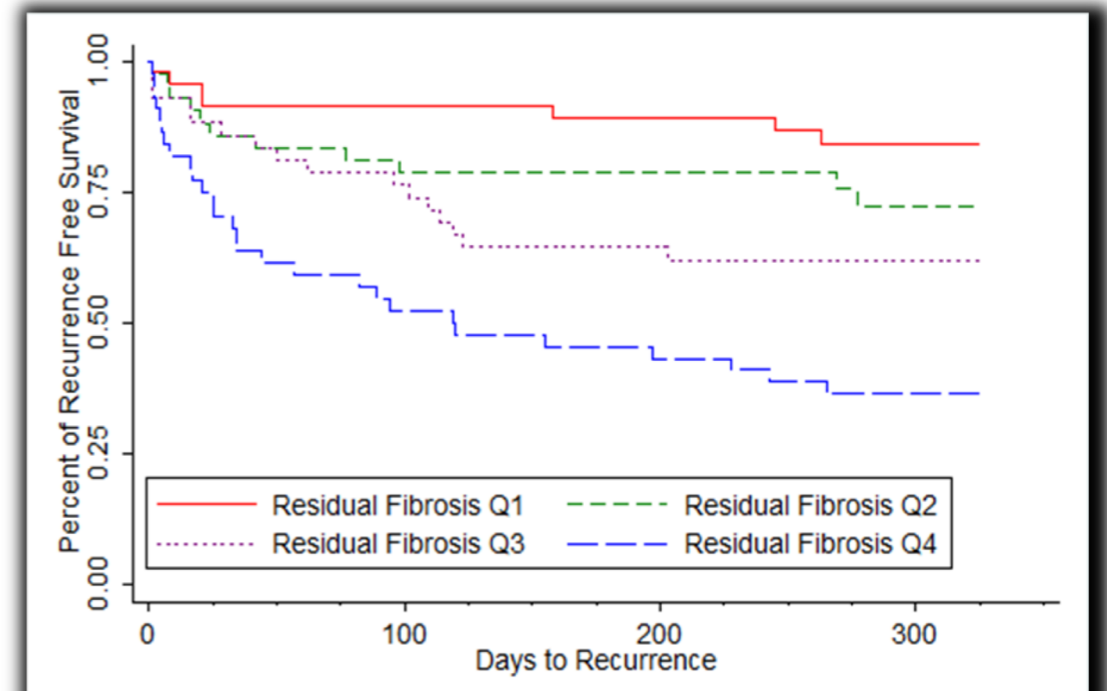
# DECAAF II: Background

Higher Degree of Atrial Fibrosis Predicts Ablation Procedure Outcome



Marrouche et al. DECAAF JAMA. 2014

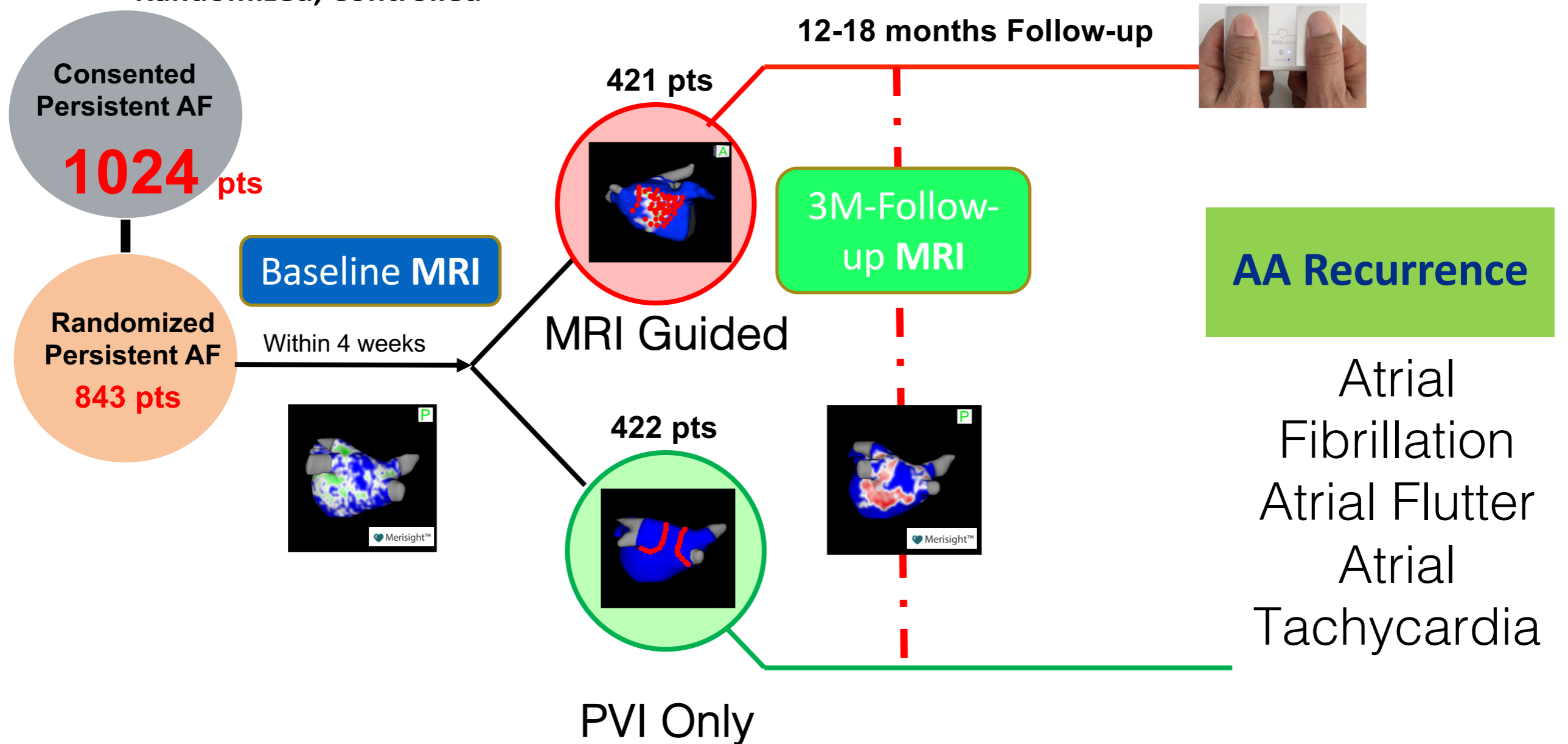
Higher Degree of Atrial Fibrosis Covered by Ablation Scar Improves Ablation Procedure Outcome



