

2024
13 et 14 avril

12ème

SÉMINAIRE de ARDIOLOGIE
INTERVENTIONNELLE de TROYES



Ablation de FA : Quelle énergie choisir ?



Dr Ahmed SALHI

Dr Fatma ZOUARI

Cas clinique

Cas clinique

Mme LV âgée de 68 ans

ATCDts médicaux: BPCO

FDR CV: Dyslipidémie sous régime

Tabac sevré en 2004

- Fibrillation atriale

Septembre 2021 / paroxystique / Flécainide et Xarelto

ETT: FEVG conservée, OG non dilatée

Récidive en Janvier 2023 symptomatique (palpitations, dyspnée invalidante) => Switch Flécainide par Amiodarone par son cardiologue



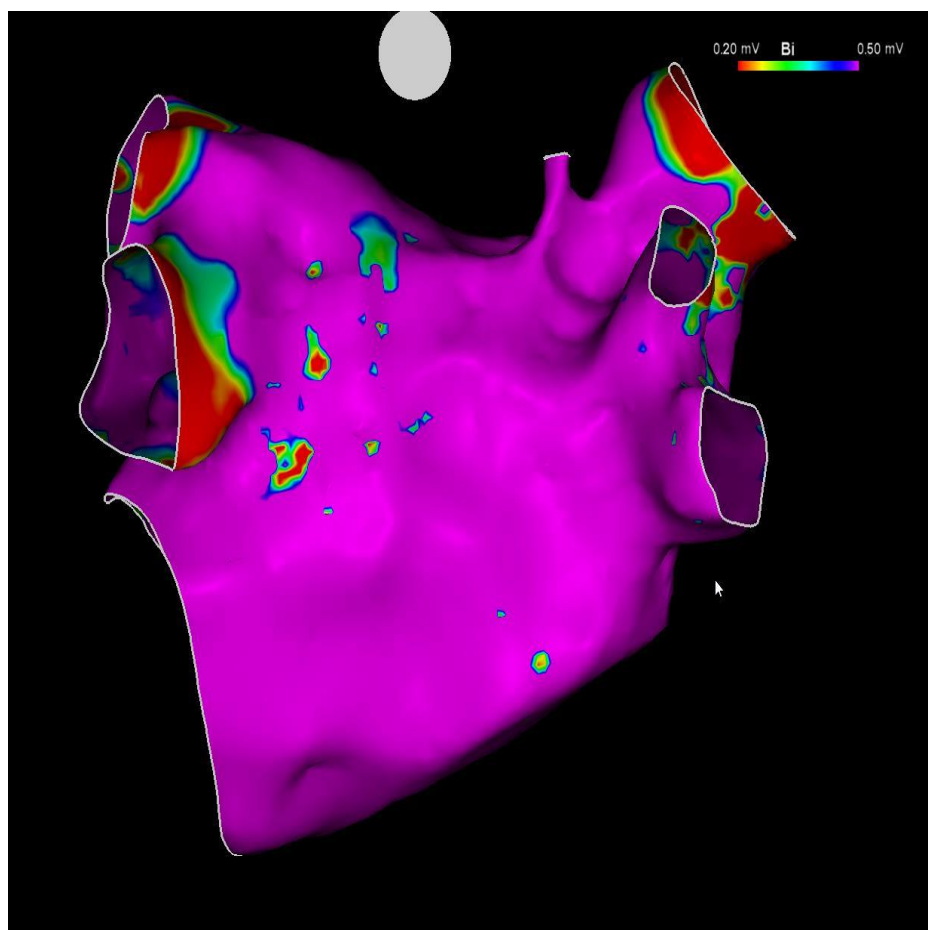
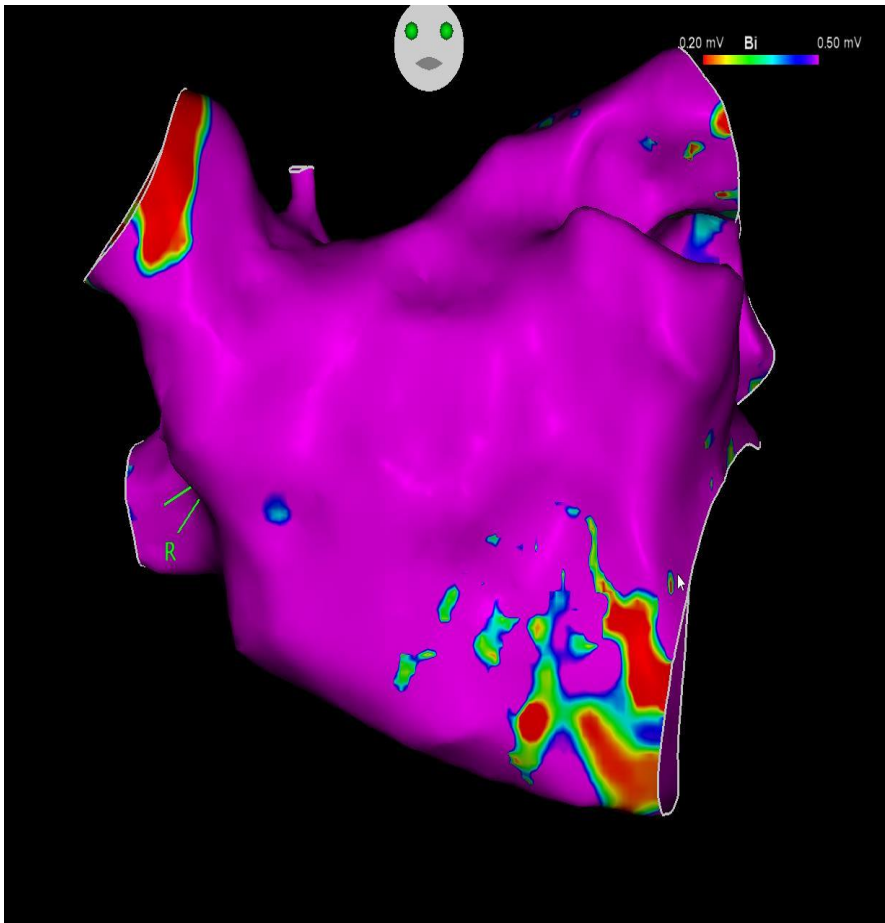
Photosensibilité à
l'amiodarone

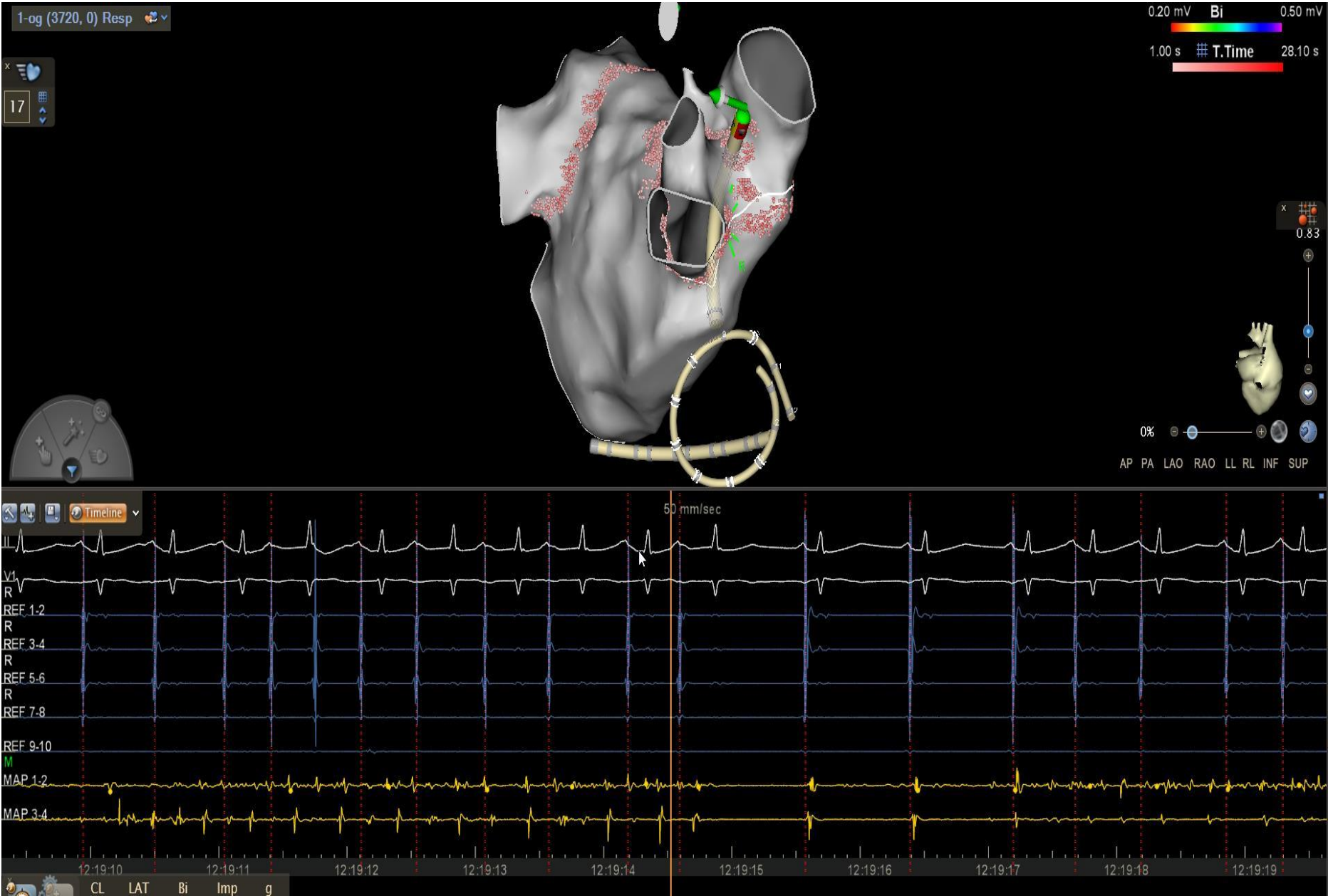


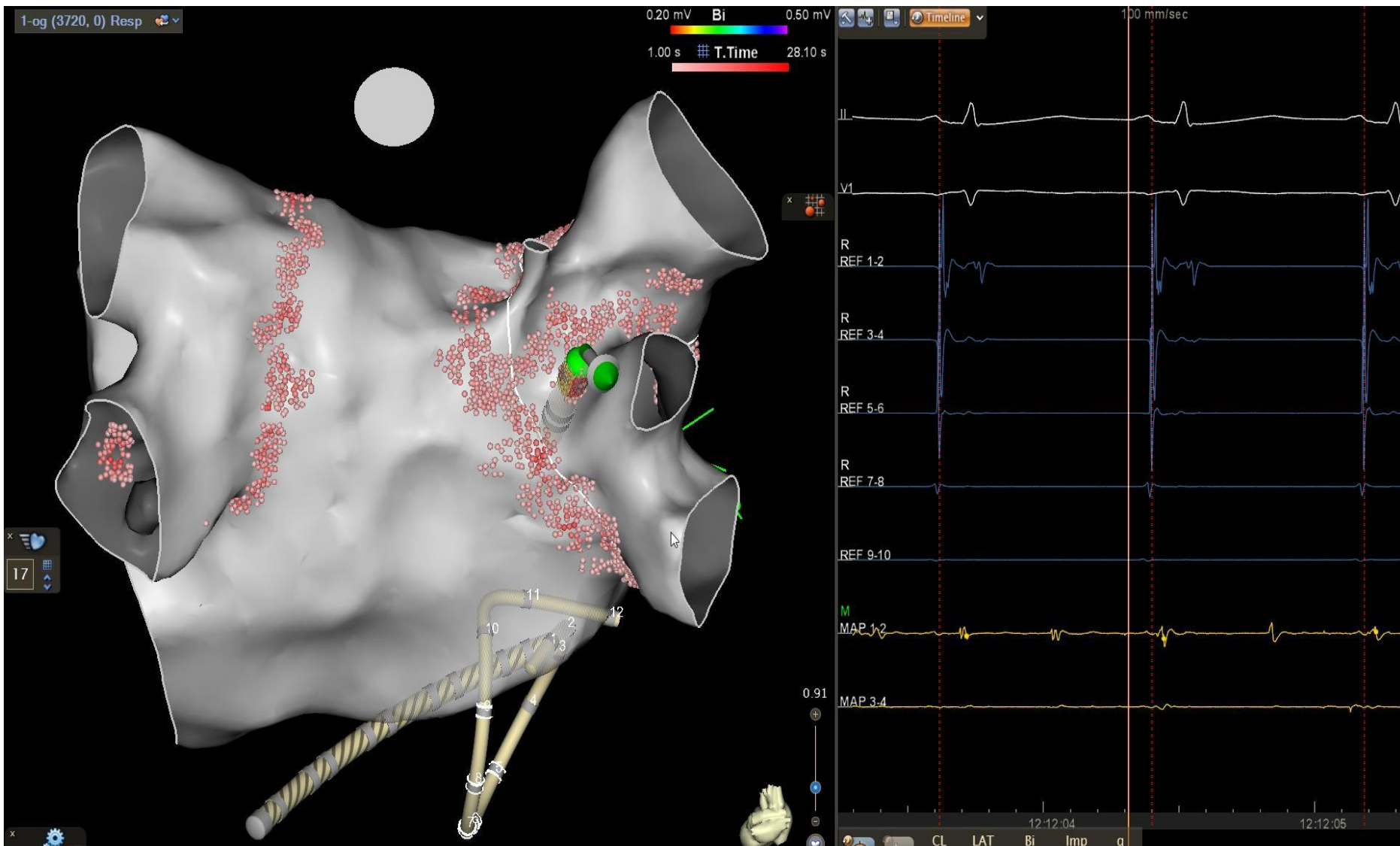
AMIODARONE

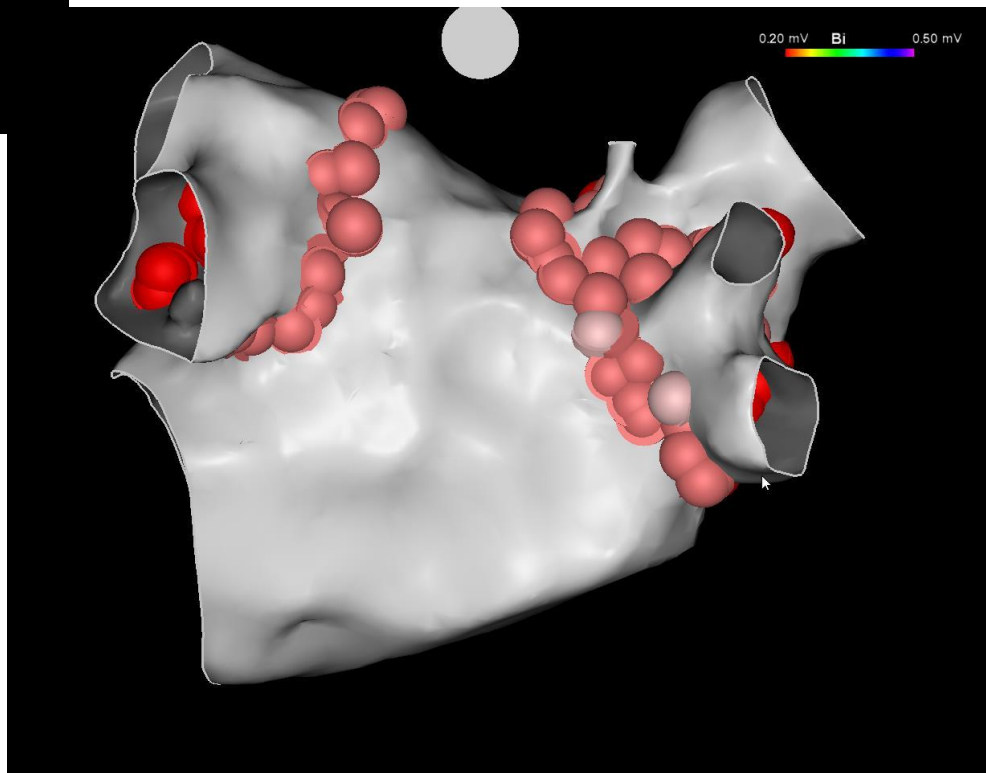
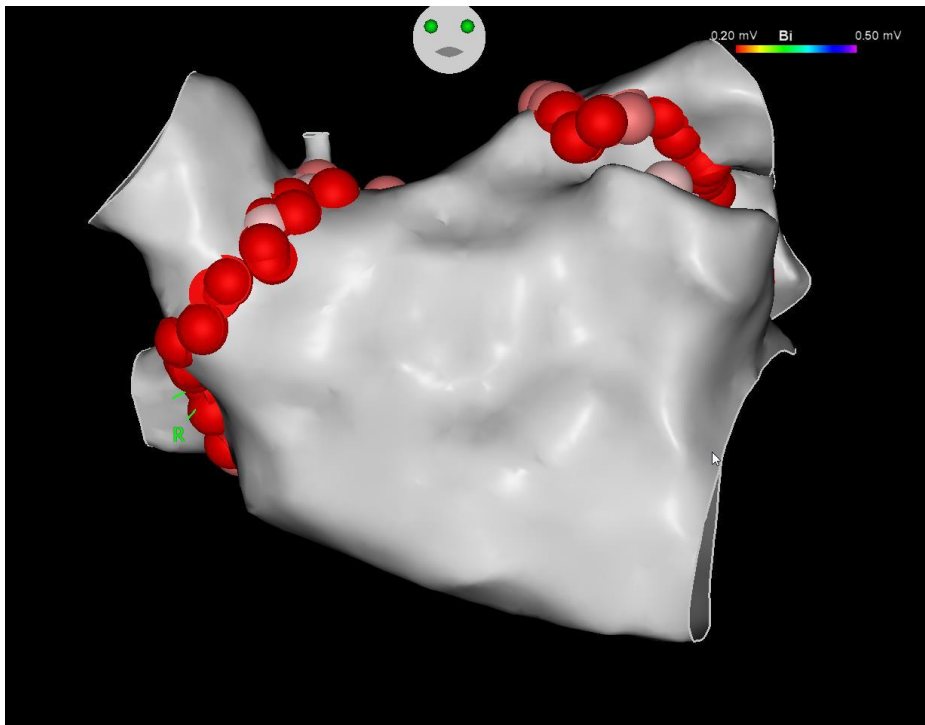


