



# ELECTRA



5-6 DÉCEMBRE 2024

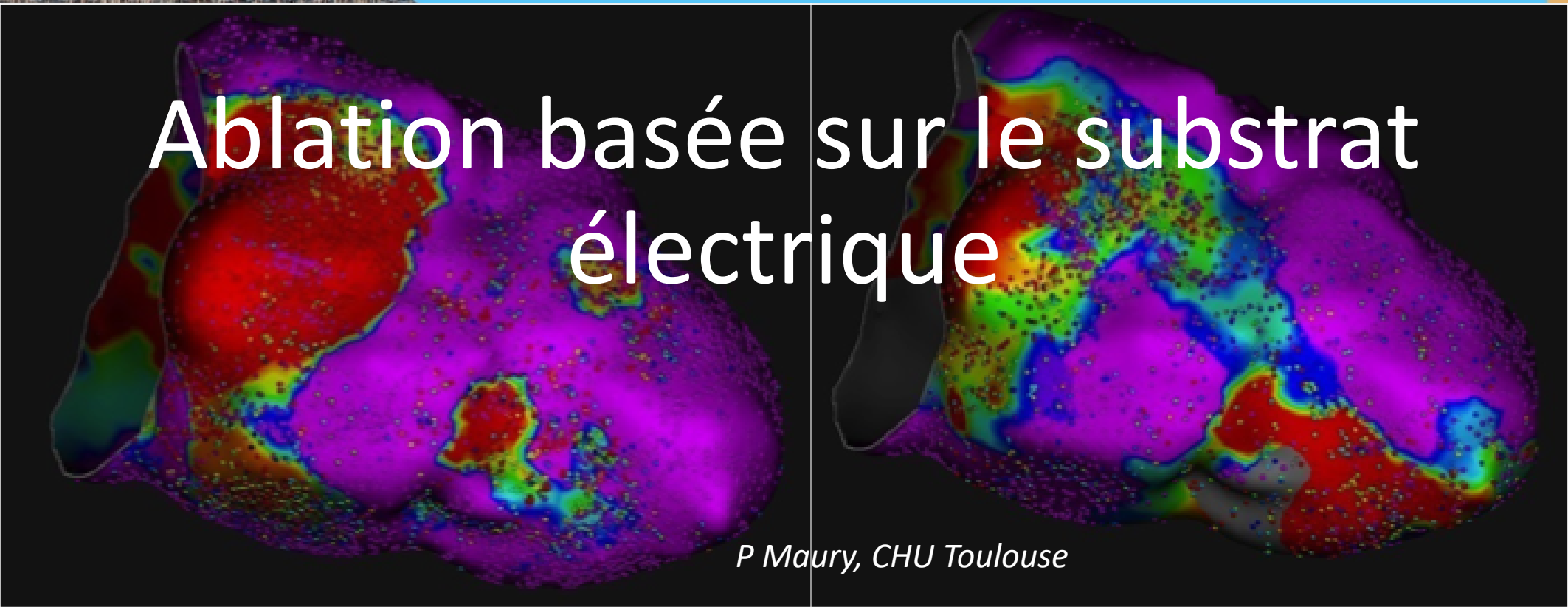
HOTEL VILLA MASSALIA,  
MARSEILLE | FRANCE

18<sup>èmes</sup> journées françaises  
pratiques de rythmologie  
& de stimulation cardiaque

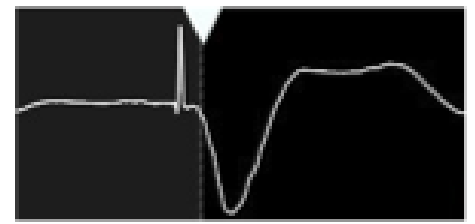
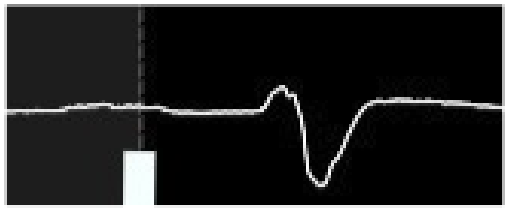
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20 ans  
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## Ablation basée sur le substrat électrique