Akoum et al. JCE. 2015

# DECAAF II : Study Design

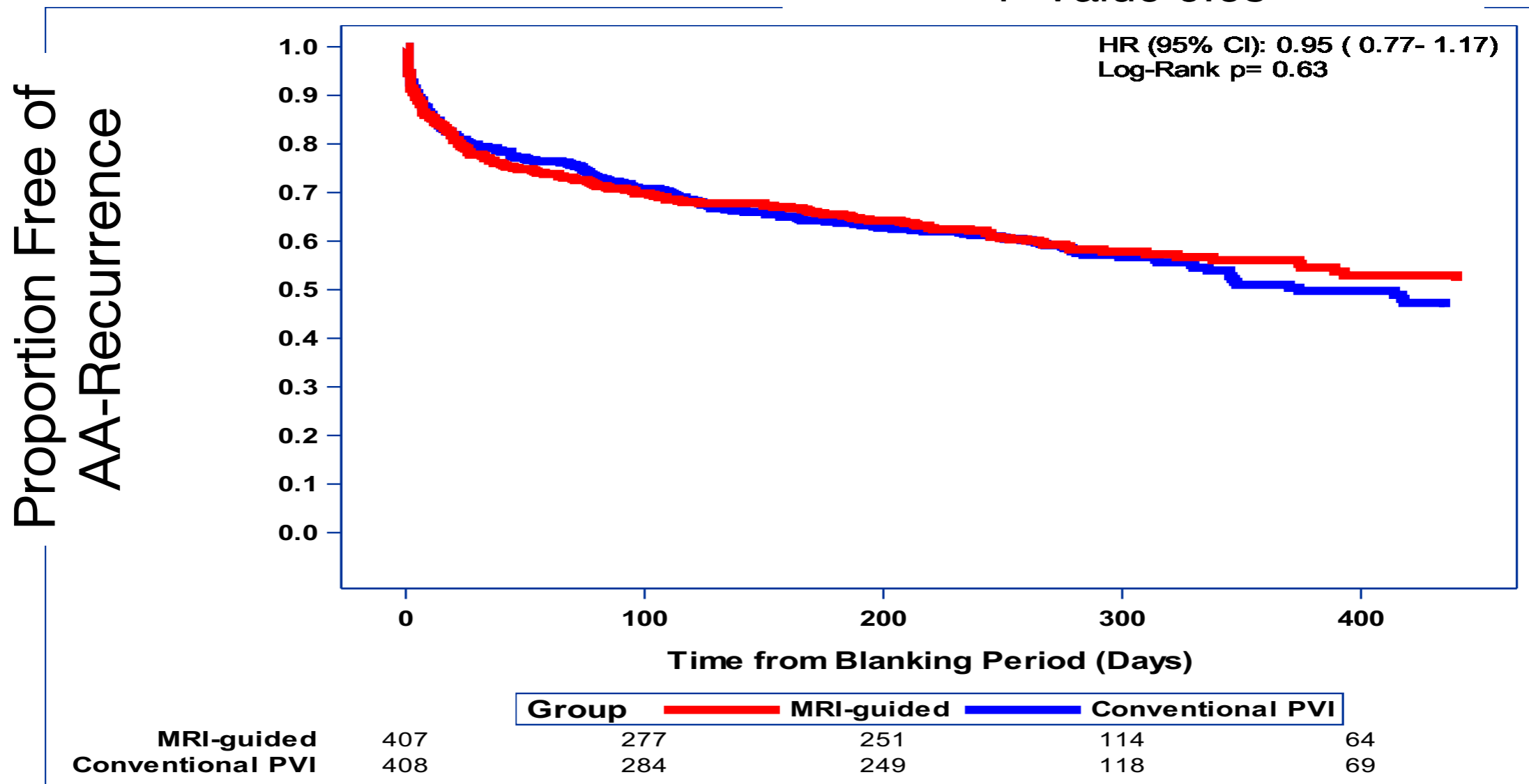
- Investigator initiated, industry-sponsored, prospective, Multicenter ( 44 sites, 3 continents), Randomized, Controlled