ABLATION

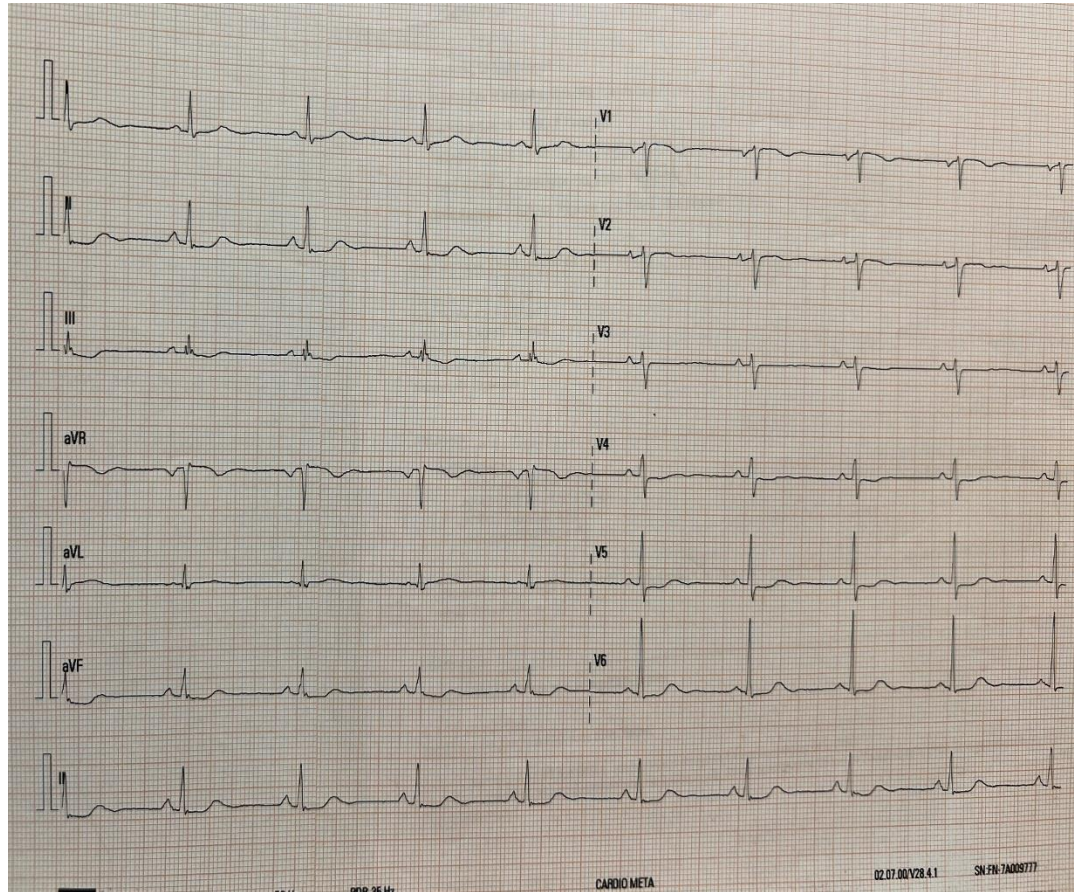








ECG à la sortie



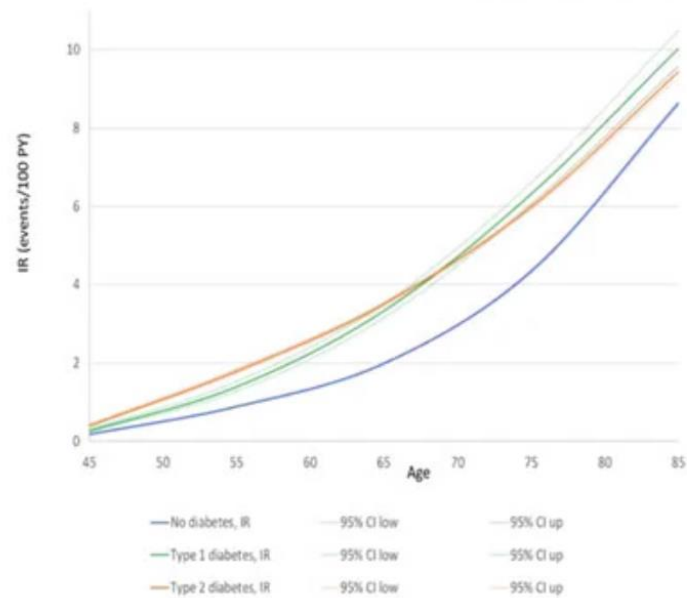
- Pas de conflits d'intérêt

Plan

- Introduction / Background
- Radiofréquence
- Cryoablation
- Électroporation
- Conclusion

Introduction

Results 1. Incidence of AF by age and diabetes type



Contrôle du rythme?

Contrôle de la fréquence?

- Nombreuses études ayant étudié l'intérêt d'une stratégie antiarythmique de contrôle du rythme = AFFIRM, RACE, AF-CHF, PIAF... toutes négatives sur la mortalité
- Pourtant rythme sinusal facteur pronostic favorable en terme de survie dans la plupart de ces études.

AFFIRM

TABLE 3. Covariates Significantly Associated With Survival Results With Echocardiographic Data Excluded

Covariate	<i>P</i>	HR	HR: 99% Confidence Limits	
			Lower	Upper
Age at enrollment*	<0.0001	1.06	1.04	1.08
Coronary artery disease	<0.0001	1.65	1.31	2.07
Congestive heart failure	<0.0001	1.83	1.45	2.32
Diabetes	<0.0001	1.56	1.22	2.00
Stroke or transient ischemic attack	<0.0001	1.54	1.17	2.05
Smoking	<0.0001	1.75	1.29	2.39
First episode of atrial fibrillation	0.0067	1.27	1.01	1.58
Sinus rhythm	<0.0001	0.54	0.42	0.70
Warfarin use	<0.0001	0.47	0.36	0.61
Digoxin use	<0.0001	1.50	1.18	1.89
Rhythm-control drug use	0.0005	1.41	1.10	1.83

*Per year of age.

Contrôle du rythme?

Contrôle de la fréquence?

- Analyse post-hoc d'AFFIRM =
 - rythme sinusal 53% de réduction de mortalité,
 - mais anti-arythmiques majorent de 49% la mortalité.
- Donc bien sélectionner les patients relevant d'une stratégie de contrôle du rythme
- Toujours privilégier la sécurité d'emploi à l'efficacité du ttt anti-arythmiques

Place de l'ablation de FA dans le contrôle du rythme?

- Données témoignant de l'efficacité dans le contrôle de rythme
- Plusieurs études démontrant un BENEFICE EN TERME DE MORBI MORTALITE EN CAS D'INSUFFISANCE CARDIAQUE A FEVG ALTEREE

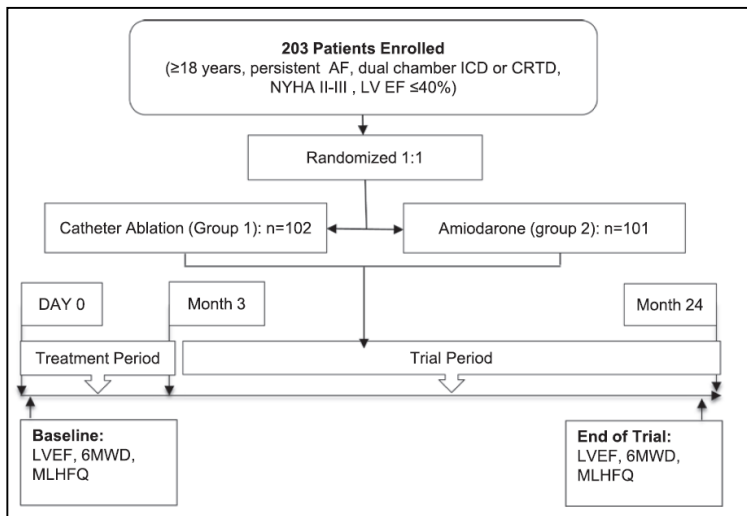
AATAC trial

CASTLE AF

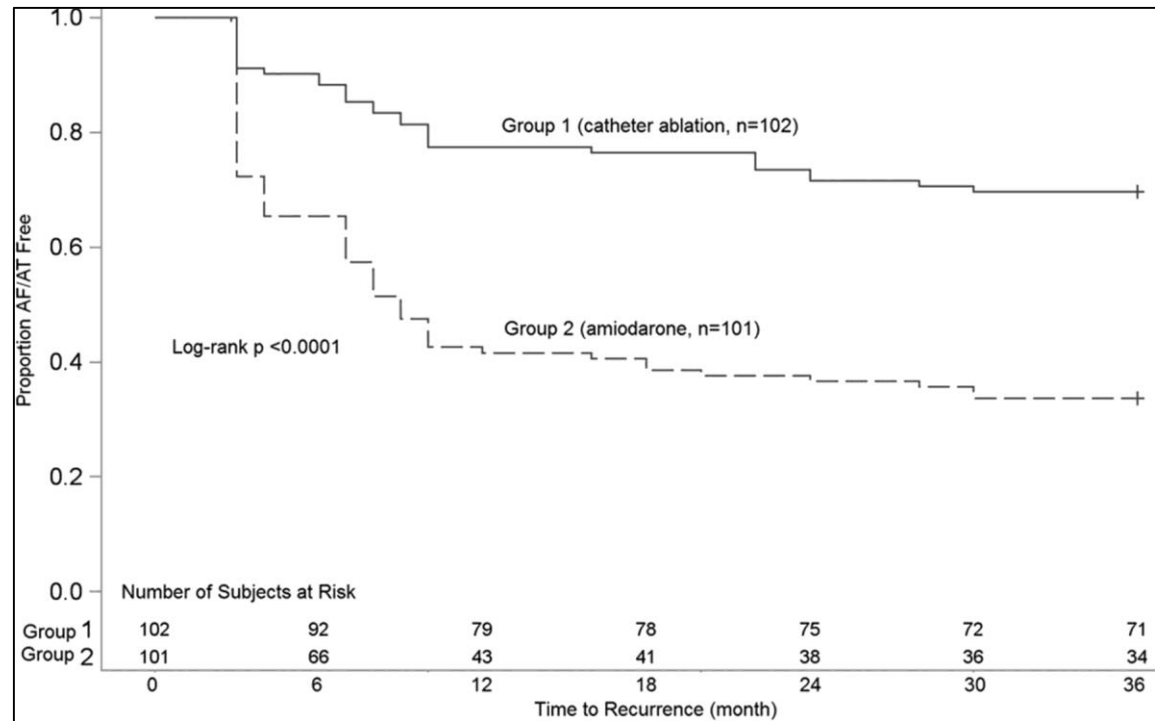


vs ttt antiarythmique

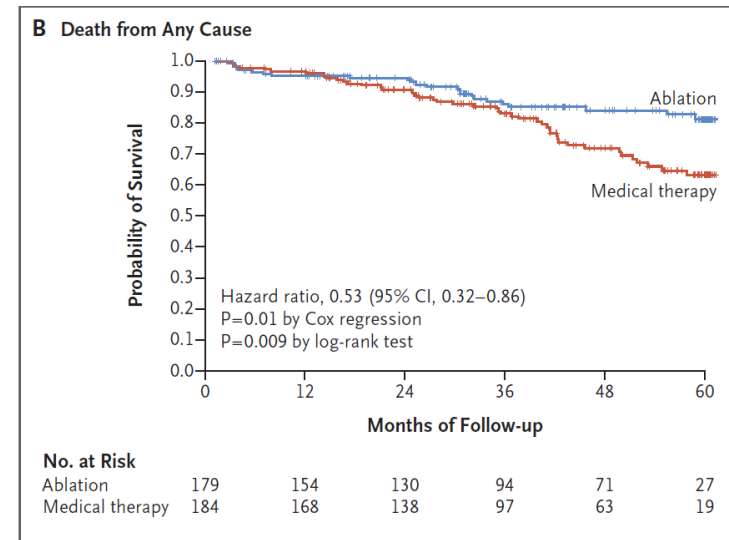
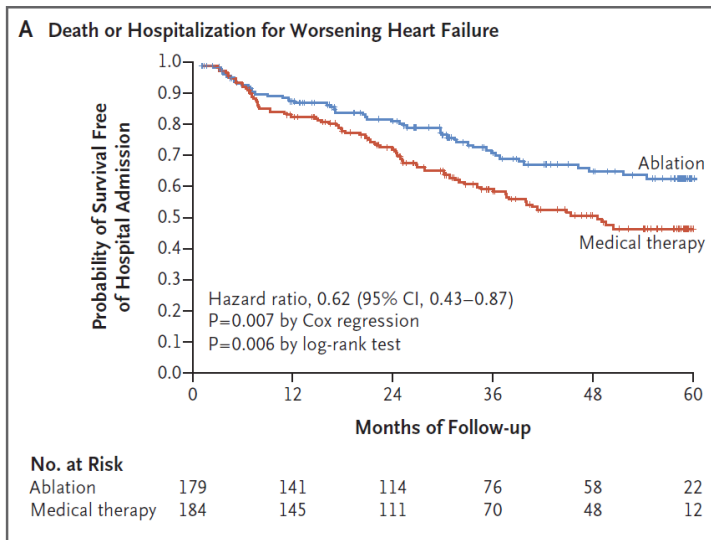
AATAC



-45% d'hospitalisation; $p < 0.001$
 -56% de mortalité; $p = 0.037$



CASTLE AF



Place de l'ablation de FA dans le contrôle du rythme?

- Données témoignant de l'efficacité dans le contrôle du rythme
- Jusqu'à récemment, pas de bénéfice démontré d'une telle stratégie sur la mortalité chez les patients « non insuffisant cardiaque »

« Rythm control » vs « Rate control »

Nouvelles données
EAST AFNET 4

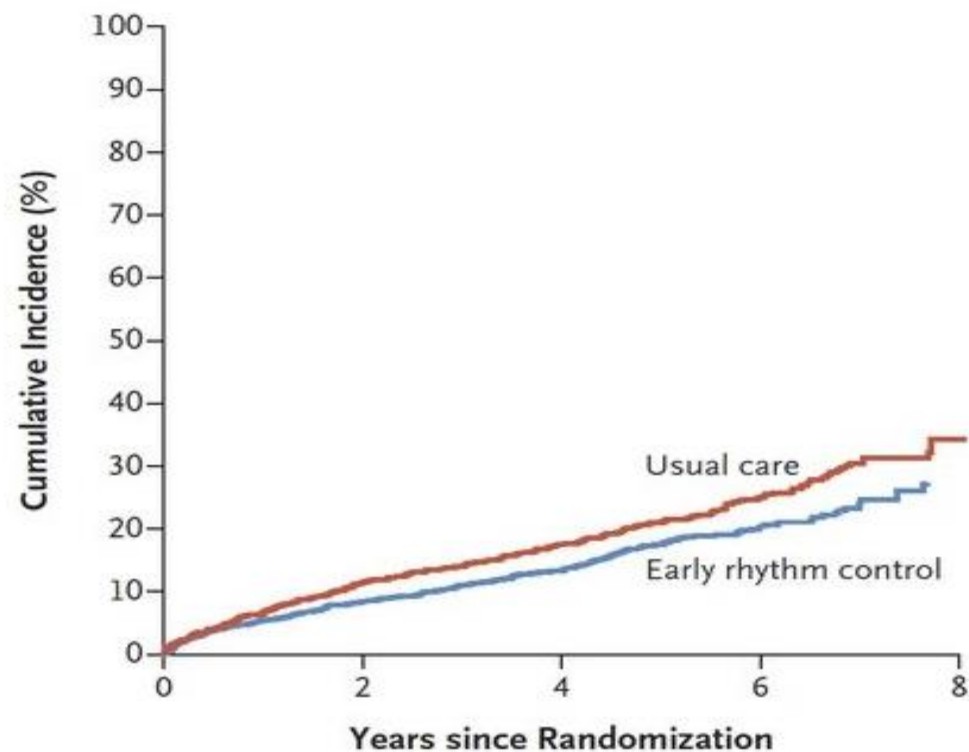
ORIGINAL ARTICLE

Early Rhythm-Control Therapy in Patients with Atrial Fibrillation

P. Kirchhof, A.J. Camm, A. Goette, A. Brandes, L. Eckardt, A. Elvan, T. Fetsch, I.C. van Gelder, D. Haase, L.M. Haegeli, F. Hamann, H. Heidbüchel, G. Hindricks, J. Kautzner, K.-H. Kuck, L. Mont, G.A. Ng, J. Rekosz, N. Schoen, U. Schotten, A. Suling, J. Taggeselle, S. Themistoclakis, E. Vettorazzi, P. Vardas, K. Wegscheider, S. Willems, H.J.G.M. Crijns, and G. Breithardt, for the EAST-AFNET 4 Trial Investigators*

Table 2. Efficacy Outcomes.*

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) [†] P = 0,005
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) [‡]
Stroke	40/6813 (0.6)	62/6856 (0.9)	0.65 (0.44 to 0.97) [‡]
Hospitalization with worsening of heart failure	139/6620 (2.1)	169/6558 (2.6)	0.81 (0.65 to 1.02) [‡]
Hospitalization with acute coronary syndrome	53/6762 (0.8)	65/6816 (1.0)	0.83 (0.58 to 1.19) [‡]
Second primary outcome — nights spent in hospital/yr	5.8±21.9	5.1±15.5	1.08 (0.92 to 1.28) [§]
Key secondary outcomes at 2 yr			
Change in left ventricular ejection fraction — %	1.5±9.8	0.8±9.8	0.23 (−0.46 to −0.91) [¶]
Change in EQ-5D score	−1.0±21.4	−2.7±22.3	1.07 (−0.68 to 2.82) [¶]
Change in SF-12 Mental Score ^{**}	0.7±10.6	1.6±10.1	−1.20 (−2.04 to −0.37) [¶]
Change in SF-12 Physical Score ^{**}	0.3±8.5	0.1±8.2	0.33 (−0.39 to 1.06) [¶]
Change in MoCA score	0.1±3.3	0.1±3.2	−0.14 (−0.39 to 0.12) [¶]
Sinus rhythm — no. of patients with feature/total no. (%)	921/1122 (82.1)	687/1135 (60.5)	3.13 (2.55 to 3.84) ^{††}
Asymptomatic — no. of patients with feature/total no. (%) ^{‡‡}	861/1159 (74.3)	850/1171 (72.6)	1.14 (0.93 to 1.40) ^{††}



No. at Risk

Usual care	1394	1169	888	405	34
Early rhythm control	1395	1193	913	404	26

Figure 2. Aalen-Johansen Cumulative-Incidence Curves for the First Primary Outcome.