*P Maury, CHU Toulouse*





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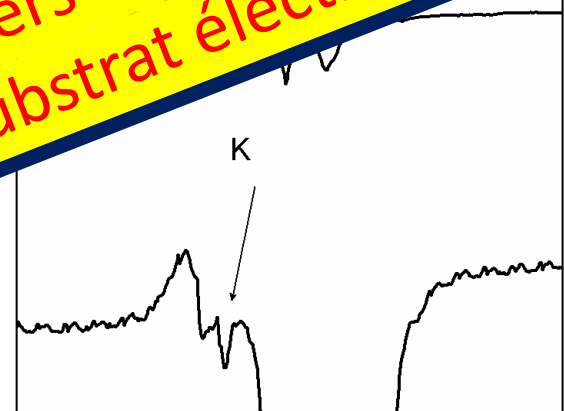
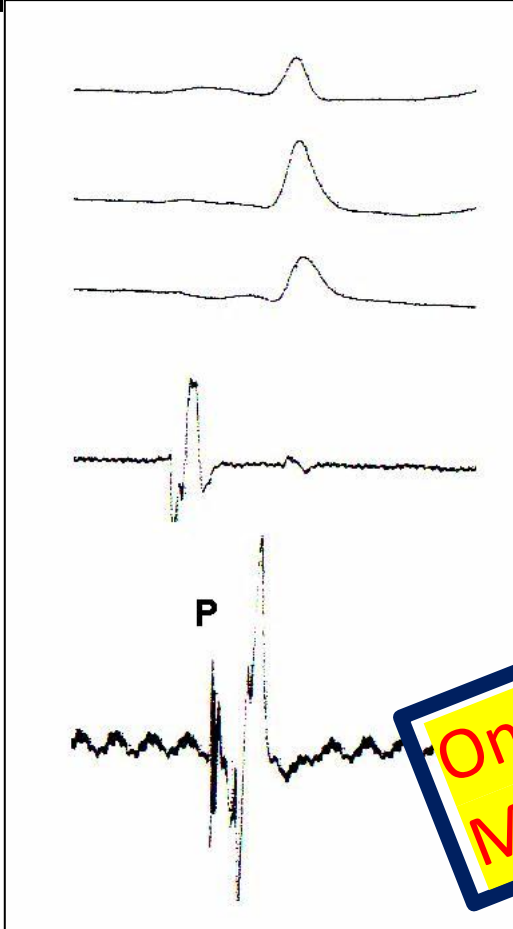
18<sup>èmes</sup> journées françaises  
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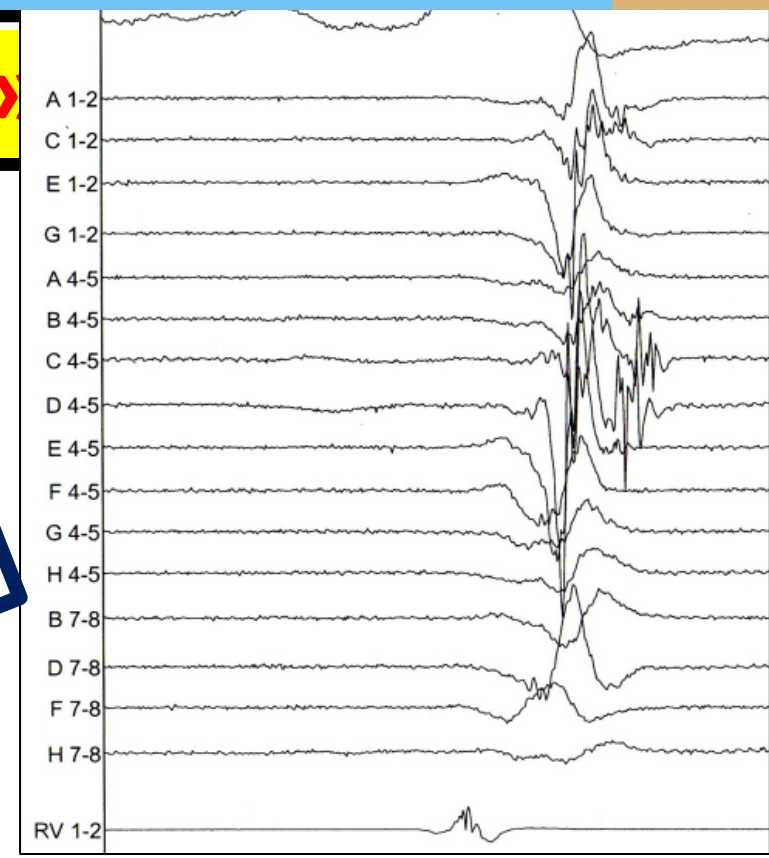
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## Profession : « électro-physiologiste »



Only electricity matters ... OK.....  
Mais c'est quoi le substrat électrique ???