# DECAAF II: Results

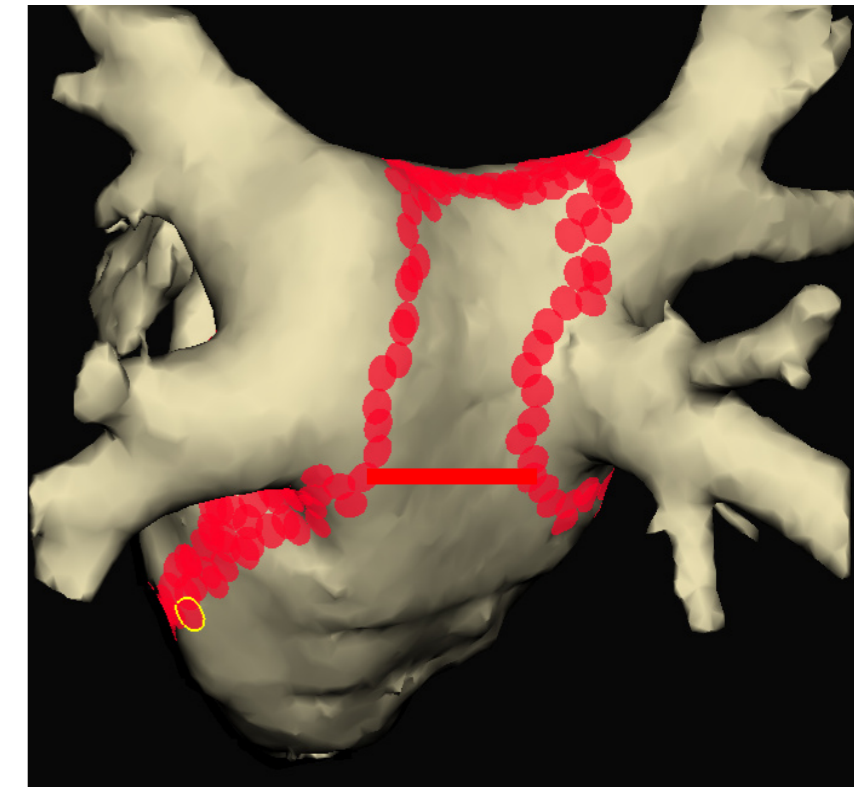
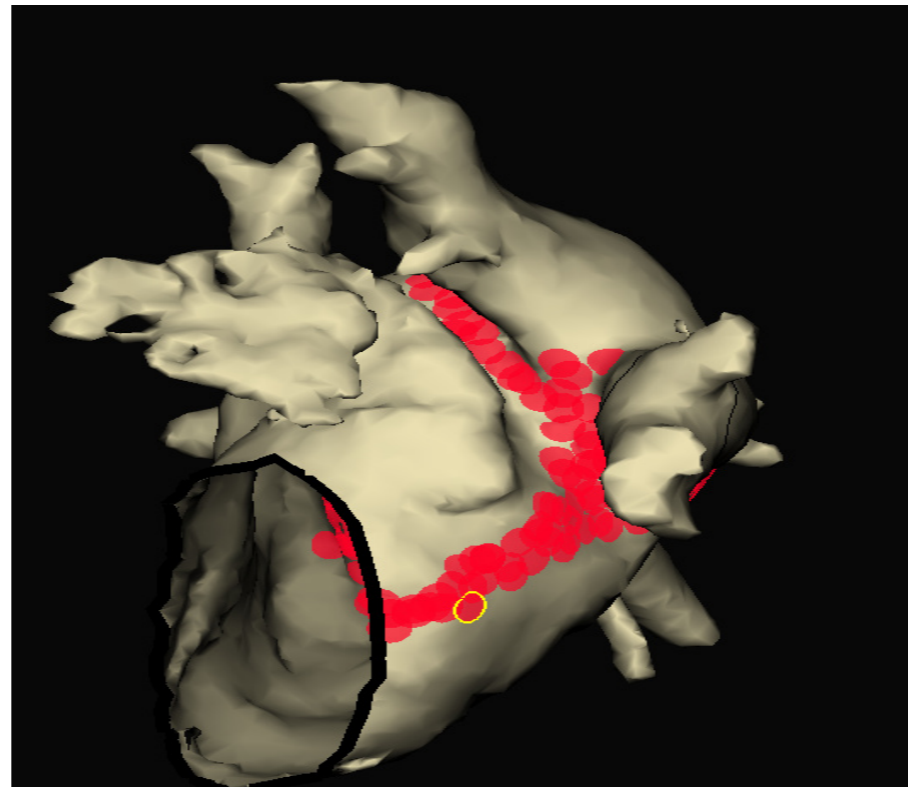
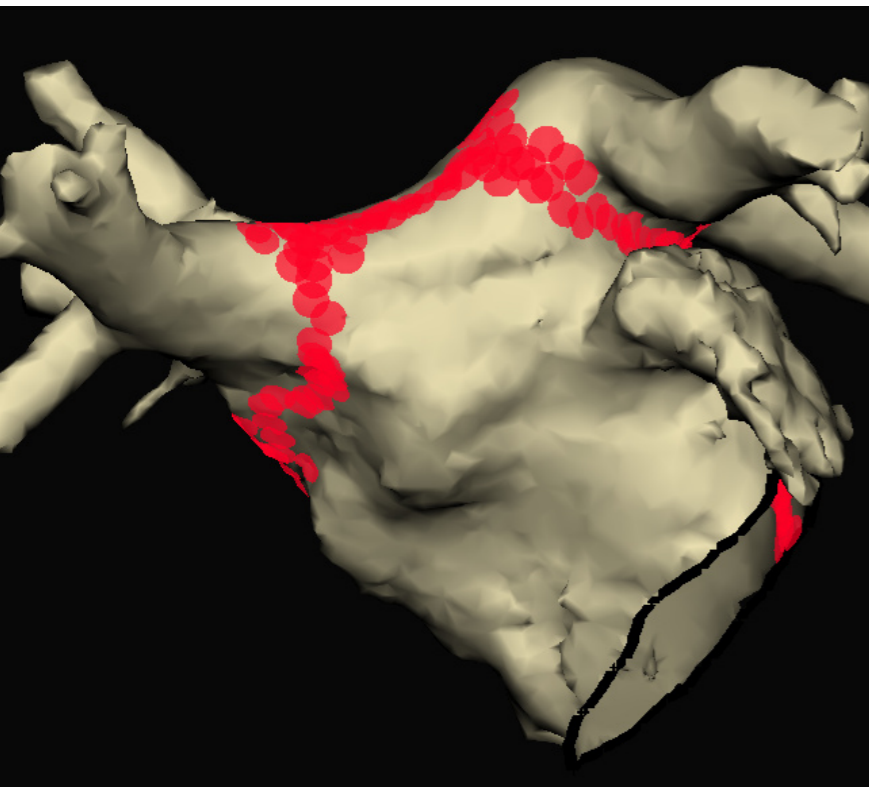
## ITT Analysis of Primary Endpoint