The first primary outcome was a composite of death from cardiovascular causes, stroke, or hospitalization with worsening of heart failure or acute coronary syndrome.

Table 3. Safety Outcomes.*

Outcome	Early Rhythm Control (N = 1395)		Usual Care (N = 1394)
	number (percent)		
Primary composite safety outcome	231 (16.6)		223 (16.0)
Stroke	40 (2.9)	p = 0,03	62 (4.4)
Death	138 (9.9)		164 (11.8)
Serious adverse event of special interest related to rhythm-control therapy	68 (4.9)		19 (1.4)
Serious adverse event related to antiarrhythmic drug therapy			
Nonfatal cardiac arrest	1 (0.1)		1 (0.1)
Toxic effects of atrial fibrillation–related drug therapy	10 (0.7)		3 (0.2)
Drug-induced bradycardia	14 (1.0)		5 (0.4)
Atrioventricular block	2 (0.1)		0
Torsades de pointes tachycardia	1 (0.1)		0
Serious adverse event related to atrial fibrillation ablation			
Pericardial tamponade	3 (0.2)		0
Major bleeding related to atrial fibrillation ablation	6 (0.4)		0
Nonmajor bleeding related to atrial fibrillation ablation	1 (0.1)		2 (0.1)
Other serious adverse event of special interest related to rhythm-control therapy			
Blood pressure–related event†	1 (0.1)		0
Hospitalization for atrial fibrillation	11 (0.8)		3 (0.2)
Other cardiovascular event	5 (0.4)		1 (0.1)
Other event	1 (0.1)		3 (0.2)
Syncope	4 (0.3)		1 (0.1)
Hospitalization for worsening of heart failure with decompensated heart failure	3 (0.2)		0
Implantation of a pacemaker, defibrillator, cardiac resynchronization device, or any other cardiac device	8 (0.6)		4 (0.3)

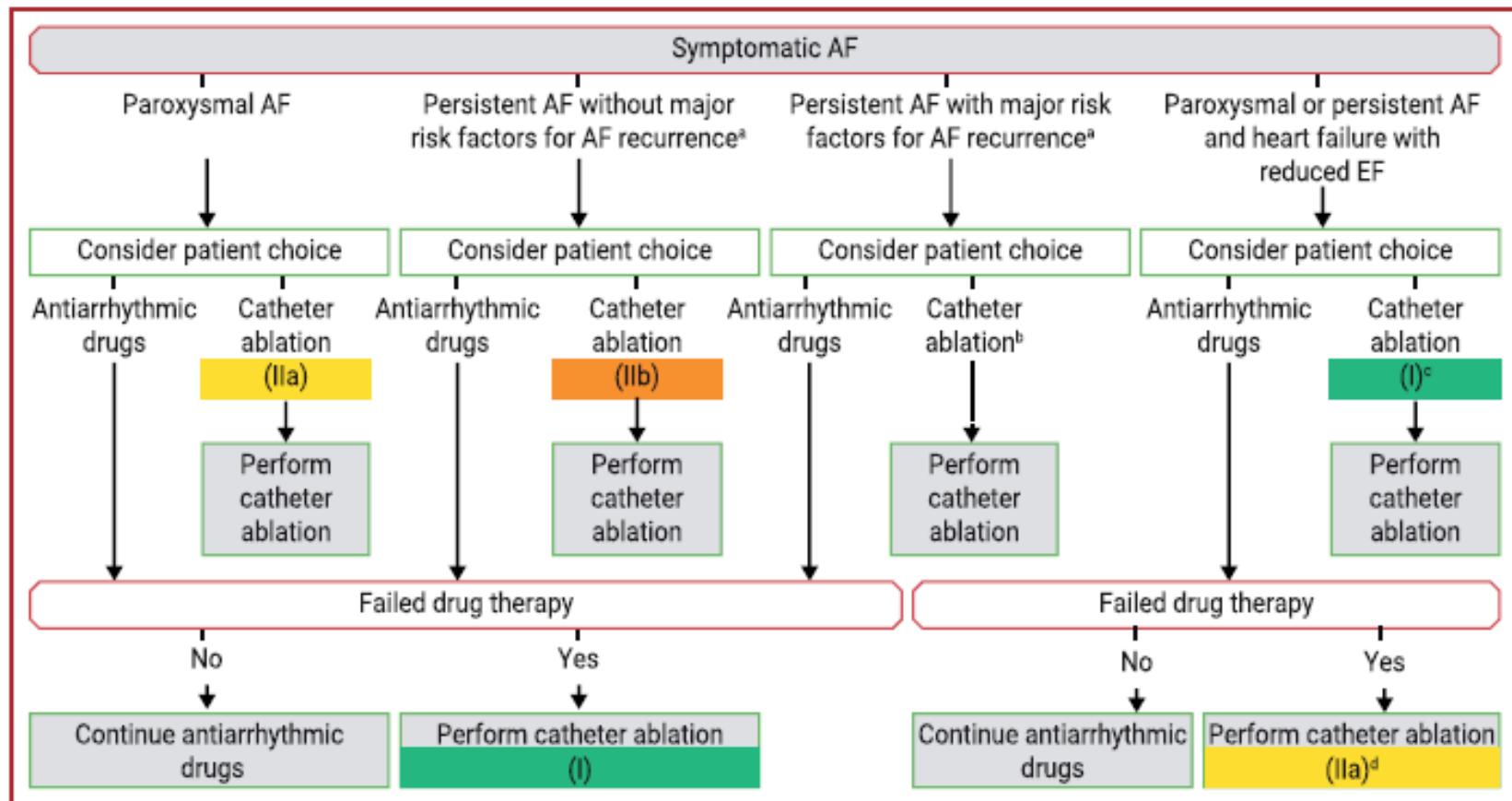
Table 3. Safety Outcomes.*

Outcome	Early Rhythm Control (N = 1395)		Usual Care (N = 1394)
	number (percent)		
Primary composite safety outcome	231 (16.6)		223 (16.0)
Stroke	40 (2.9)	p = 0,03	62 (4.4)
Death	138 (9.9)		164 (11.8)
Serious adverse event of special interest related to rhythm-control therapy	68 (4.9)		19 (1.4)
Serious adverse event related to antiarrhythmic drug therapy			
Nonfatal cardiac arrest	1 (0.1)		1 (0.1)
Toxic effects of atrial fibrillation–related drug therapy	10 (0.7)		3 (0.2)
Drug-induced bradycardia	14 (1.0)		5 (0.4)
Atrioventricular block	2 (0.1)		0
Torsades de pointes tachycardia	1 (0.1)		0
Serious adverse event related to atrial fibrillation ablation			
Pericardial tamponade	3 (0.2)		0
Major bleeding related to atrial fibrillation ablation	6 (0.4)		0
Nonmajor bleeding related to atrial fibrillation ablation	1 (0.1)		2 (0.1)
Other serious adverse event of special interest related to rhythm-control therapy			
Blood pressure–related event†	1 (0.1)		0
Hospitalization for atrial fibrillation	11 (0.8)		3 (0.2)
Other cardiovascular event	5 (0.4)		1 (0.1)
Other event	1 (0.1)		3 (0.2)
Syncope	4 (0.3)		1 (0.1)
Hospitalization for worsening of heart failure with decompensated heart failure	3 (0.2)		0
Implantation of a pacemaker, defibrillator, cardiac resynchronization device, or any other cardiac device	8 (0.6)		4 (0.3)

Table 3. Safety Outcomes.*

Outcome	Early Rhythm Control (N = 1395)		Usual Care (N = 1394)
	number (percent)		
Primary composite safety outcome	231 (16.6)		223 (16.0)
Stroke	40 (2.9)	p = 0,03	62 (4.4)
Death	138 (9.9)		164 (11.8)
Serious adverse event of special interest related to rhythm-control therapy	68 (4.9)		19 (1.4)
Serious adverse event related to antiarrhythmic drug therapy			
Nonfatal cardiac arrest	1 (0.1)		1 (0.1)
Toxic effects of atrial fibrillation–related drug therapy	10 (0.7)		3 (0.2)
Drug-induced bradycardia	14 (1.0)		5 (0.4)
Atrioventricular block	2 (0.1)		0
Torsades de pointes tachycardia	1 (0.1)		0
Serious adverse event related to atrial fibrillation ablation			
Pericardial tamponade	3 (0.2)		0
Major bleeding related to atrial fibrillation ablation	6 (0.4)		0
Nonmajor bleeding related to atrial fibrillation ablation	1 (0.1)		2 (0.1)
Other serious adverse event of special interest related to rhythm-control therapy			
Blood pressure–related event†	1 (0.1)		0
Hospitalization for atrial fibrillation	11 (0.8)		3 (0.2)
Other cardiovascular event	5 (0.4)		1 (0.1)
Other event	1 (0.1)		3 (0.2)
Syncope	4 (0.3)		1 (0.1)
Hospitalization for worsening of heart failure with decompensated heart failure	3 (0.2)		0
Implantation of a pacemaker, defibrillator, cardiac resynchronization device, or any other cardiac device	8 (0.6)		4 (0.3)

Recommendations



©ESC 2020



ESC

European Society of Cardiology

European Heart Journal (2020) 42, 373–498
doi:10.1093/eurheartj/ehaa612

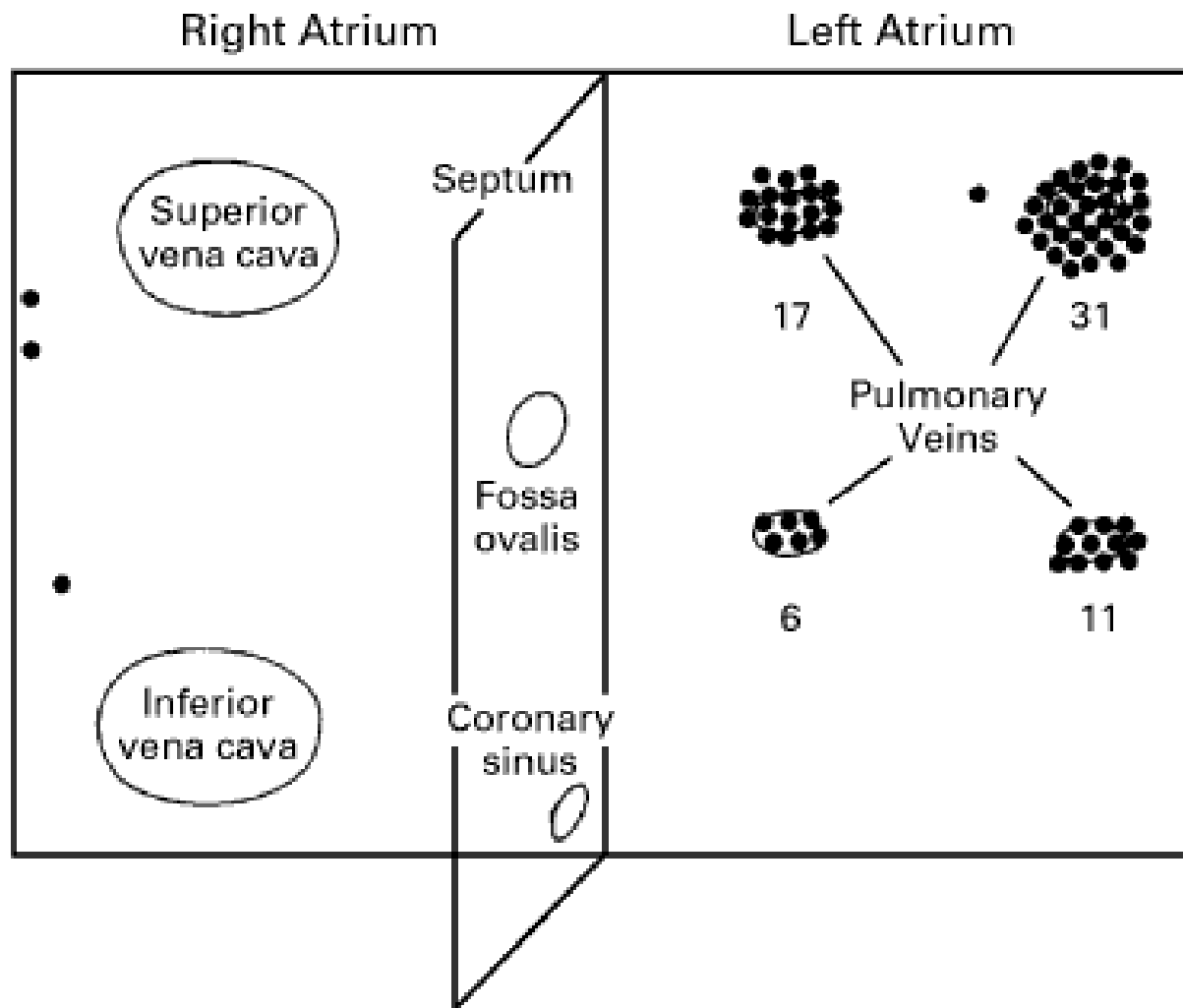
ESC GUIDELINES

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

Recommandations

L'isolation des VP reste la pierre angulaire de l'ablation par cathéter

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	A
If patient has history of CTI-dependent AFL or if typical AFL is induced at the time of AF ablation, delivery of a CTI lesion may be considered. 731–733,819–821	IIb	B
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	IIb	B



Radiofréquence

Ablation par radiofréquence

- Couplée à un système de cartographie
- Efficacité des points d'ablation dépendant de plusieurs facteurs

- Puissance en W
- Durée en s
- Force de contact avec tissu en g
- Stabilité du cathéter



=> ablation index

Ablation par radiofréquence

- Cathéters
 - irrigués
 - Capteur de force
 - Détectés par 3D



Ablation par radiofréquence

- Ablation « point par point » avec points contigus

Pulmonary vein isolation using ablation index vs. CLOSE protocol with a surround flow ablation catheter

Benjamin Berte^{1*}, Gabriella Hilfiker¹, Federico Moccetti¹, Thomas Schefer¹, Vanessa Weberndörfer¹, Florim Cuculi¹, Stefan Toggweiler¹, Frank Ruschitzka², and Richard Kobza¹



Ablation par radiofréquence

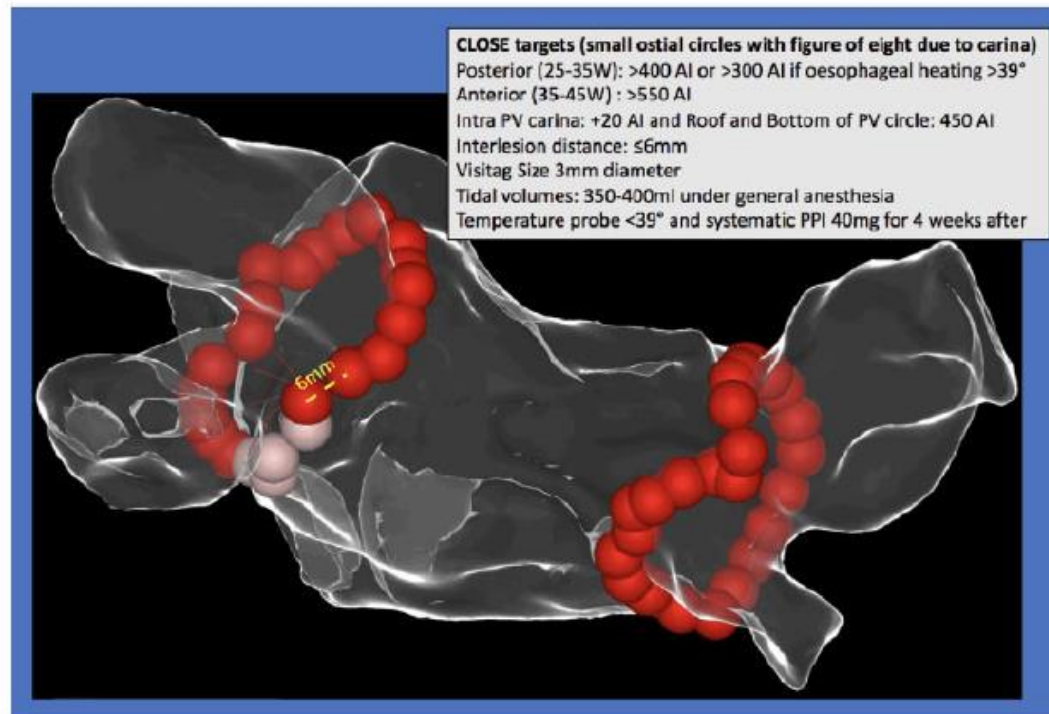


Figure 1 The CLOSURE protocol. Posterior view, glass-mode, using the CARTO 3 system and the CLOSURE protocol. Yellow dotted line shows inter Visitag (3 mm size) lesion distance which is measured between each point and which should be max 6 mm. AI, ablation index; PV, pulmonary vein; PPI, proton pump inhibitor.