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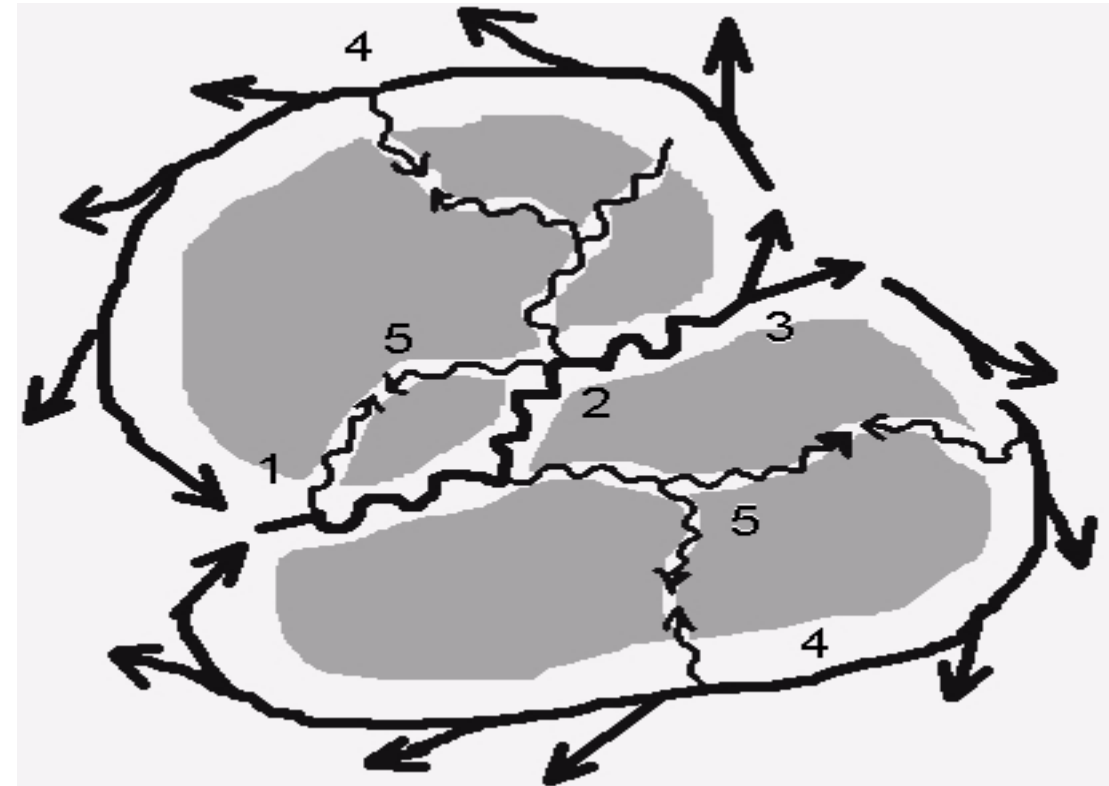
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## circuit en « 8 »

- (1) : zone d'entrée dans l'isthme
- (2) : isthme : zone de conduction lente
- (3) : zone de sortie de l'isthme
- (4) : portion externe du circuit

## mais autres circuits possibles

- boucle externe (« *outer loop* ») (4)
- boucle interne (« *inner loop* »)
- circuits satellites (« *bystander* ») (5)