HR (95% CI): 0.95 (0.77 – 1.17)  
P-Value 0.63

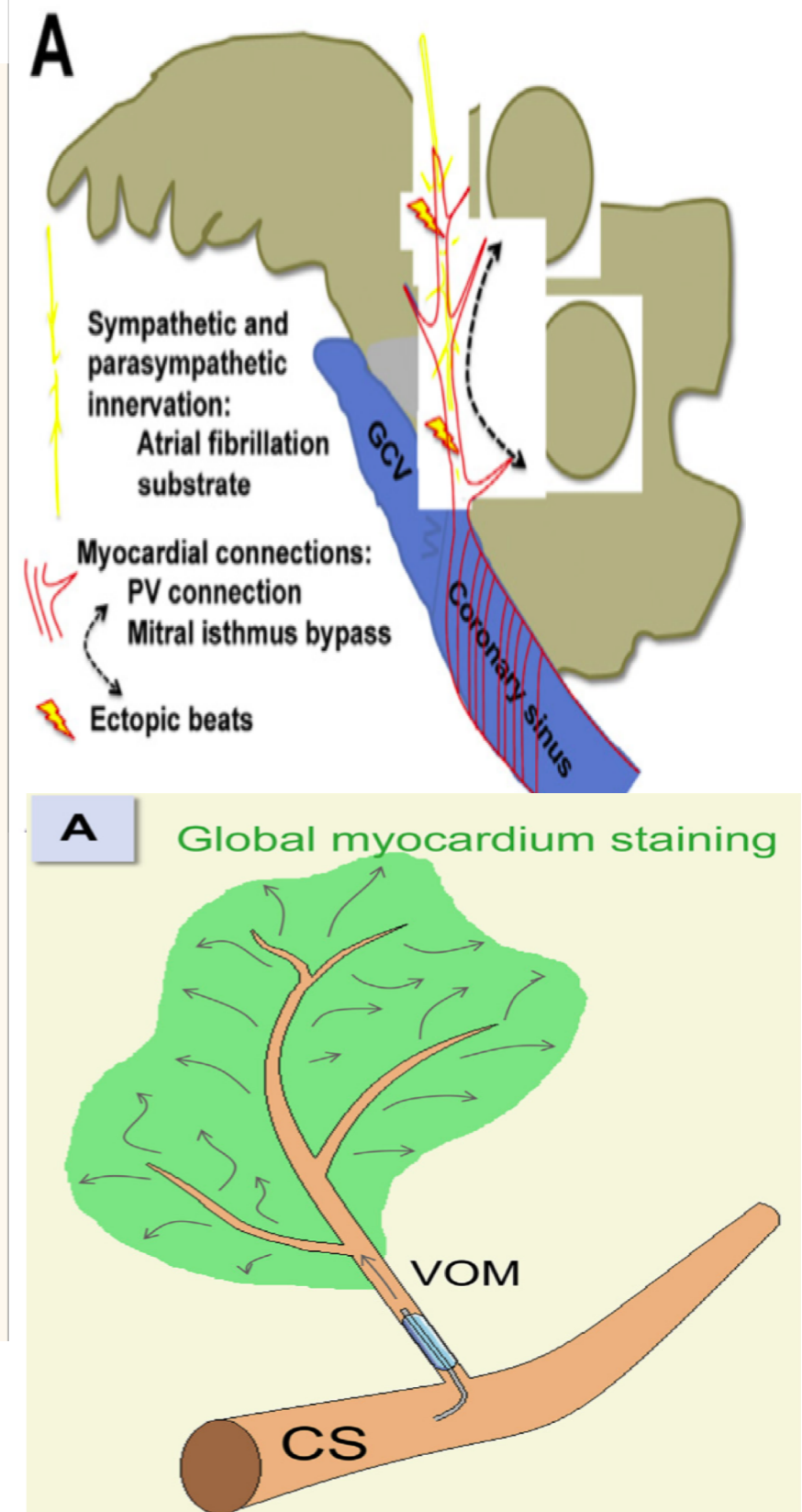
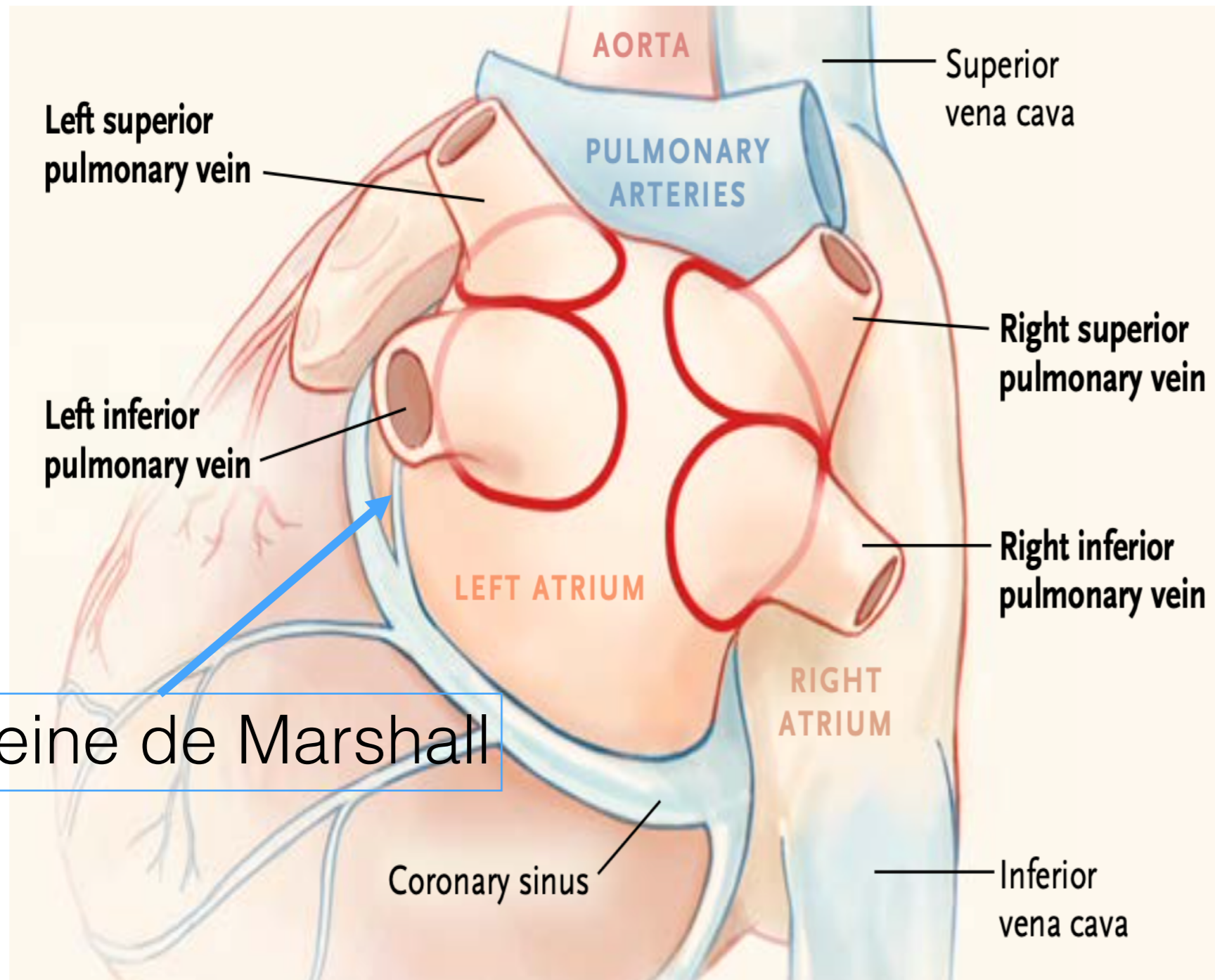