ESC

European Society
of Cardiology

Europace (2020) 22, 84–89
doi:10.1093/europace/euz244

Ablation par radiofréquence

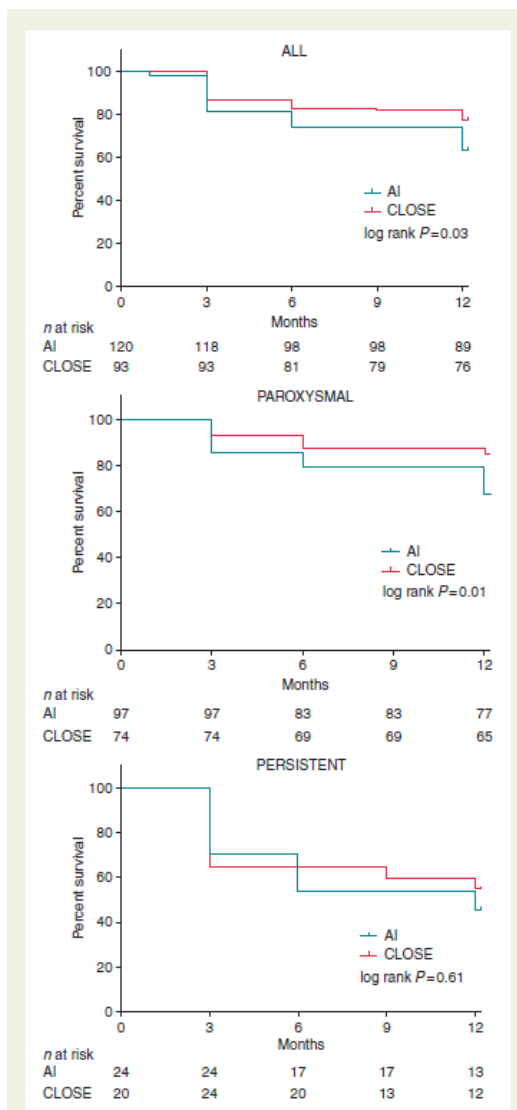


Figure 3 Kaplan-Meier curves of the follow-up. AI, ablation index.

Conclusion

The CLOSE protocol is more efficient than a PVI approach solely using AI, especially in paroxysmal AF. The use of a surround flow CF catheter appears to be safe using the conventional CLOSE targets.



Ablation par radiofréquence

- Limites
 - Taux de succès 70 à 80% sur les formes paroxystique (PVI)
 - Moindre sur les formes persistantes (40-70% selon l'ancienneté de la FA et le remodelage atrial)
 - Récidives sous forme de Flutters

Ablation par radiofréquence

- Complications = communes à toutes les techniques d'ablation de FA
 - Tamponnade / effusions péricardique (transeptal) => ETO
 - Risque thromboembolique / AVC => AOD / AVK en continu, HNF avec monitoring très rapproché des ACT
 - Point de ponction => ponction sous échoguidage

Ablation par radiofréquence

- Complications = rares mais spécifiques à la RF
 - Sténoses des veines pulmonaires
 - Risque de fistule atrio-oesophagienne

Risque de sténoses des VP

- Le plus souvent ASYMPTOMATIQUE
- Dyspnée
- Hémoptysie
- Cas extrêmes = greffes cœur / poumons

Risque de sténoses des VP

- Moins de risque en réalisant une ablation plus «antrale»
- Pas trop antrale au risque de former des «corridors» dans l'OG propices aux flutters gauches

Fistule atrio oesophagienne

- Complication redoutable
- Rare 1/1.000 à 1/10.000
- Fatale dans 60 à 80% des cas

Fistule atrio oesophagienne

- Délai médian d'apparition des symptômes = 21 jours [2-63]
- Présentations cliniques variées
- Tableaux neurologiques (embolies gazeuses, coma, AVC, convulsions)
- Parfois fébriles (inconstant)
- Symptômes digestifs (hémorragies digestives)

Fistule atrio oesophagienne

- Selon une étude allemande, 47 % des patients développeraient des lésions ulcéreuses œsophagiennes après ablation. Le plus souvent bénignes, évoluent spontanément vers la guérison.
- **Physiopathologie de la FAO**
- Rapport anatomique étroit entre l'œsophage et le mur postérieur de l'oreillette gauche
- Mécanisme exact de la formation des lésions œsophagiennes mal compris.
- Apparition différée des lésions œsophagiennes pas en faveur d'un mécanisme lésionnel thermique pur.
- Plusieurs facteurs semblent concourir à l'apparition des lésions :
 - **les lésions de la muqueuse œsophagienne** liées à :
 - des lésions thermiques ,
 - à une ischémie du mur antérieur de l'œsophage favorisée par l'occlusion des artères vascularisant l'œsophage
 - **le reflux gastro-œsophagien** favorisé par les lésions des nerfs péri-œsophagiens au cours de l'ablation
 - **la dysmotilité œsophagienne**, type de germes

Fistule atrio-oesophagienne



ESC

European Society
of Cardiology

European Heart Journal (2023) **44**, 2458–2469

<https://doi.org/10.1093/eurheartj/ehad250>

FASTTRACK CLINICAL RESEARCH

Arrhythmias

**A worldwide survey on incidence,
management, and prognosis of oesophageal
fistula formation following atrial fibrillation
catheter ablation: the POTTER-AF study**

Fistule atrio-oesophagienne

Prognosis following oesophageal fistula formation in patients undergoing catheter ablation for AF The POTTER-AF Study

553 729 procedures in
214 centers from
35 countries



138 oesophageal fistulae

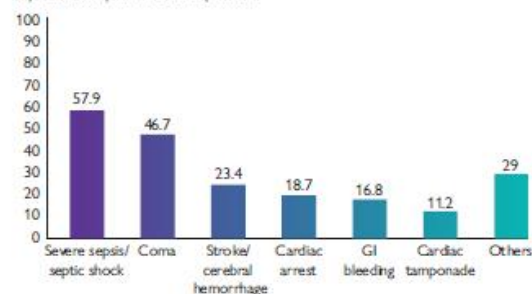
Total incidence: 0.025%
Radiofrequency: 0.038%
Cryoballoon: 0.0015% } $p < 0.001$



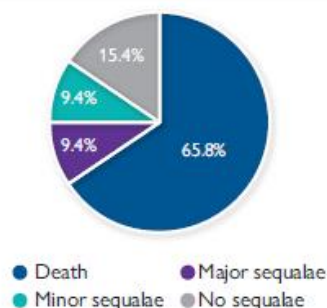
POTTER-AF

Complications

Reported complications, % of patients



Outcome



Factors associated with survival

Use of an oesophageal temperature probe
OR: 0.231 (95% CI: 0.074, 0.724),
 $p = 0.012$

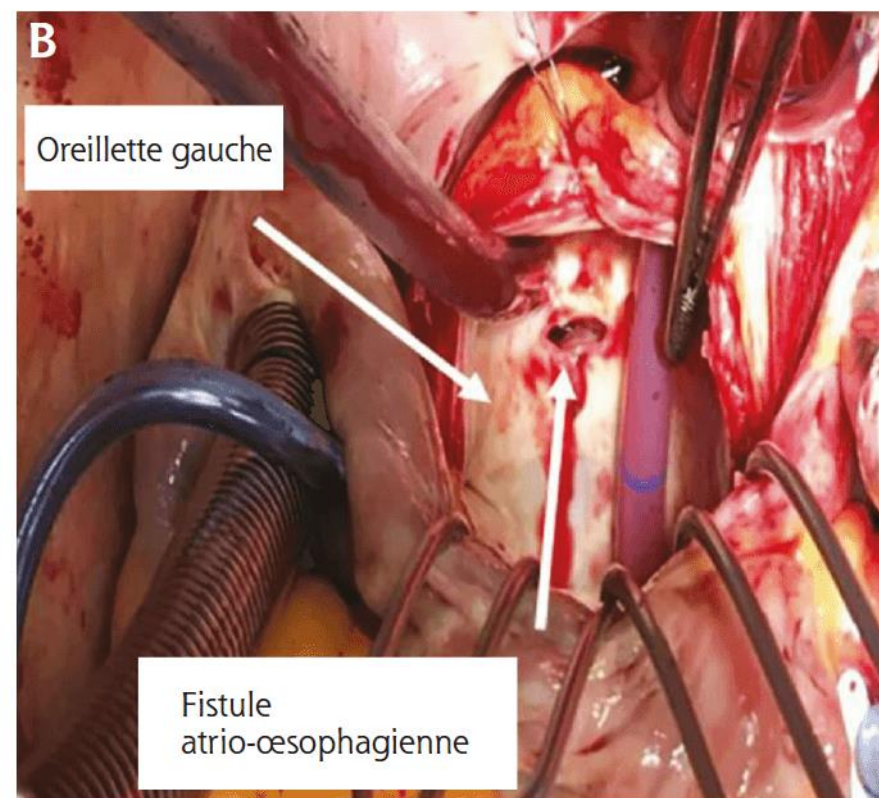
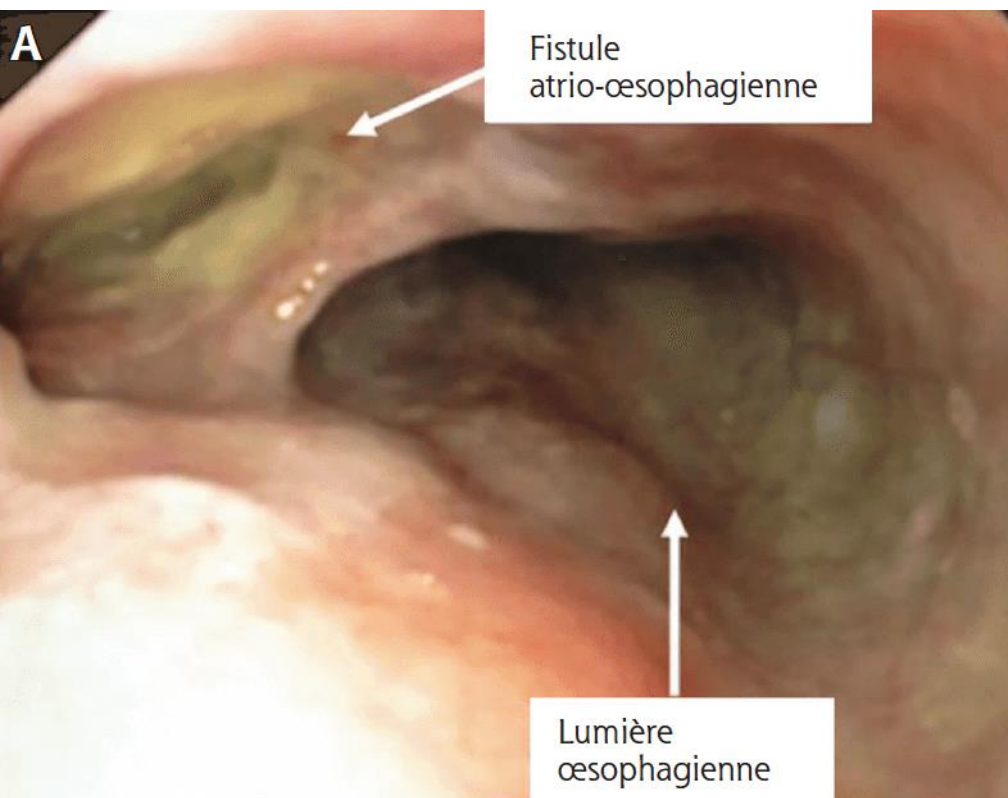
Treatment by oesophageal surgery
OR: 0.329 (95% CI: 0.123, 0.881),
 $p = 0.027$

Type of anesthesia: conscious sedation
OR: 0.229 (95% CI: 0.060, 0.865)
 $p = 0.030$

Fistule atrio-oesophagienne

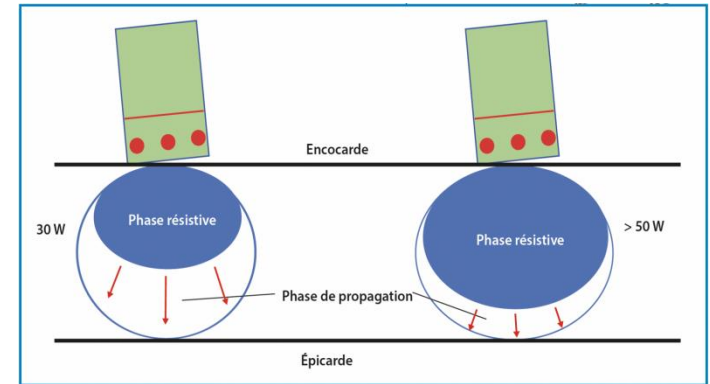
- Sonde thermique utilisée chez 24% des patients ayant développé une FAO
- IPP chez 74% d'entre
- Faible puissance 30 W en moyenne

Fistule atrio oesophagienne



Radiofréquence « haute puissance »

- Haute puissance 45 / 50 W
- Temps de tirs plus courts
- Stabilité du cathéter
- Lésions plus rapidement transmurales (« phase résistive » du tir de RF)
- Lésion moins profonde (« phase de propagation », moins de risque d'obtenir des lésions extra-murales)



Cryoablation

New Advancements in Pulmonary Vein Isolation

Arctic Front Advance™ Cryoballoon



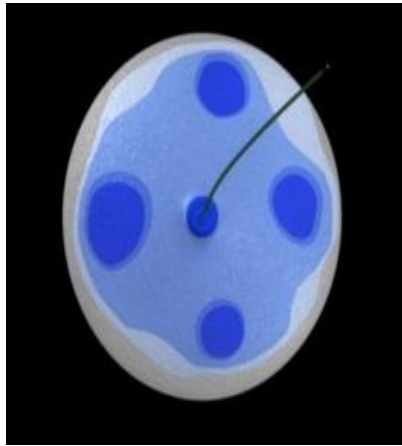
EvenCool™ Cryo Technology provides an improved cooling uniformity

Designed to provide a more contiguous lesion and treat a broader range of pulmonary vein anatomies

Improved Temperature Uniformity with Arctic Front Advance™ Cryoballoon

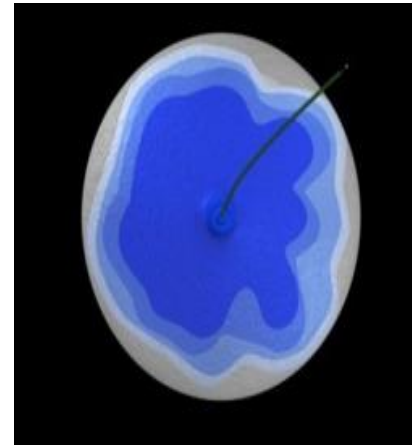
Surface temperature is 83% more uniform for the 28 mm balloon