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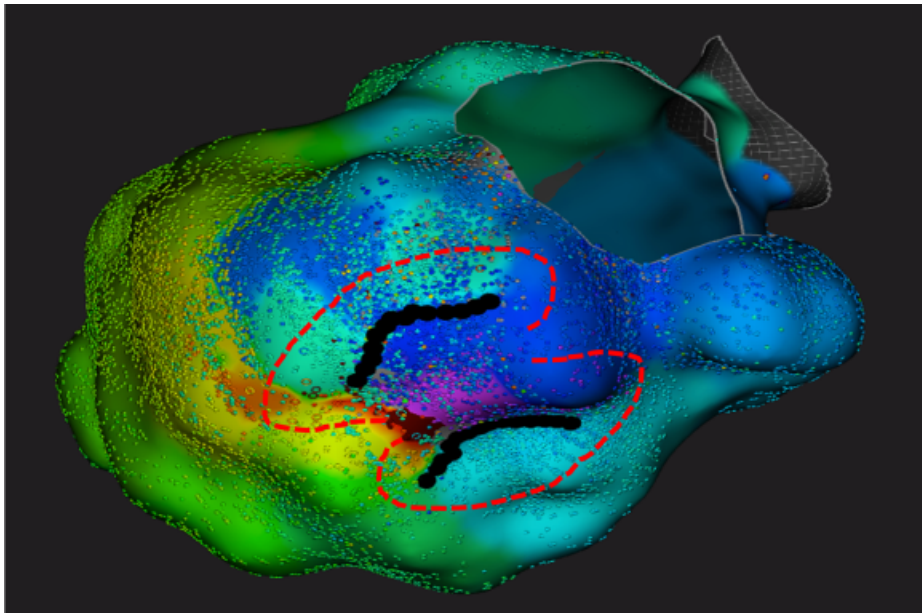
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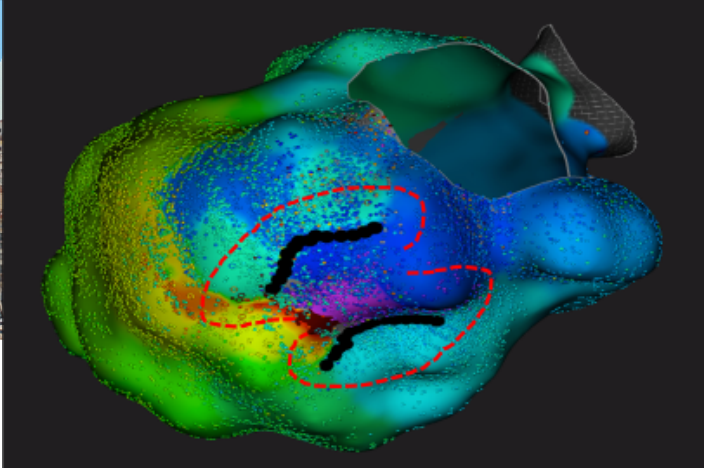
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*cellules électriquement peu altérées et channels désorganisées par la fibrose*

Réseau tridimensionnel complexe

1. activation ralentie, conduction fractionnée, en zig-zag
2. bloc unidirectionnels