# Segmentation OG

- Ligne d'ablation sur le toit et l'isthme latéral gauche
- Ligne postéro-inférieure pour isoler le mur postérieur
- Difficulté à bloquer l'isthme mitral avec risque de flutter secondaire++



# Alcoolisation de la veine de Marshall



# Alcoolisation de la veine de Marshall

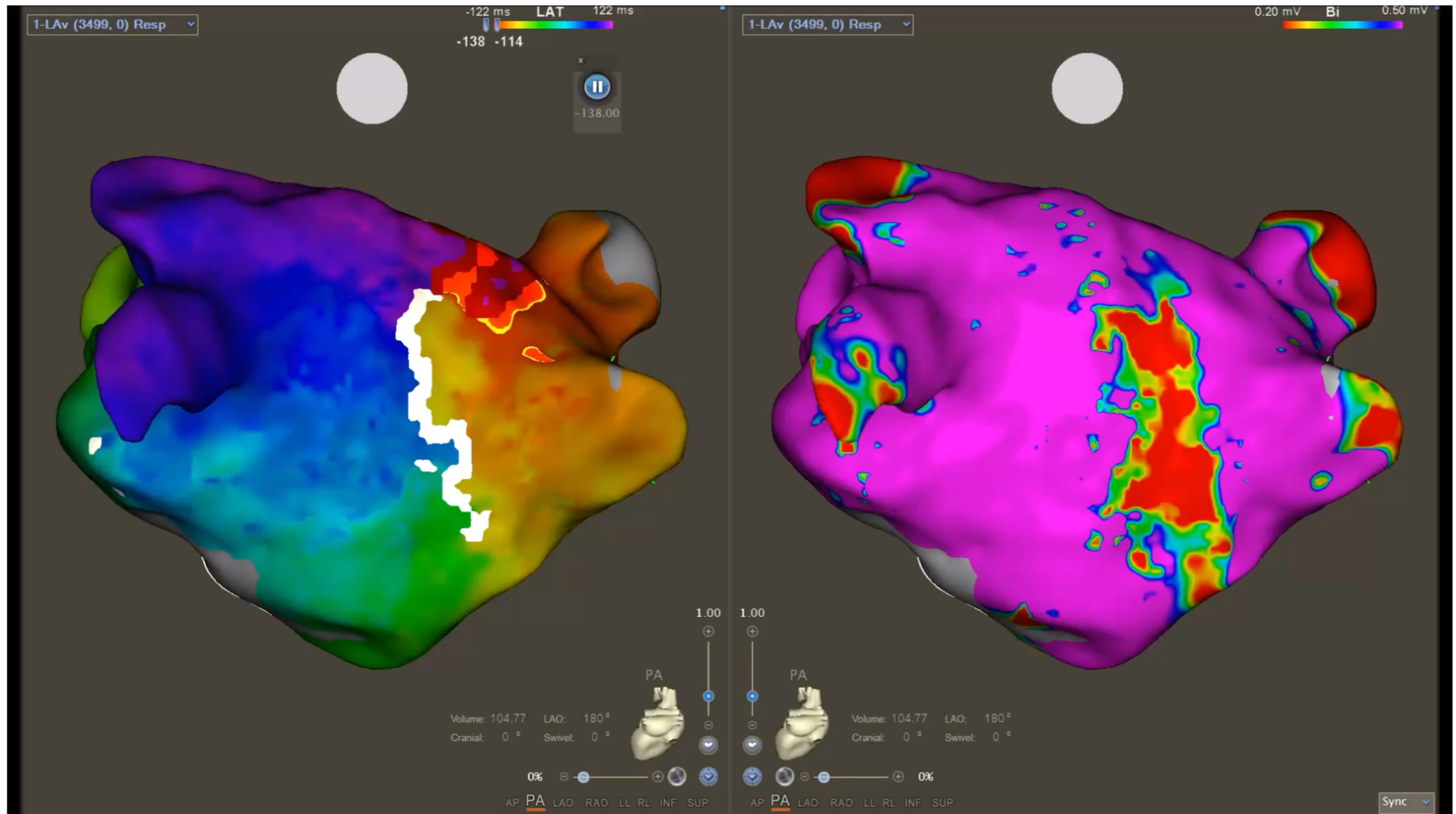
- Injection d'Ethanol pour créer une lésion atriale dans la région de la veine
- Elimine les foyers veineux déclencheurs d'arythmie,
- Détruit les fibres nerveuses para et sympathiques péri-veineuse
- Facilite l'ablation de la crête des veines pulmonaires gauche et de l'isthme latéral gauche