Arctic Front™

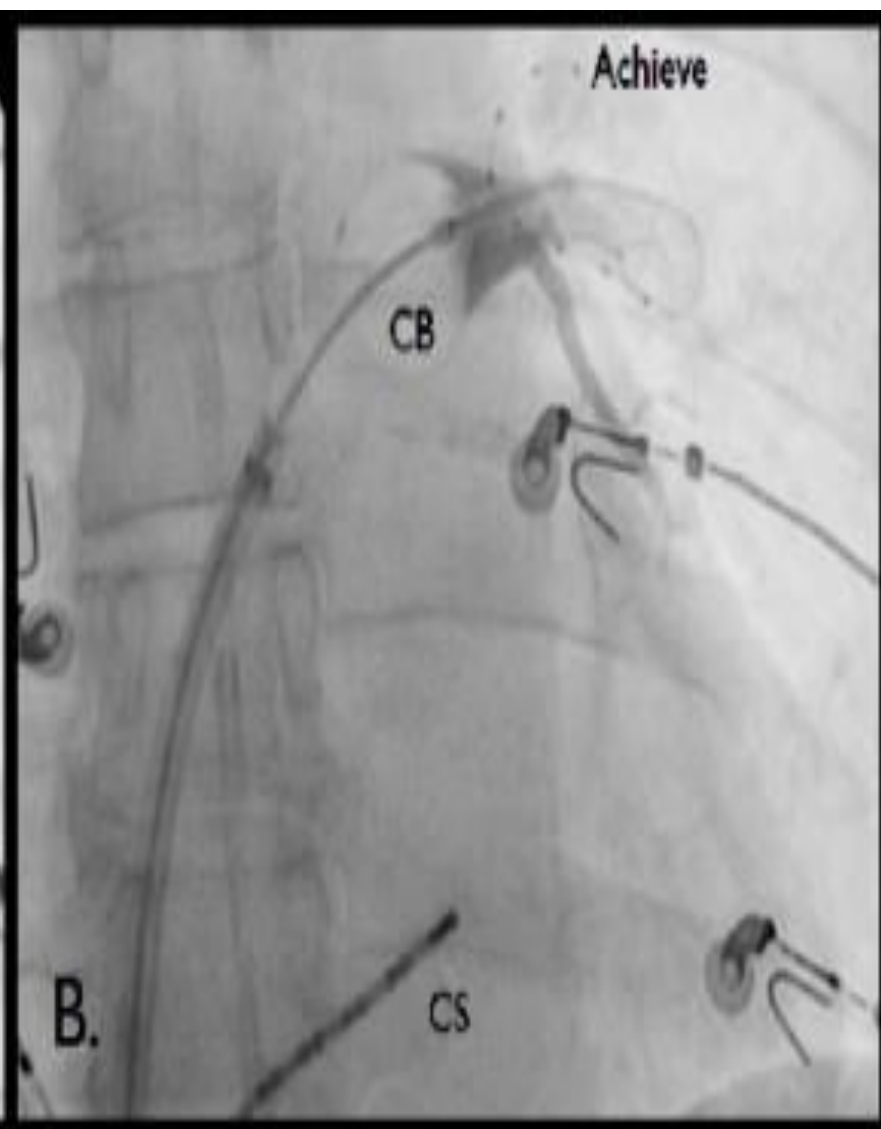
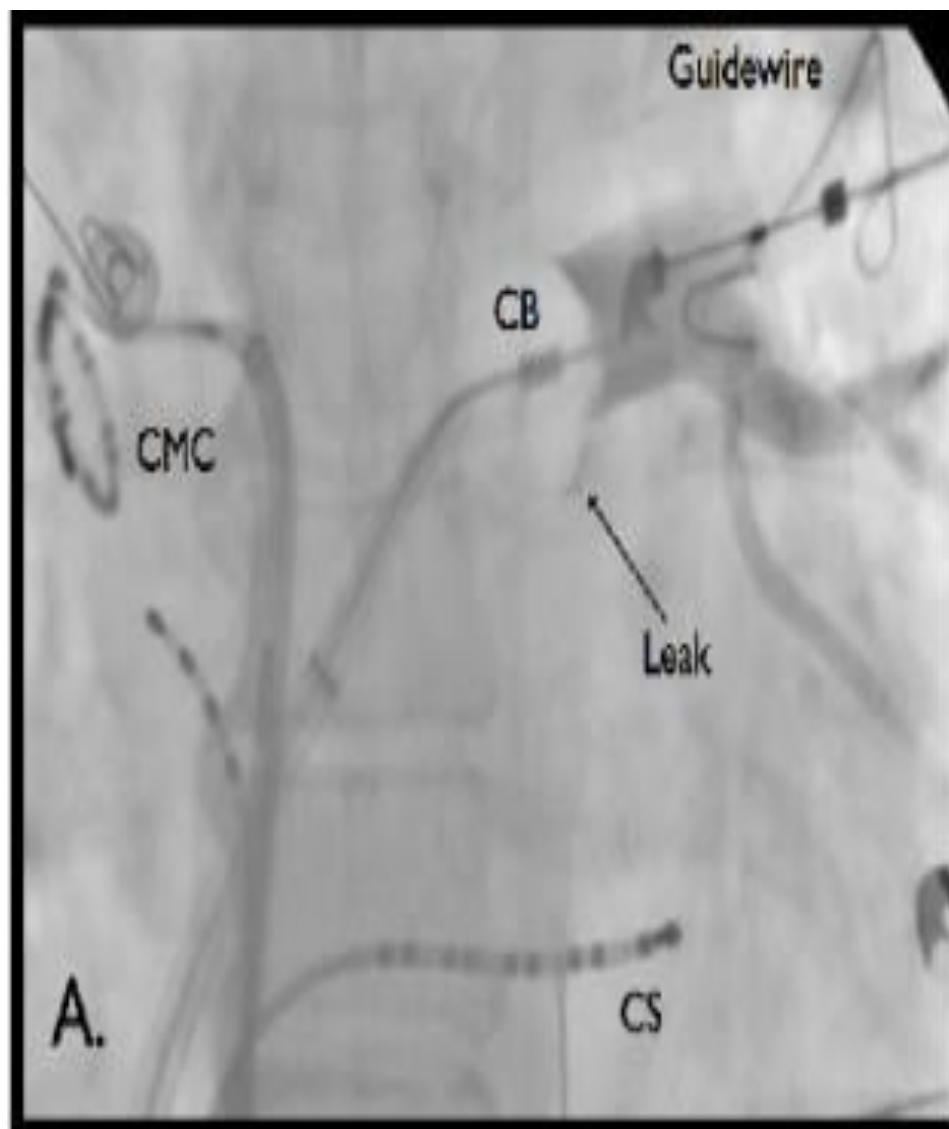


Refrigerant distribution near equator of balloon

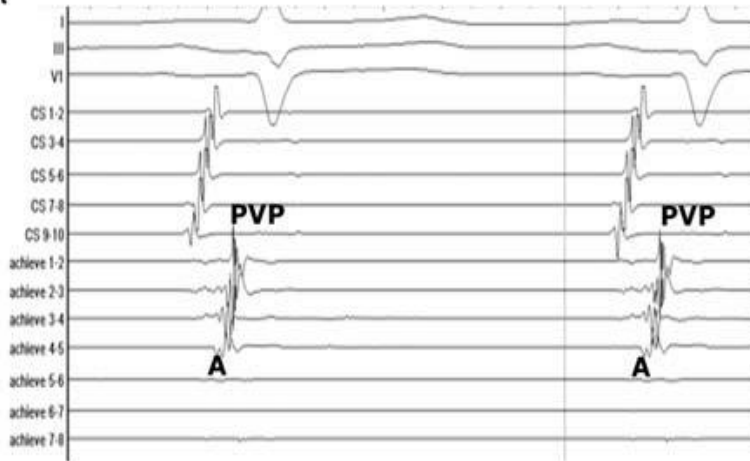
Arctic Front Advance™



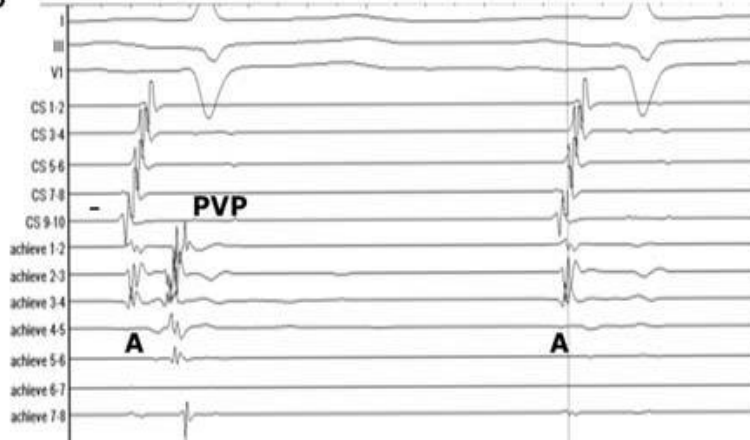
Improved surface temperature gradient and anterior cooling



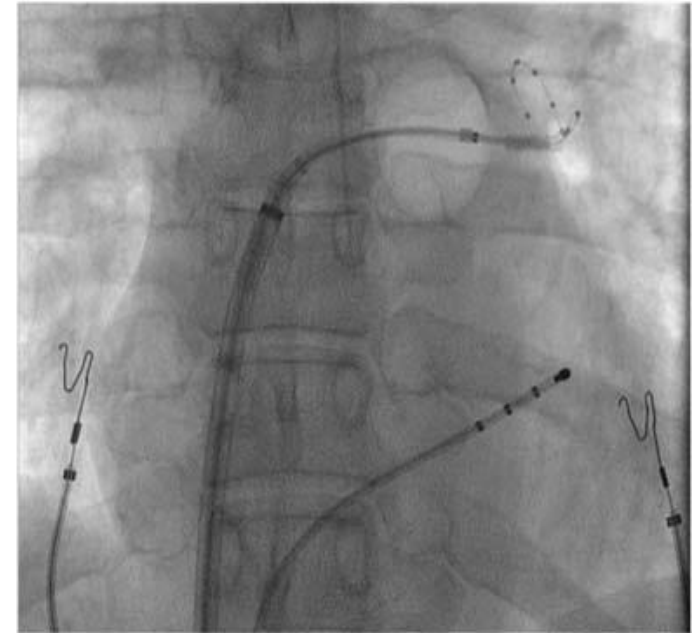
A



B



C



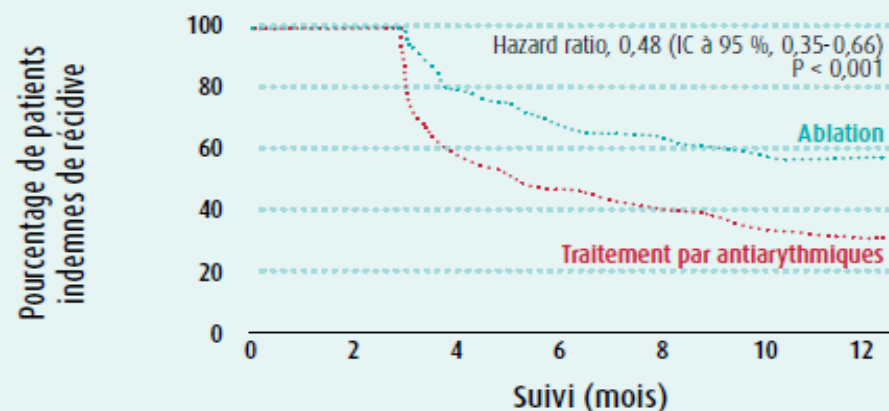
Qu'en est-il des études ??

Tableau 1. Études randomisées contrôlées comparant la PVI au cryoballon par rapport aux antiarythmiques comme traitement de première ligne d'une FA

	EARLY-AF ¹⁴	STOP AF First ¹⁵	Cryo-FIRST ¹⁶
Région	Canada	États-Unis	Europe, Australie, Amérique latine
Nombre de patients inclus	303	203	220
Suivi	<i>Internal loop recorder</i>	Holter de 24 h tous les 6 mois, suivi transtéléphonique	Holter de 7 jours tous les 3 mois
Absence de l'arythmie auriculaire après 12 mois	57,1 % vs 32,2 % (P < 0,001)	74,6 % vs 45,0 % (P < 0,001)	82,2 % vs 67,6 % (P = 0,01)
Asymptomatique après 12 mois	85,1 % vs 73,2 %	Non étudié	86,5 % vs 70,4 %
Complications	14 patients (9,1 %) vs 24 patients (16,1 %)	15 patients (14 %) vs 14 patients (14 %)	26 patients (24,3 %) vs 37 patients (33 %)

Figure 1. Critères d'évaluation principaux des études randomisées contrôlées comparant la PVI au cryoballon par rapport aux antiarythmiques comme traitement de première ligne d'une FA

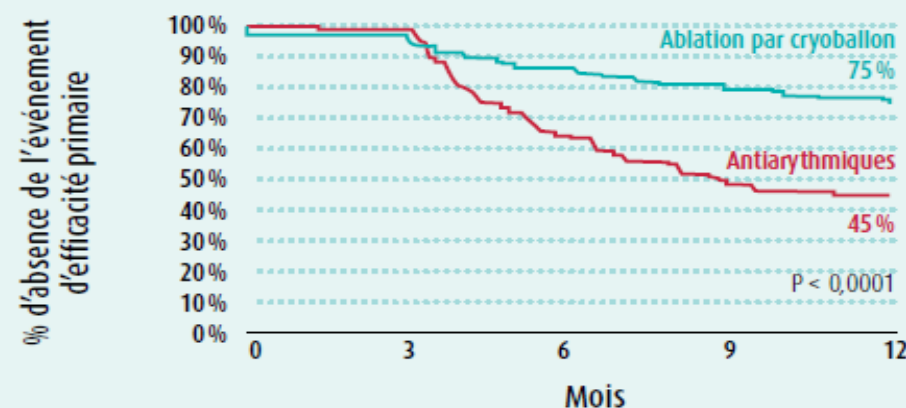
EARLY-AF



Nombre de patients à risque

Ablation	154	154	123	105	96	86	55
Traitement par antiarythmiques	149	149	89	69	60	49	27

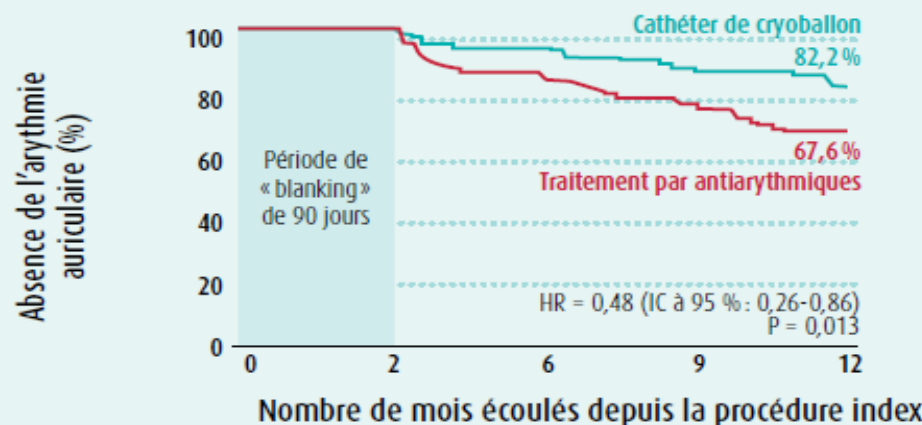
STOP AF First



Nombre de patients à risque

Ablation par cryoballon	104	99	88	81	70
Antiarythmiques	99	93	60	44	39

Cryo-FIRST



Nombre de sujets à risque

Cathéter de cryoballon	107	94	88	80	53
Traitement par antiarythmiques	111	104	86	75	38

Cryo - First

Table 4 Serious adverse events

Adverse event, events (subjects)	Cryoballoon CA (n = 107)			AAD (n = 111)		
	All	Procedure related	System related	All	Drug related	Procedure related (cross over)
Total	42 (26)	11 (9)	2 (1)	56 (37)	4 (4)	1 (1)
Acute coronary syndrome	0	0	0	1 (1)	0	0
Acute kidney injury	0	0	0	1 (1)	0	0
Adverse drug reaction	0	0	0	3 (3)	2 (2)	0
Arteriospasm coronary	1 (1)	1 (1)	0	0	0	0
Atrial arrhythmia recurrence	15 (11)	1 (1)	0	34 (28)	2 (2)	0
AVNRT	1 (1)	0	0	0	0	0
Bronchitis	1 (1)	0	0	0	0	0
Chest pain	1 (1)	0	0	0	0	0
Gastrointestinal pain	1 (1)	0	0	0	0	0
Impaired gastric emptying	1 (1)	1 (1)	0	1 (1)	0	0
Impaired healing	0	0	0	1 (1)	0	0
Lung disorder/infection	4 (1)	1 (1)	0	0	0	0
Non-sustained ventricular tachycardia	0	0	0	1 (1)	0	0
Oedema peripheral	0	0	0	1 (1)	0	0
Orthostatic hypotension	0	0	0	1 (1)	0	0
Palpitations	0	0	0	1 (1)	0	0
Pericardial disorder ^a	3 (3)	3 (3)	1 (1)	0	0	0
Phrenic nerve paralysis	0	0	0	1 (1) ^b	0	1 (1)
Pneumonia	1 (1)	0	0	0	0	0
Procedural failure ^c	1 (1)	1 (1)	0	0	0	0
Pyrexia	1 (1)	1 (1)	0	0	0	0
Syncope	0	0	0	1 (1)	0	0
Transient ischaemic attack	1 (1)	1 (1)	1 (1)	0	0	0
Vascular access site haemorrhage	1 (1)	1 (1)	0	0	0	0
Other	9 (9)	0	0	9 (7)	0	0

Atrial arrhythmia recurrence was only classified as a serious adverse event if it resulted in hospitalization.

^aNone of these events resulted in cardiac tamponade.