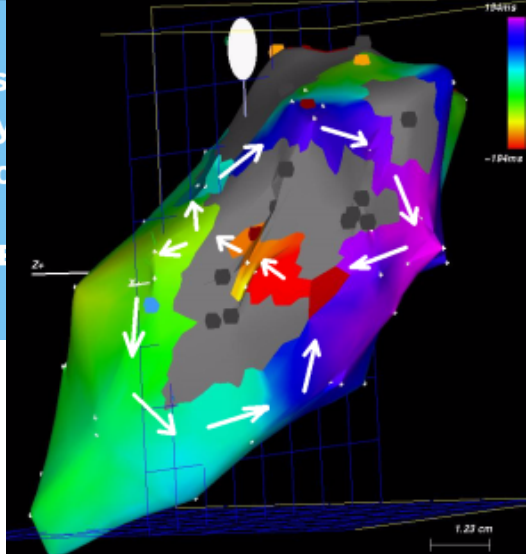


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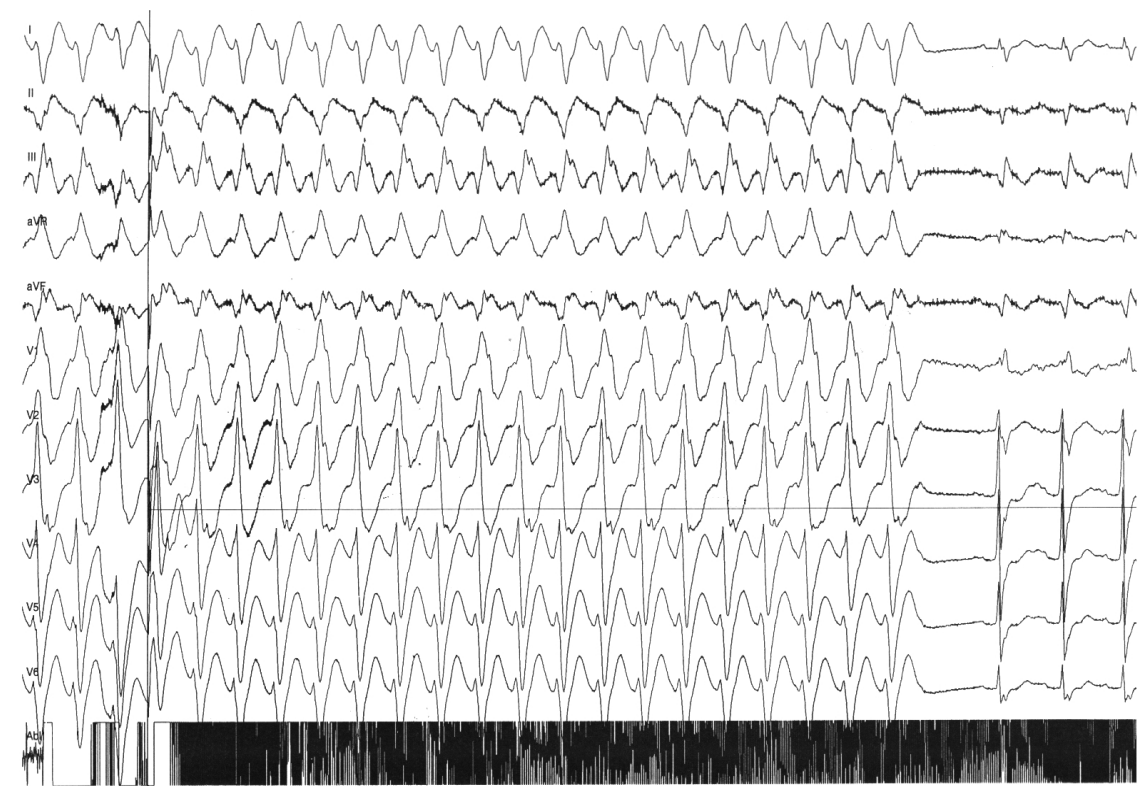
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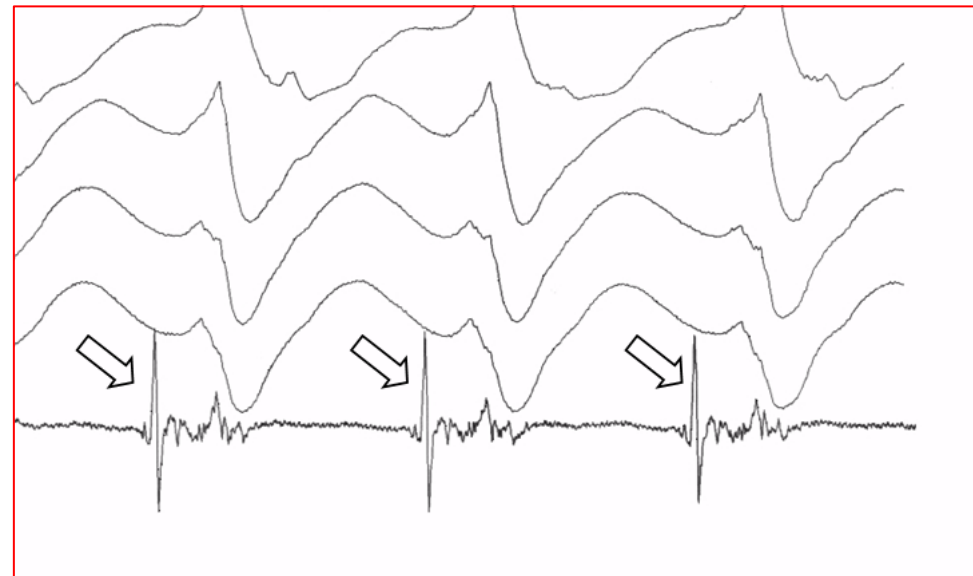
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## Le must pour l'electrophysiologiste ....