# Alcoolisation V Marshall

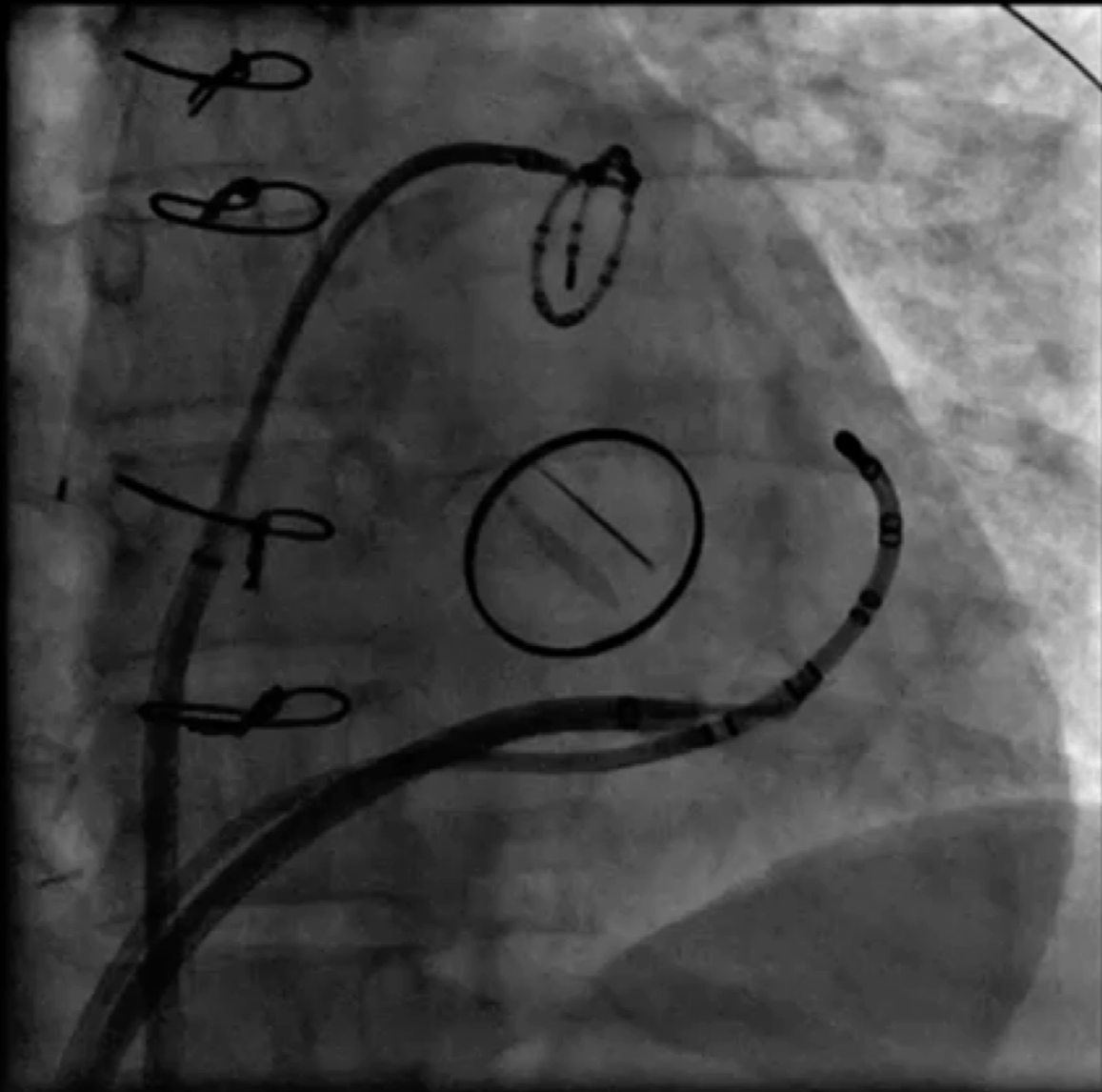
## Fa persistente

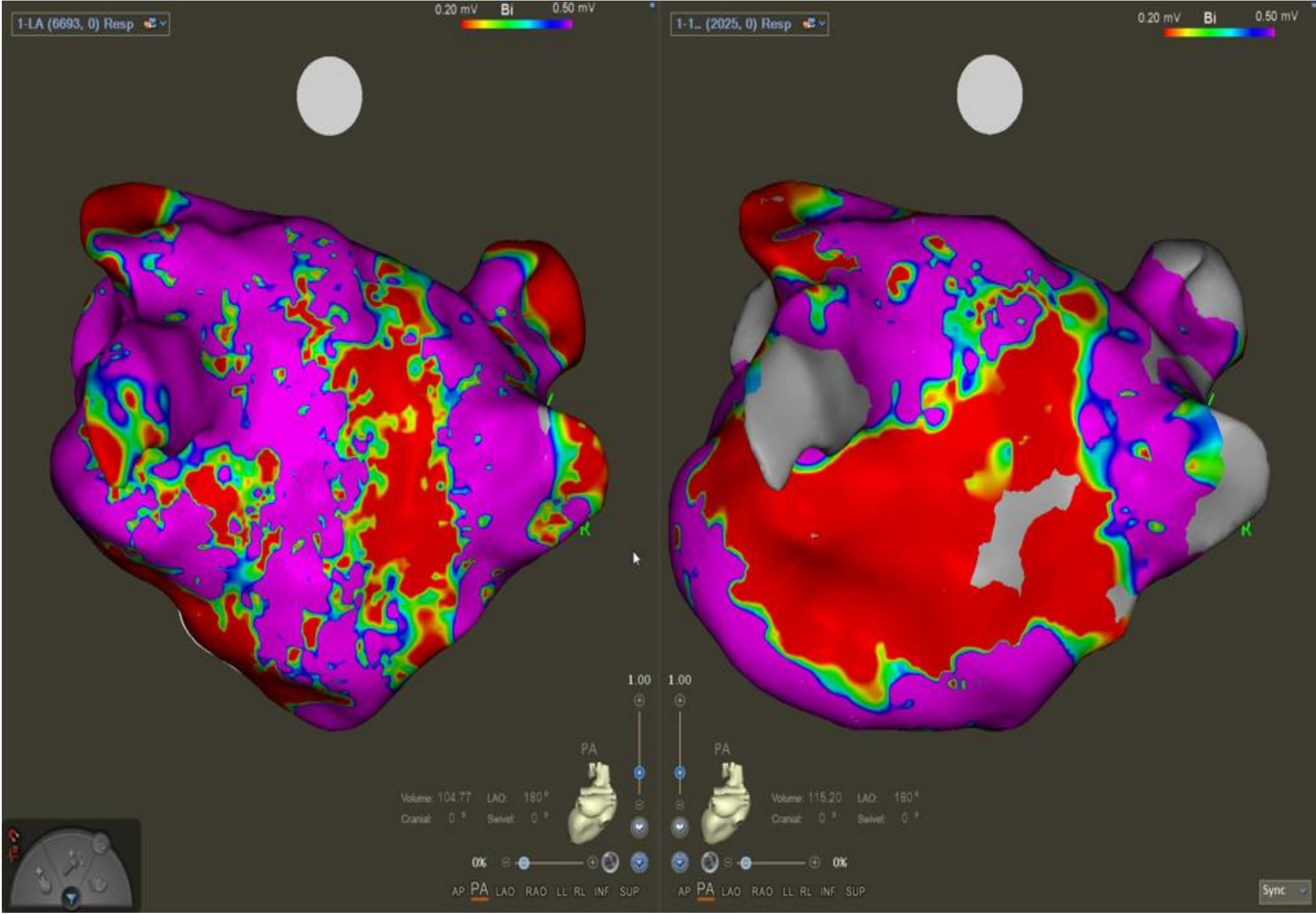


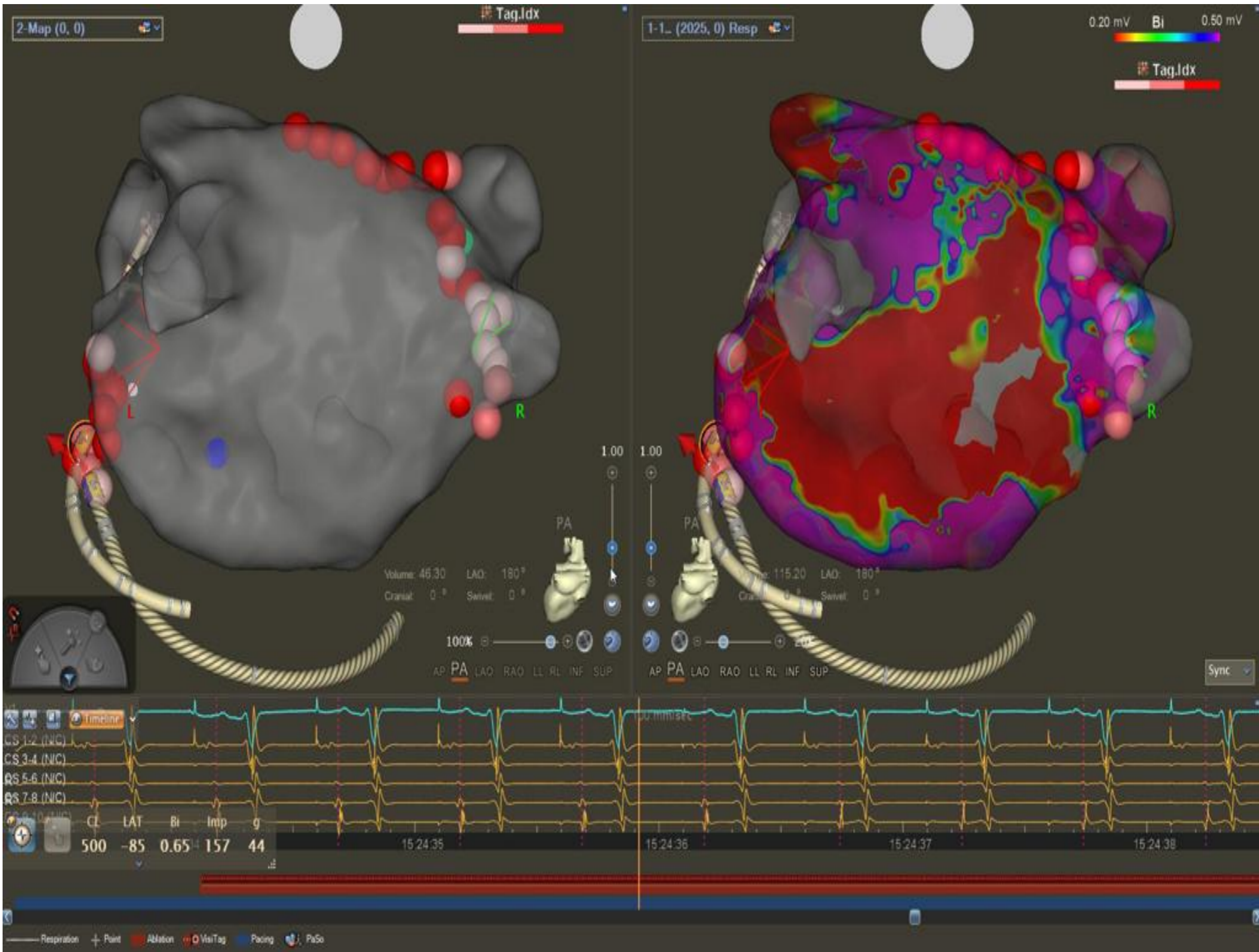
# Flutter atypique post RVM











# Cas clinique

Infirmierie protestante

Dr C.Durand

Flutter gauche ablation

Redo procedure after PVI + Roof line + Mitral line

65 y.o male

# Traiter les facteurs favorisants:

1. Obésité +++
2. SAS, HTA, Alcool, tabac, diabète