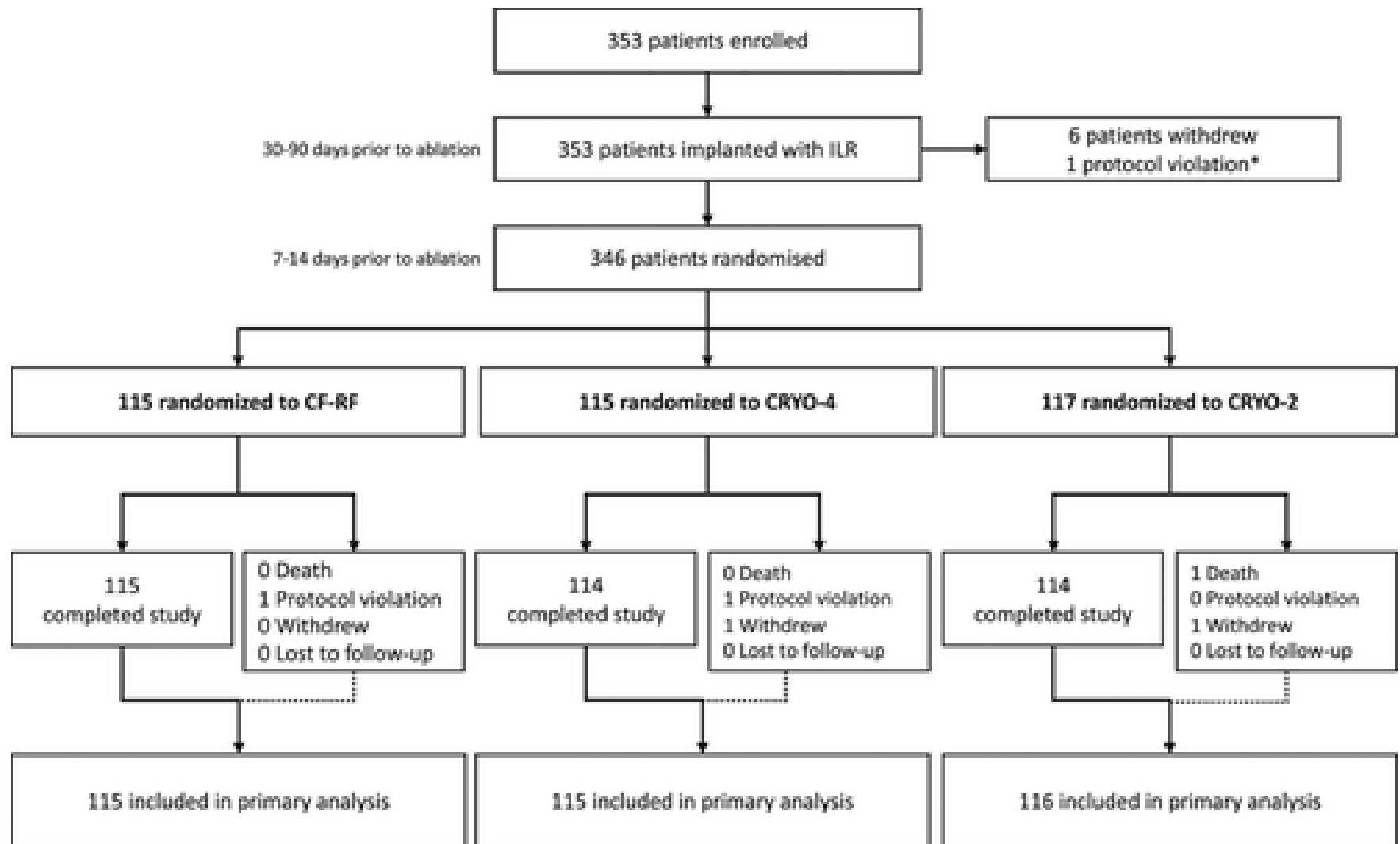
^bTransient phrenic nerve palsy was experienced by one subject randomized to AAD who underwent CA.

^cFailure of the transseptal puncture was observed in one subject randomized to cryoballoon; a second procedure was successful. AAD, antiarrhythmic drug; AVNRT, atrioventricular nodal reentry tachycardia; CA, catheter ablation.

Cryoablation

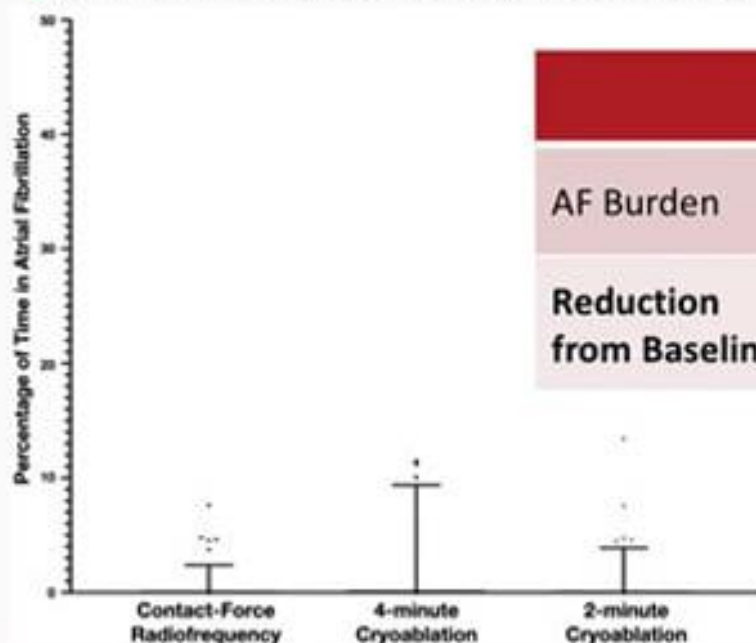
- Risque de paralysie phrénique +++
- Monitoring du pacing phrénique (VCS / OD latérale haute)
- Paralysie phrénique transitoire 5 à 6 % des cas
- 0.5 à 3 % de paralysie persistante selon les séries

CIRCA-DOSE



Atrial Fibrillation Progression After Cryoablation vs. Radiofrequency Catheter Ablation

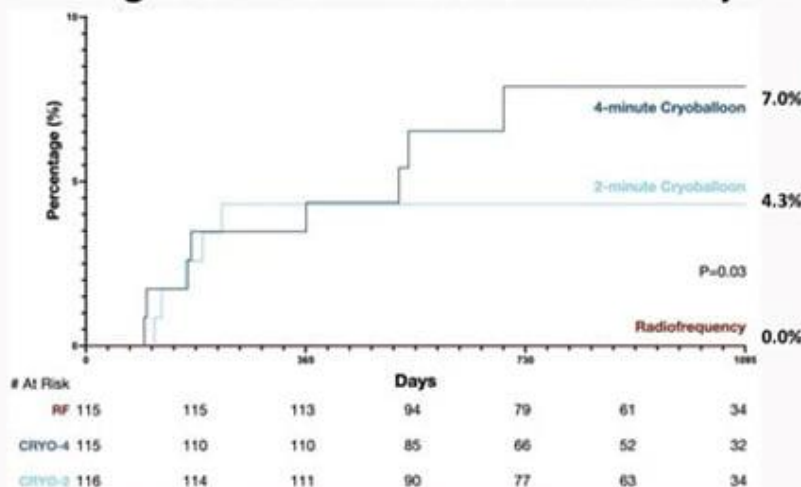
- Atrial Tachyarrhythmia Burden (% Time in AF)



	CF-RF	CRYO-4	CRYO-2
AF Burden	0.00 (0.00, 0.12)	0.00 (0.00, 0.19)	0.00 (0.00, 0.12)
Reduction from Baseline	99.5% (94.0%, 100.0%)	99.9% (93.3%, 100.0%)	99.1% (87.0%, 100.0%)

Atrial Fibrillation Progression After Cryoablation vs. Radiofrequency Catheter Ablation

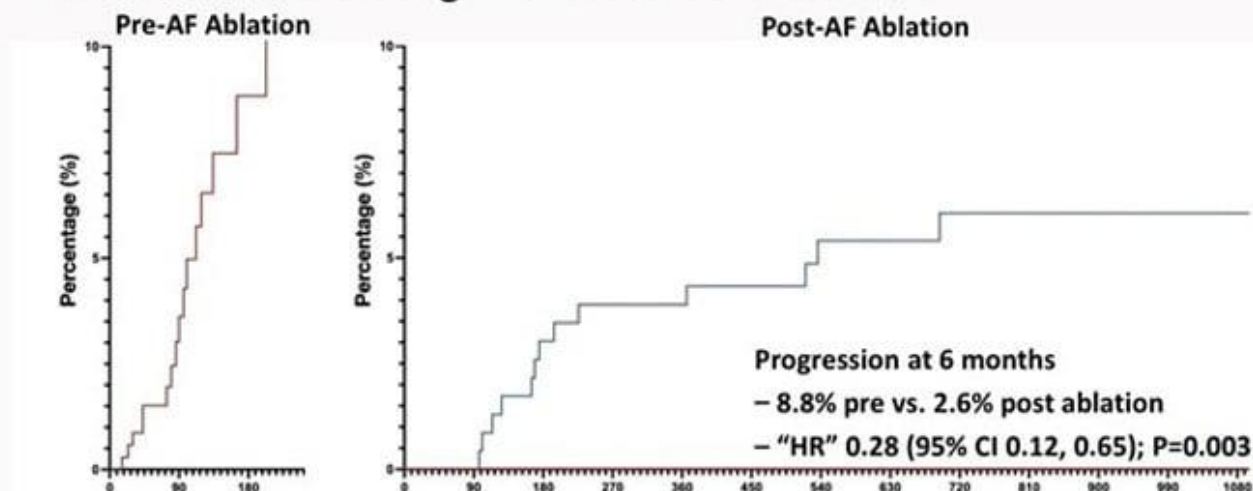
• Progression to Persistent Atrial Tachyarrhythmia



	HR (95%CI)	P
CRYO-4 vs. CF-RF	17.73* (2.21, 2293.41)	0.003
CRYO-2 vs. CF-RF	7.737# (1.934-30.96)	0.004
CRYO-4 vs. CRYO-2	11.06* (1.25, 1452.01)	0.027
CRYO-2 vs. CRYO-4	7.455# (1.291-43.04)	0.025

Atrial Fibrillation Progression After Cryoablation vs. Radiofrequency Catheter Ablation

• Atrial Fibrillation Progression Pre-Post Ablation



Électroporation : l'avenir ?

Electroporation

- Qu'est ce que c'est ?

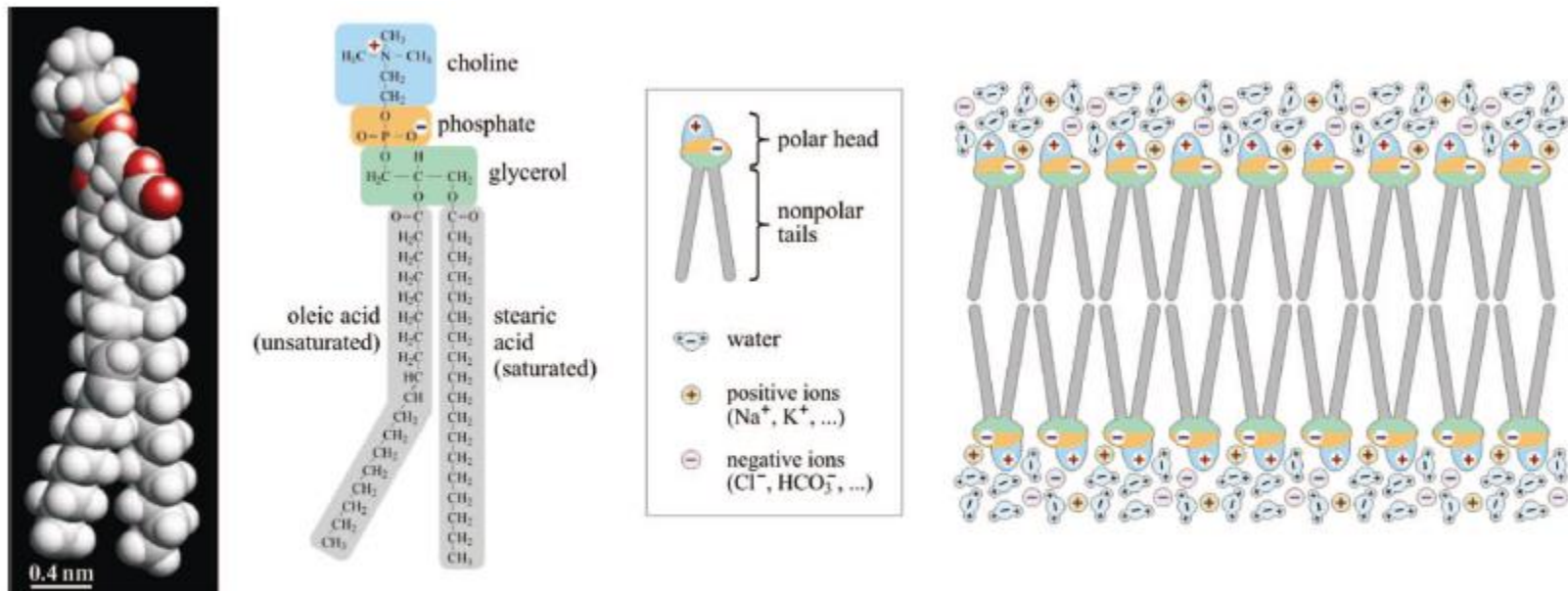


Figure 1. Left: space-filling model and structural formula of the SOPC (1-stearoyl-2-oleoyl-phosphatidylcholine) molecule, a typical membrane lipid. Right: a bilayer of such lipids in an aqueous electrolyte solution.

Electroporation

- Qu'est ce que c'est ?

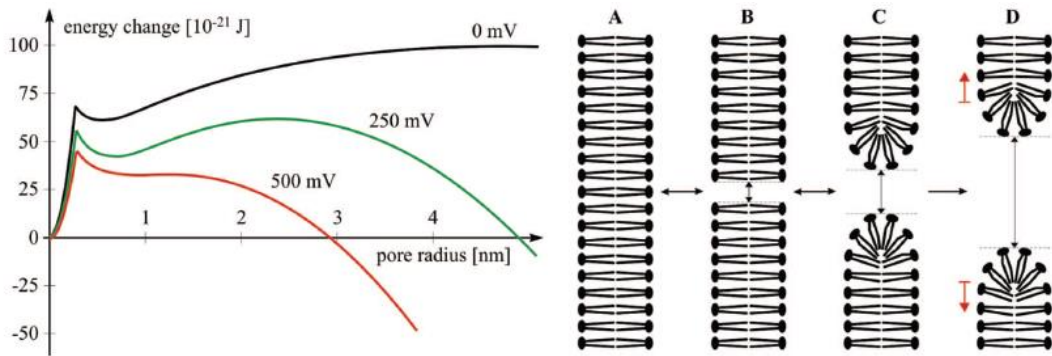


Figure 3. Left: change in lipid bilayer energy caused by formation of an aqueous pore, plotted as a function of the pore radius and voltage across the bilayer. Right: bilayer without pores (A), with a hydrophobic pore (B), its reversible transition into a metastable hydrophilic pore (C), and its irreversible transition into an unstable self-expanding hydrophilic pore (D; at membrane voltages above ~ 500 mV).

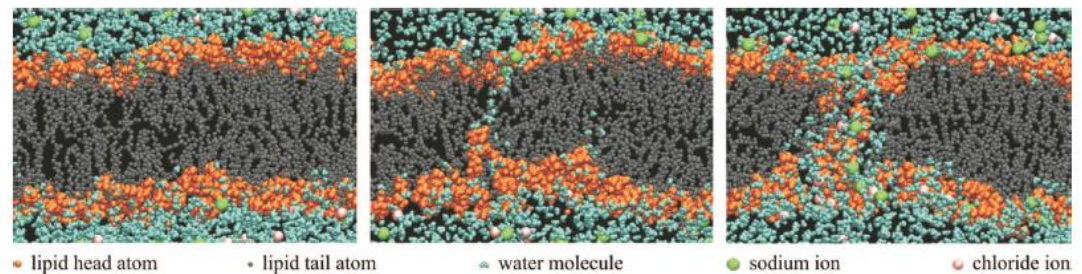


Figure 4. A molecular dynamics simulation of an aqueous pore forming in a lipid bilayer exposed to an electric field perpendicular to the bilayer plane. Left: the intact bilayer. Middle: water molecules penetrate the bilayer, forming a "water wire." Right: the adjacent lipids reorient with their heads toward the water molecules in the bilayer, stabilizing the aqueous pore and allowing the ions to enter.