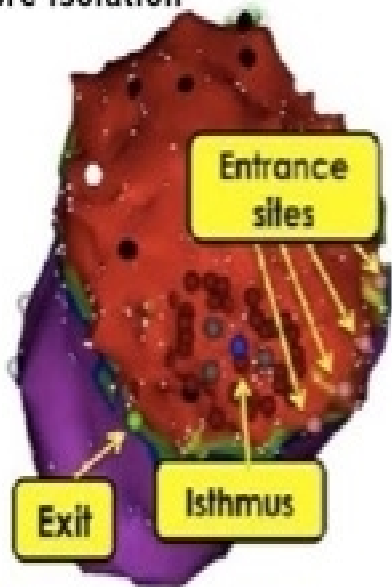
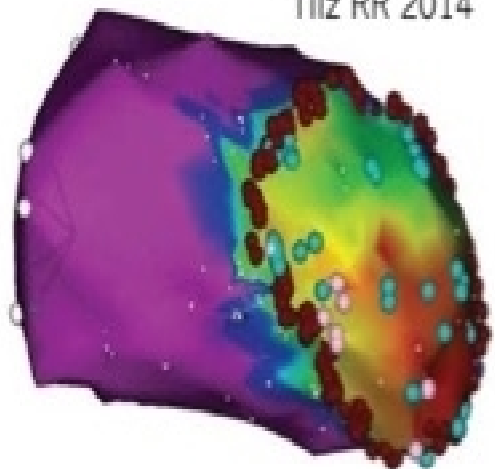
... déclenchement  
cartographie....  
... entrainement  
RF et arret TV...



isolation

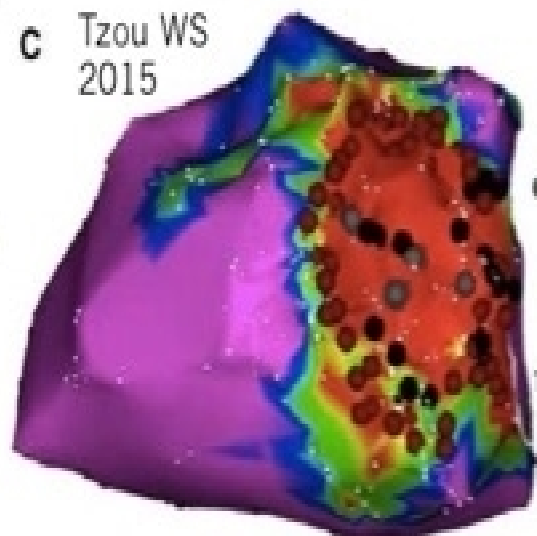
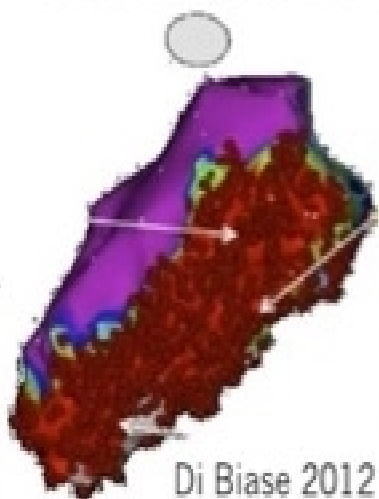
Core isolation

Tilz RR 2014



Scar homogeneization

C Tzou WS 2015

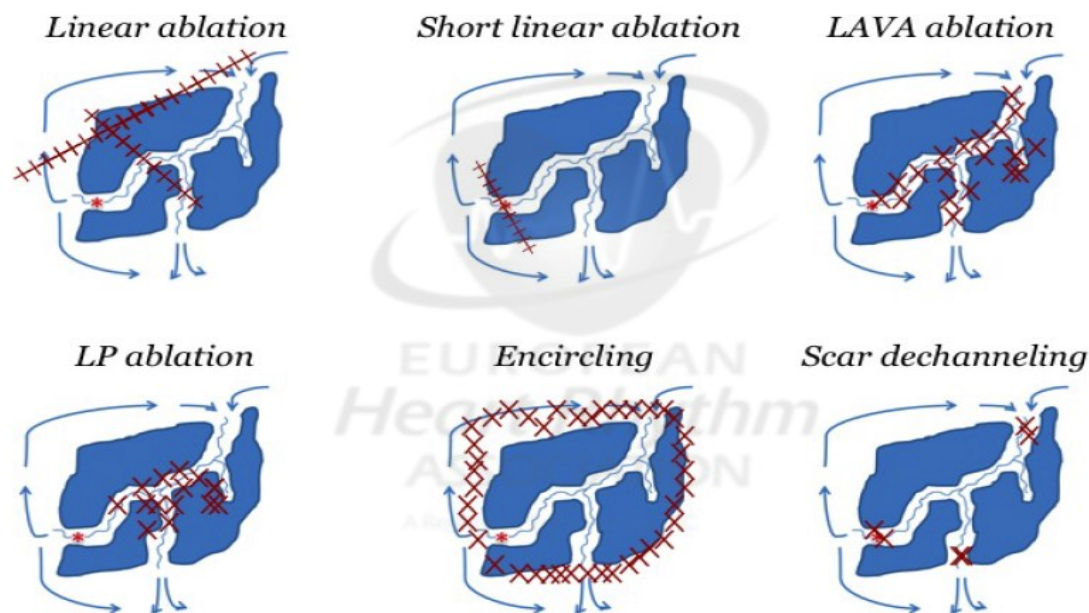


Di Biase 2012

...plus pragmatique ..