3. Exercice : inactif 5x, athlète 5x plus de FA

## Lifestyle modification and other strategies to improve outcomes of ablation

Weight loss is recommended in obese patients with AF, particularly those who are being evaluated to undergo AF ablation.<sup>636,638,639,643,646,772,786–791</sup>

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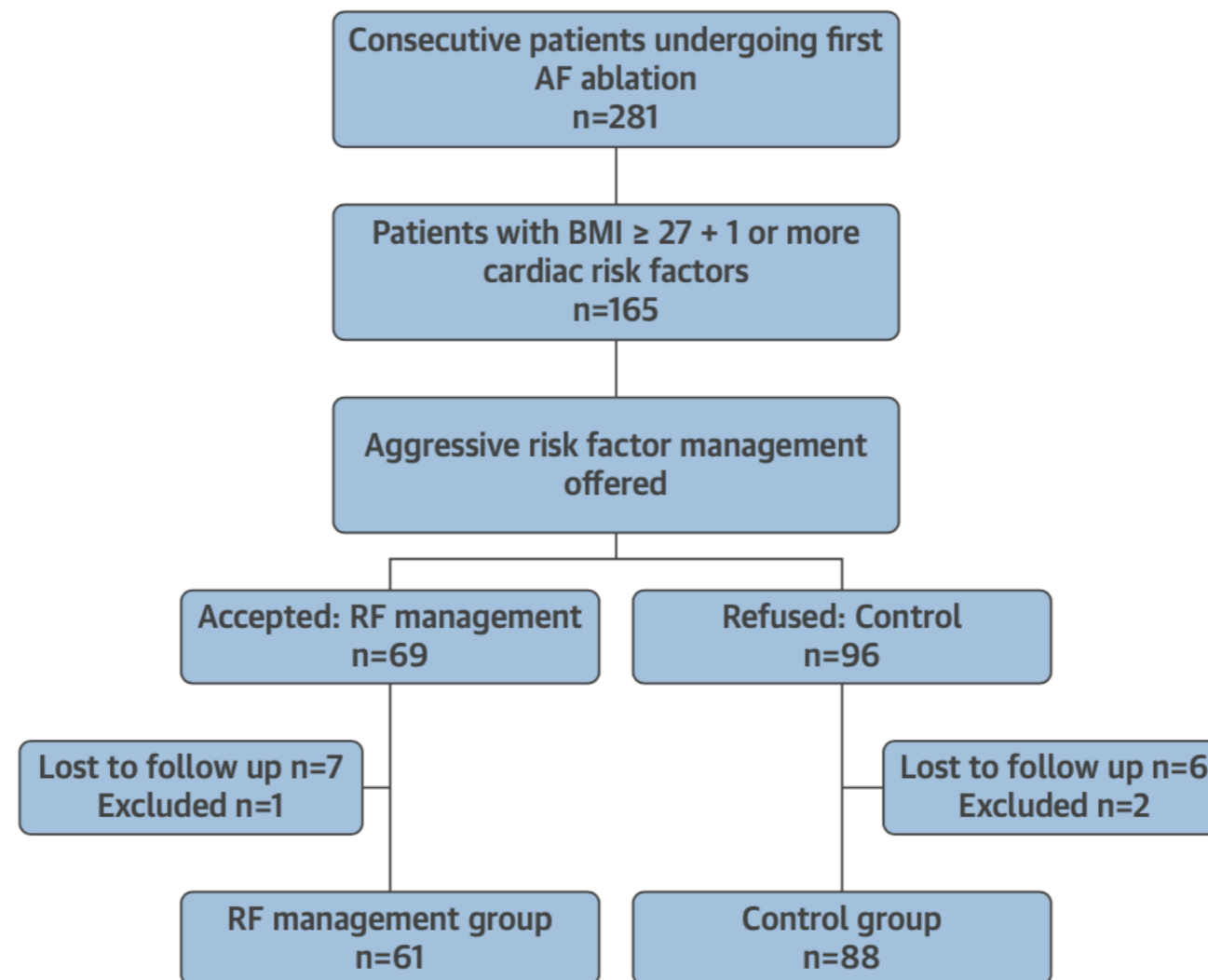
Strict control of risk factors and avoidance of triggers are recommended as part of a rhythm control strategy.<sup>636,637</sup>

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# Aggressive Risk Factor Reduction Study for Atrial Fibrillation and Implications for the Outcome of Ablation

The ARREST-AF Cohort Study

Sanders Jaac nov 2014



- RFM : Risk Factor Management  
perte de poids, sevrage alcool/tabac,  
traitement SAS, contrôle HTA dyslipidémie et diabète