Électroporation

- Champs électrique pulsé
- Selon caractéristiques

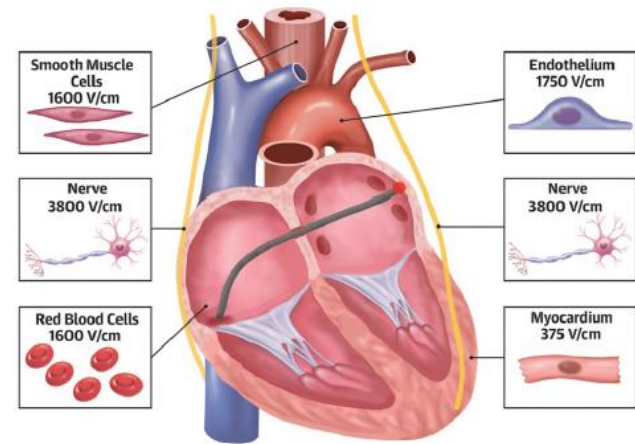
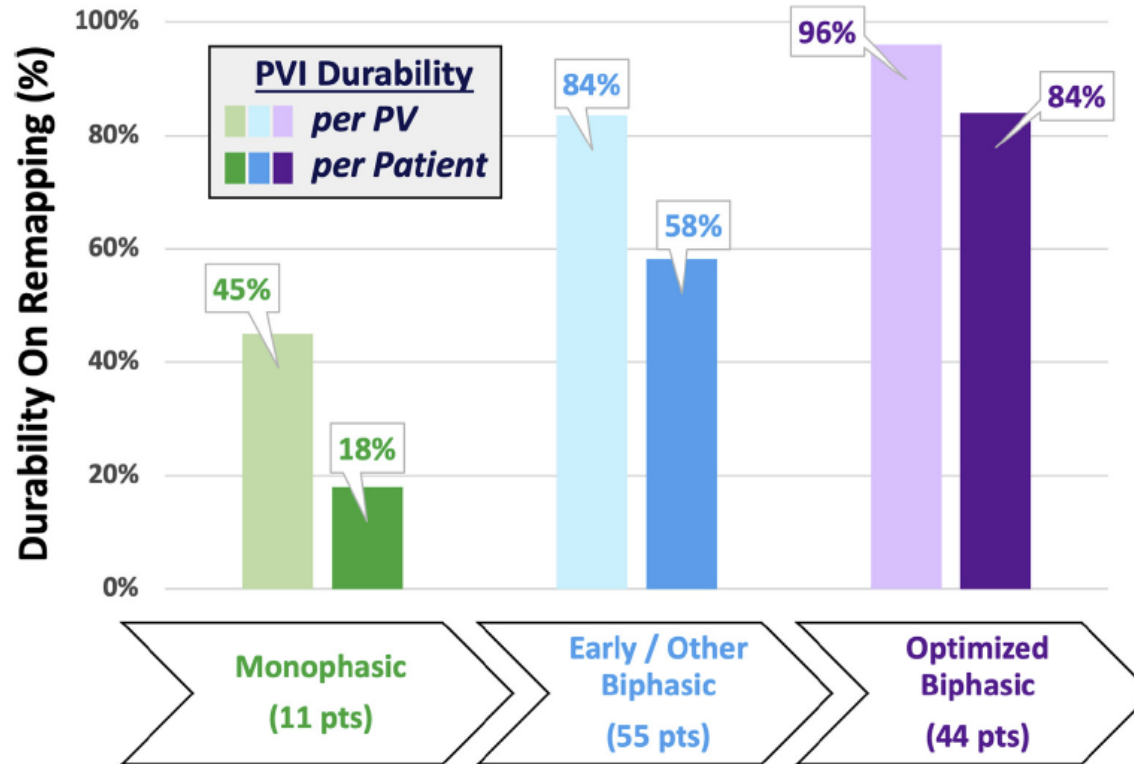


Fig. 6. Pulsed-field ablation (PFA) selectivity. PFA offers the potential to selectively target myocardial tissue while avoiding detrimental effects on nearby structures such as red blood cells, the phrenic nerve, the esophagus, or coronary vessels. Reprinted from JACC: EP, 33(7), Romero *et al.*, Pulsed-field ablation: What are the unknowns and when will they cease to concern us?, with permission from Elsevier [21].

- spécificité d'action selon le type de cellule
- Lésion réversibles / irréversibles

Électroporation

FIGURE 4 Durability of PV Isolation With Pulsed Field Ablation

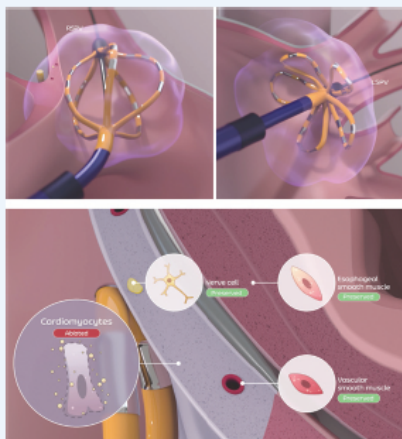


The durability of pulmonary vein isolation (PVI) improved with modification of energy delivery waveforms from a monophasic waveform to nonoptimized biphasic waveform, and increased further with the final optimized biphasic waveform.

Électroporation

CENTRAL ILLUSTRATION PFA for Paroxysmal AF

PFA Catheter & Mechanism of Ablation



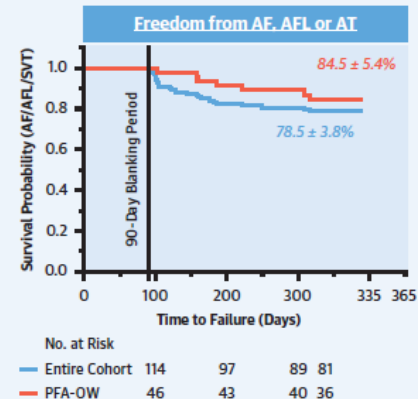
Safety

• Esophageal Damage	0%
◦ Esophageal Dysmotility	0%
◦ Atrioesophageal Fistula	0%
• Pulmonary Vein Stenosis	0%
• Phrenic Nerve Injury	0%
• Stroke	0%
◦ Transient Ischemic Attack	0.9%
• Pericardial Effusion	0.8%
• Vascular injury	1.7%
• Death	0%

Efficacy

Durability of PV Isolation (Invasive Remapping)

PFA Waveform	Per PV Basis		Per Pt Basis	
	No. %	Durable	No. %	Durable
All	429	84.8%	110	64.5%
PFA-OW	173	96.0%	44	84.1%



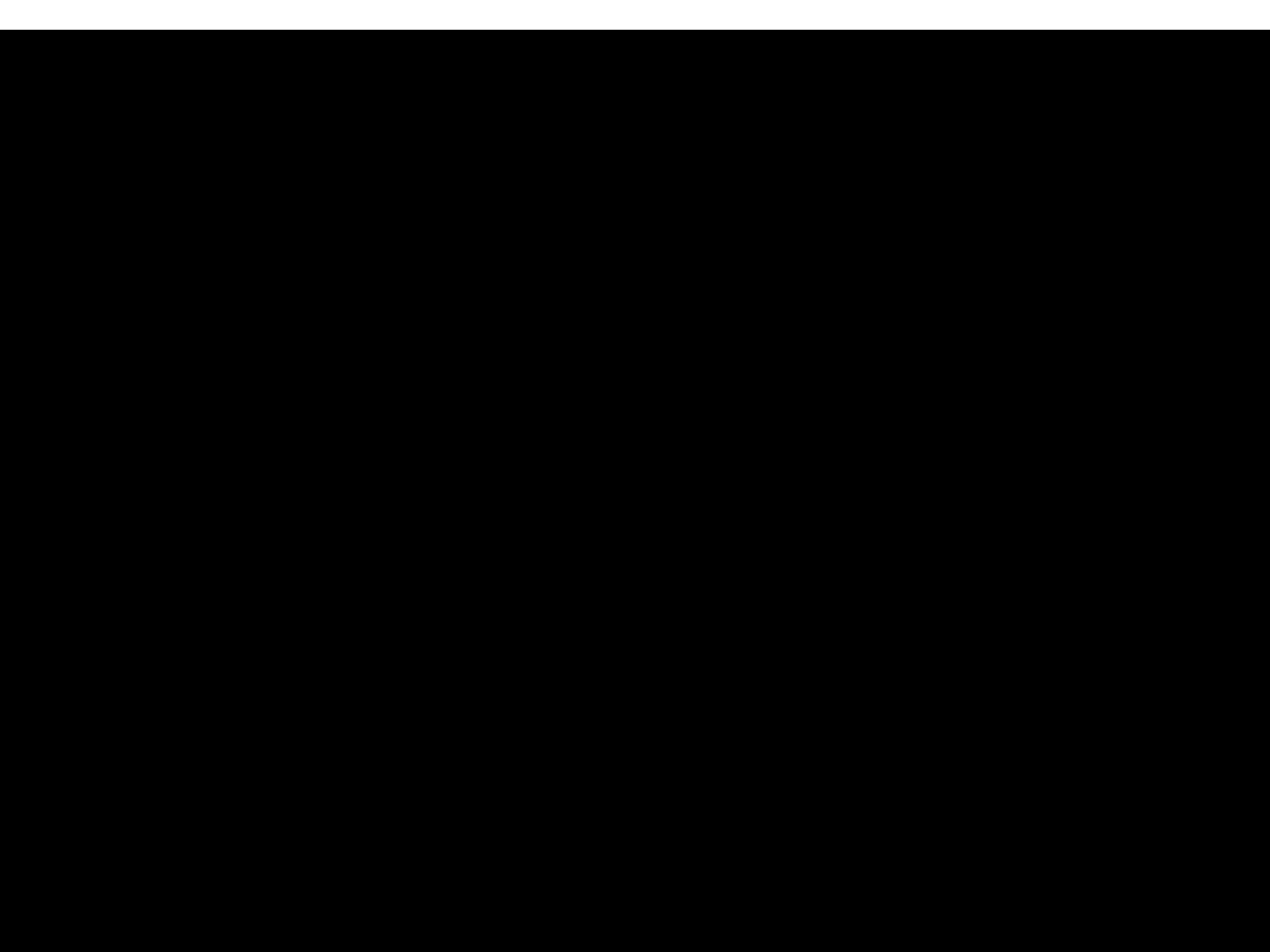
Reddy, V.Y. et al. J Am Coll Cardiol EP. 2021;7(5):614-27.

The pulsed field ablation (PFA) catheter can be positioned at the pulmonary vein (PV) ostium in a basket or flower petal configuration. The nonthermal ablative energy delivered by the electrodes produces micropores in the cardiomyocyte cell membrane, culminating in cell necrosis. As cardiomyocytes have a low energy threshold for pulsed electrical fields, there is preferential cardiomyocyte ablation, while sparing adjacent tissues—nerves, vessels, and esophagus. This resulted in a favorable safety profile. The durability of PV isolation (PVI) with PFA improved with successive modification of the waveform and optimization of delivery. The 1-year Kaplan-Meier (K-M) curves for freedom from arrhythmia are shown for the full cohort (blue line) and the optimized biphasic energy PFA waveform (PFA-OW) cohort (red line). AF = atrial fibrillation; AFL = atrial flutter; AT = atrial tachycardia; LSPV = left superior pulmonary vein; Pt = patient; RSPV = right superior pulmonary vein; SVT = supraventricular tachycardia.

Électroporation

TABLE 4 Summary of Additional Safety Assessments (N = 121)

	Number of Patients Assessed	Findings
Esophagus Findings		
EGD	38	No esophageal lesions
CMR	18	No esophageal enhancement
Phrenic nerve		
Fluoroscopy at end of procedure	121	No paresis/palsy
Fluoroscopy at ~3 months	110	
Brain MRI	18	16 of 18 (89) DW-negative*
PV stenosis		
EAM at ~3 months	110	No PV stenosis or narrowing
CT at ~3 months	74	
*1 patient with a history of TIAs experienced a TIA the day after the procedure, prompting a brain MRI, which revealed a small lesion on diffusion-weighted imaging but not FLAIR imaging. The other 17 brain MRIs revealed 1 patient with a DW-positive finding. CMR = cardiac magnetic resonance; CT = computed tomography; DW = diffusion weighted; EAM = electroanatomical mapping; EGD = esophagogastroduodenoscopy; MRI = magnetic resonance imaging; PV = pulmonary vein.		



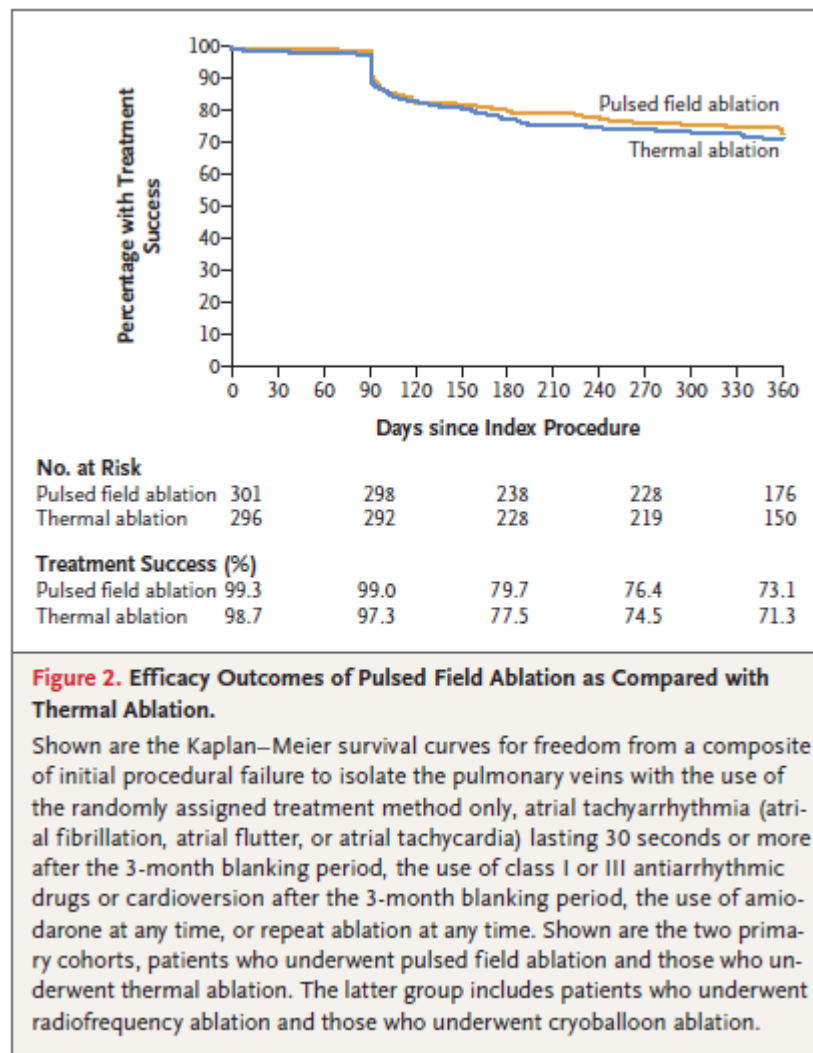
Électroporation

ORIGINAL ARTICLE

Pulsed Field or Conventional Thermal Ablation for Paroxysmal Atrial Fibrillation

Vivek Y. Reddy, M.D., Edward P. Gerstenfeld, M.D., Andrea Natale, M.D.,
William Whang, M.D., Frank A. Cuoco, M.D., Chinmay Patel, M.D.,
Stavros E. Mountantonakis, M.D., Douglas N. Gibson, M.D.,
John D. Harding, M.D., Christopher R. Ellis, M.D., Kenneth A. Ellenbogen, M.D.,
David B. DeLurgio, M.D., Jose Osorio, M.D., Anitha B. Achyutha, M.Tech., M.S.E.,
Christopher W. Schneider, M.Eng., Andrew S. Mugglin, Ph.D.,
Elizabeth M. Albrecht, Ph.D., Kenneth M. Stein, M.D.,
John W. Lehmann, M.D., M.P.H., and Moussa Mansour, M.D.,
for the ADVENT Investigators*

Électroporation



Électroporation

ORIGINAL RESEARCH ARTICLE



Safety and Effectiveness of Pulsed Field Ablation to Treat Atrial Fibrillation: One-Year Outcomes From the MANIFEST-PF Registry

Mohit K. Turagam¹, MD; Petr Neuzil², MD PhD; Boris Schmidt³, MD; Tobias Reichlin⁴, MD; Kars Neven, MD; Andreas Metzner, MD; Jim Hansen, MD; Yuri Blaauw, MD; Philippe Maury⁵, MD; Thomas Arentz, MD; Philipp Sommer, MD; Ante Anic⁶, MD; Frédéric Anselme⁷, MD; Serge Boveda⁸, MD, PhD; Tom Deneke⁹, MD; Stephan Willems, MD; Pepijn van der Voort, MD; Roland Tilz¹⁰, MD; Moritoshi Funasako, MD; Daniel Scherr, MD; Reza Wakili¹¹, MD; Daniel Steven¹², MD; Josef Kautzner¹³, MD; Johan Vijgen¹⁴, MD; Pierre Jais¹⁵, MD; Jan Petru, MD; Julian Chun¹⁶, MD; Laurent Roten¹⁷, MD; Anna Fütting¹⁸, MD; Marc D. Lemoine¹⁹, MD; Martin Ruwald, MD; Bart A Mulder²⁰, MD; Anne Rollin, MD; Heiko Lehrmann, MD; Thomas Fink, MD; Zrinka Jurisic²¹, MD; Corentin Chaumont²², MD; Raquel Adeliño²³, MD; Karin Nentwich²⁴, MD; Melanie Gunawardene²⁵, MD; Alexandre Ouss, MD; Christian-Hendrik Heeger²⁶, MD; Martin Manninger²⁷, MD; Jan-Eric Bohnen, MD; Arian Sultan, MD; Petr Peichl²⁸, MD; Pieter Koopman²⁹, MD; Nicolas Derval³⁰, MD; Thomas Kueffer³¹, MD; Gilbert Rahe, MD; Vivek Y. Reddy³², MD