- TV bien tolérées peu fréquentes
- Activation mapping long
- entrainement: arret ou changement TV
- TV parfois non inductibles

Substrate ablation – Different Approaches



Substrate mapping ...

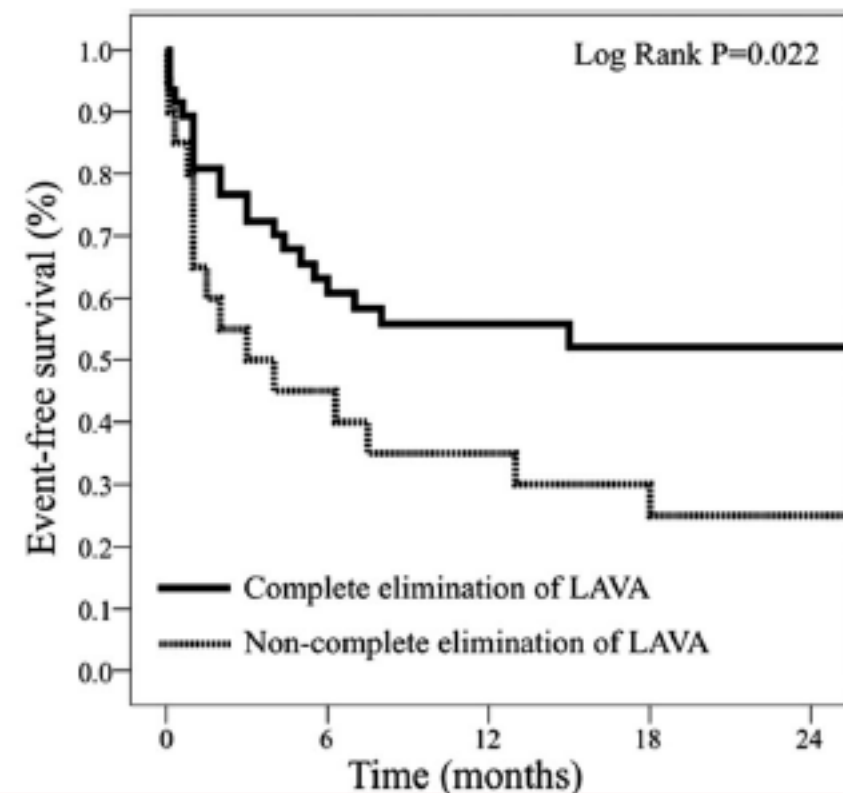
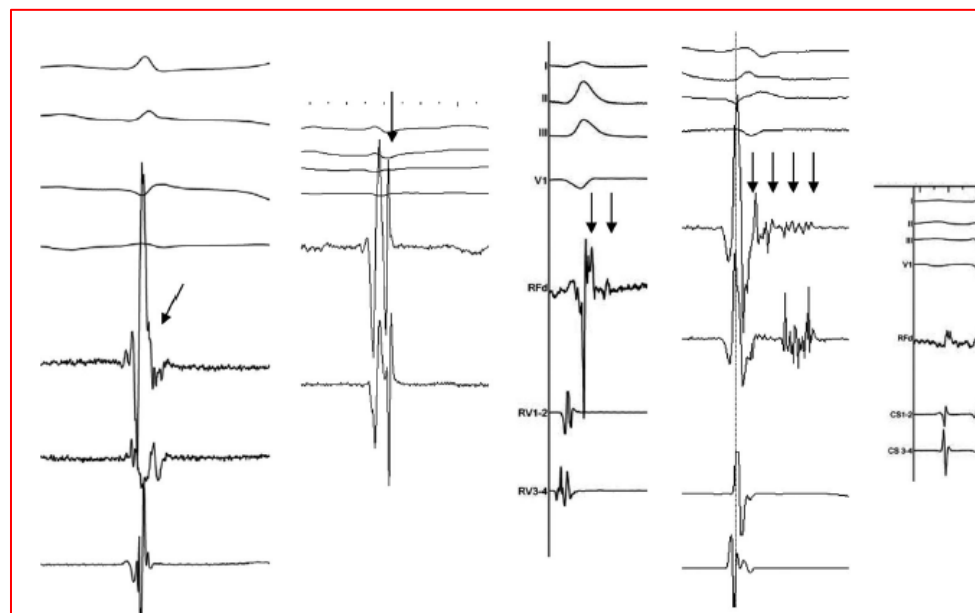
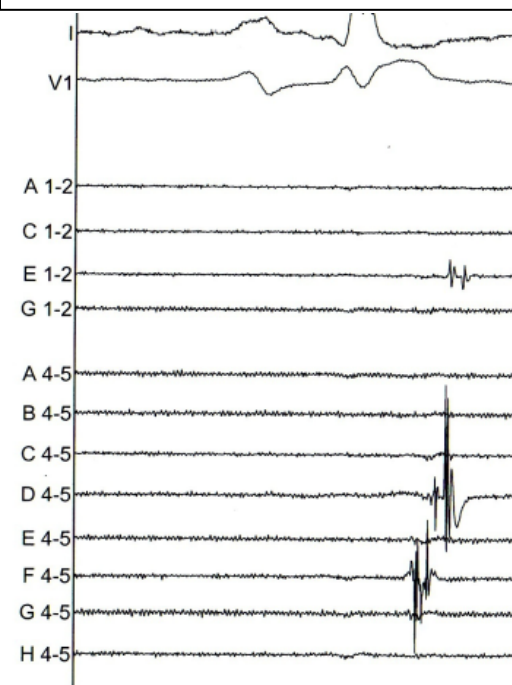