Électroporation

Table 1. Baseline Characteristics

Characteristics	Patients with available data	Value
Age, n (%) / mean±SD	1568 (100)	64.5±11.5
Female, n (%)	1568 (100)	553 (35)
Atrial fibrillation type, n (%)		
Paroxysmal	1568 (100)	1021 (65)
Persistent	1568 (100)	498 (32)
Long-standing persistent	1568 (100)	49 (3)
CHA ₂ DS ₂ -VASc, n (%) / mean±SD	1568 (100)	2.2±1.6
Medical history		
Body mass index, n (%) / mean±SD	1554 (99.1)	28±5
Atrial flutter, n (%)	1235 (78.8)	158 (12.8)
Coronary artery disease, n (%)	1235 (78.3)	167 (13.5)
Diabetes, n (%)	1568 (100)	196 (12.5)
Hypertension, n (%)	1568 (100)	959 (61.1)
Heart failure, n (%)	1568 (100)	226 (14.4)
Sleep apnea, n (%)	1104 (70.4)	102 (9.2)
Prior stroke/transient ischemic attack, n (%)	1568 (100)	97 (6.2)
Chronic obstructive pulmonary disease, n (%)	992 (63.3)	50 (5)
Echocardiographic parameters		
Left ventricular ejection fraction, n (%) / median (interquartile range)	1381 (88.1)	60 (55–64)
Left atrium diameter (mm), n (%) / median (interquartile range)	1220 (77.8)	42 (39–46)
Antiarrhythmic medications, n (%)		
Class I antiarrhythmic drugs	1566 (99.9)	343 (21.9)
Class III antiarrhythmic drugs	1567 (99.9)	279 (17.8)

Électroporation

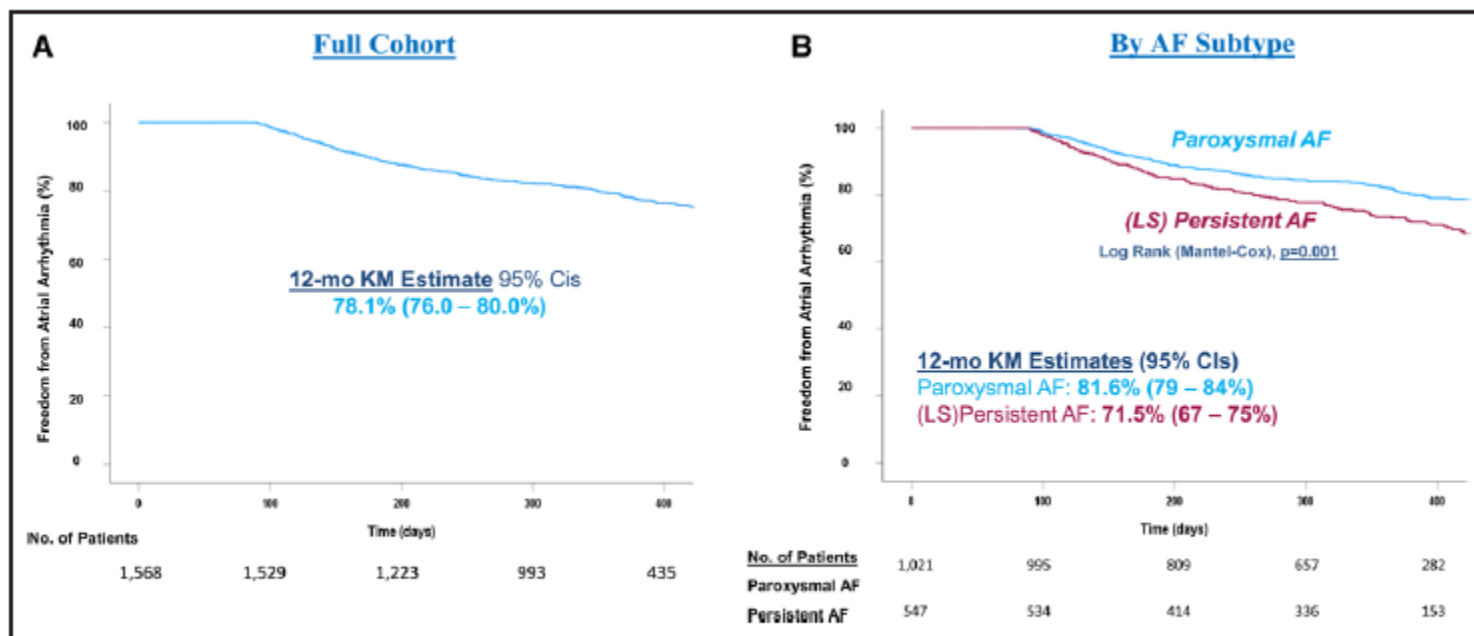


Figure 2. Primary effectiveness outcome.

Kaplan-Meier analysis demonstrating 1-year freedom from arrhythmia in either the full cohort (A) or by AF subtype: paroxysmal AF vs (long-standing) persistent AF (B). AF indicates atrial fibrillation; KM, Kaplan-Meier; and LS, long-standing.

Électroporation

Table 4. Major and Minor Adverse Events

Safety outcomes	N=1568 (%)
Acute major adverse events, n (%)	30 (1.9)
Esophageal fistula	0
Symptomatic pulmonary vein stenosis	0
Cardiac tamponade	18 (1.1)
Percutaneous drainage	14 (0.8)
Surgical drainage	2 (0.1)
Stroke	6 (0.4)
Coronary spasm	2 (0.1)
Phrenic nerve injury (persistent)	1 (0.06)
Death	1 (0.06)
Vascular complications requiring surgery	2 (0.1)
Acute minor adverse events, n (%)	63 (4.0)
Pericardial effusion without intervention	4 (0.3%)
Pericarditis	1 (0.06)
Air embolism	4 (0.3)
Transient ischemic attack	2 (0.1)
Phrenic nerve injury, transient	6 (0.4)
Vascular access complications	41 (2.6)
Hematoma	33 (2.1)
Arteriovenous fistula	5 (0.3)
Pseudoaneurysm	2 (0.1)
Deep vein thrombosis	1 (0.06)
Respiratory related	4 (0.3)
Latent major adverse events	0 (0.00)

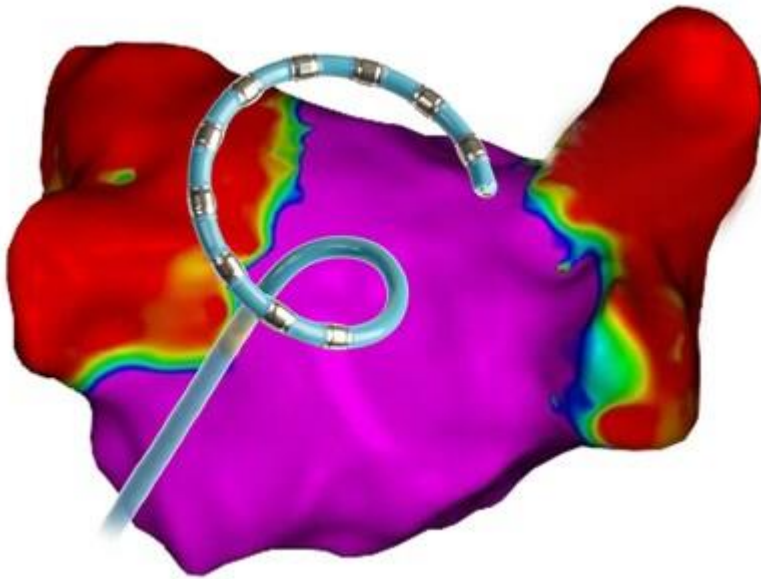
Électroporation

- Limites / complication
 - Paralysie phrénique = toutes transitoires
 - Hémolyse (ablation extensives VP + toit + mur postérieur)
 - Spasme coronaire (Cx isthme mitral)
- Avantages
 - Procédures plus rapides (temps d'anésthésie / récupération post procédure)
 - Possible en ambulatoire (surveillance post op 6 heures) ou hospitalisation très courte
 - Pas de complication majeure « différée » attendue

Électroporation

- Farapulse (Boston)
 - bientôt couplé au système de cartographie (Rythmia)
- Varipulse (Biocense)
 - Marquage CE obtenu
- Pulse select (Medtronic)

Électroporation



Couplé au carto 3D

VARIPULSE™
Catheter

 **Biosense Webster.**
Part of the Johnson & Johnson family of companies

Électroporation

Circulation: Arrhythmia and Electrophysiology

ORIGINAL ARTICLE



Paroxysmal Atrial Fibrillation Ablation Using a Novel Variable-Loop Biphasic Pulsed Field Ablation Catheter Integrated With a 3-Dimensional Mapping System: 1-Year Outcomes of the Multicenter insplRE Study

Mattias Duytschaever¹, MD, PhD; Tom De Potter², MD; Massimo Grimaldi³, MD, PhD; Ante Anic⁴, MD; Johan Vijgen⁵, MD; Petr Neuzil⁶, MD, PhD; Hugo Van Herendael, MD; Atul Verma⁷, MD; Allan Skanes⁸, MD; Daniel Scherr, MD; Helmut Pürerfellner⁹, MD; Gediminas Rackauskas¹⁰, MD; Pierre Jaïs¹¹, MD; Vivek Y. Reddy¹², MD; on behalf of the insplRE Trial Investigators*

Électroporation

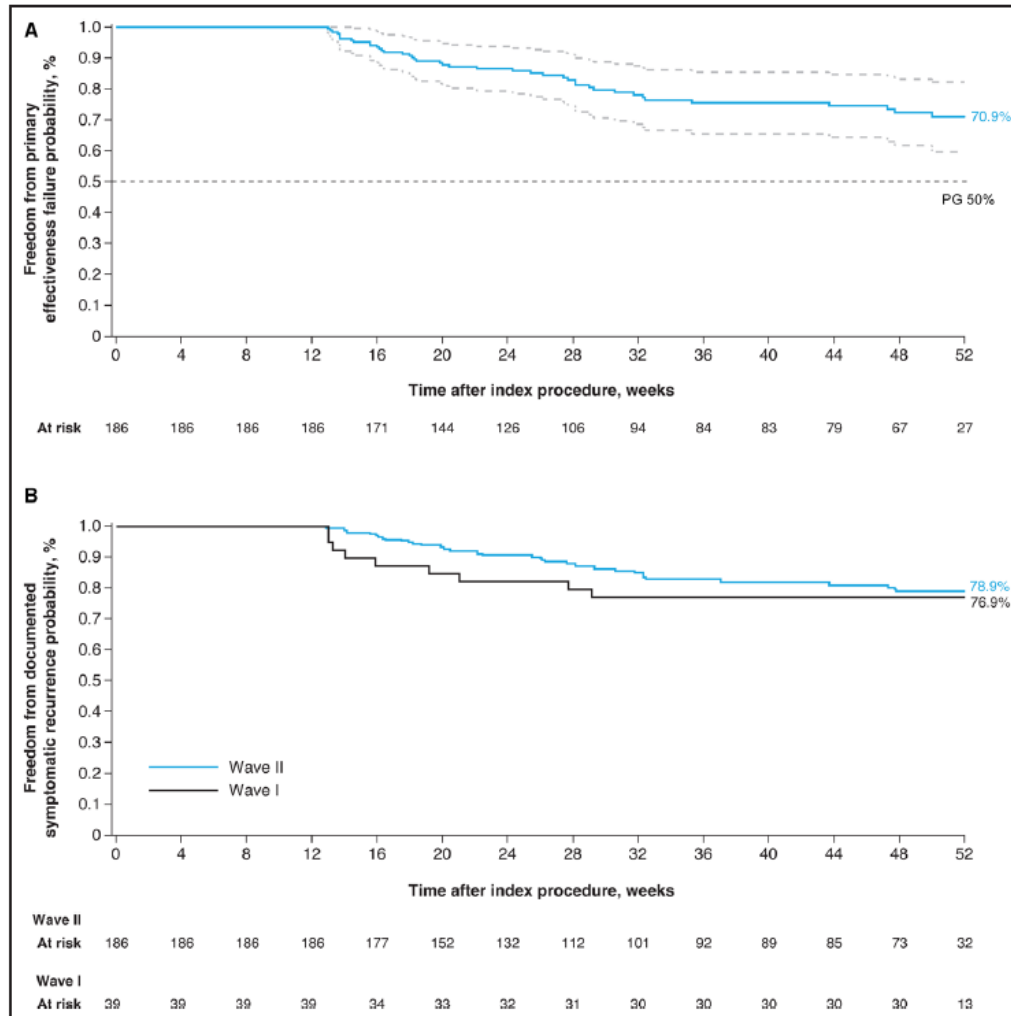
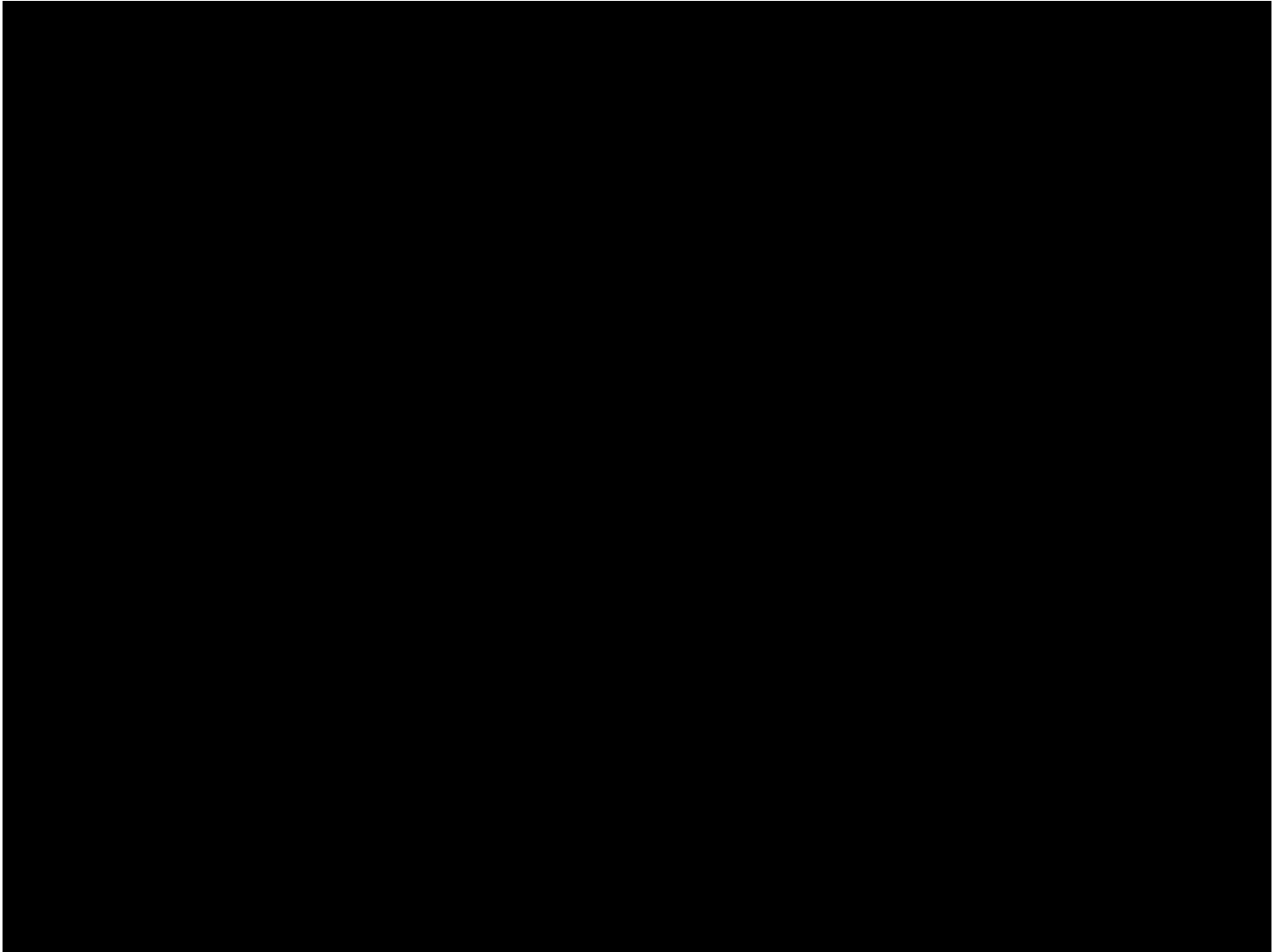


Figure 3. Freedom from primary effectiveness and documented symptomatic atrial fibrillation/atrial tachycardia/atrial flutter recurrence (clinical success) in the per-protocol population.

Kaplan-Meier analysis in the per-protocol population of (A) primary effectiveness in Wave II subjects and (B) freedom from documented symptomatic atrial fibrillation/atrial tachycardia/atrial flutter recurrence in Wave I and Wave II subjects. PG indicates performance goal.

Électroporation



Conclusion

- FA pathologie associée à une morbi-mortalité importante
- Ablation outil incontournable pour le traitement de cette arythmie, améliore le pronostic, nécessité d'améliorer la safety
- Électroporation = nouvelle énergie, technique d'avenir pour améliorer l'efficacité et la sécurité de l'ablation