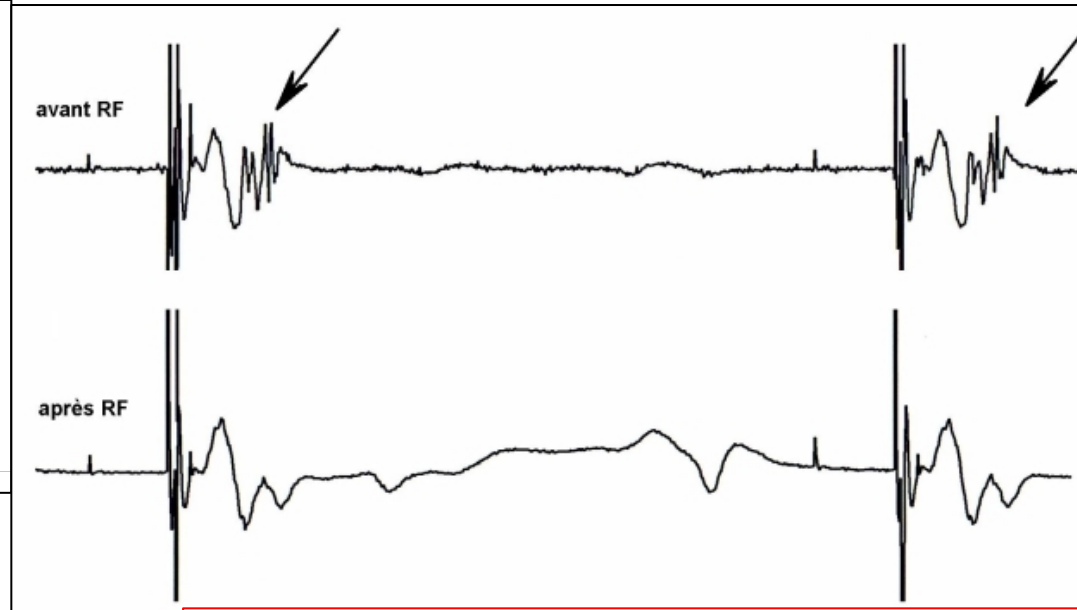


# Elimination of Local Abnormal Ventricular Activities

## A New End Point for Substrate Modification in Patients With Scar-Related Ventricular Tachycardia

Pierre Jaïs, MD; Philippe Maury, MD; Paul Khairy, MD, PhD; Frédéric Sacher, MD; Isabelle Nault, MD, FRCPC; Yuki Komatsu, MD; Méléze Hocini, MD; Andrei Forclaz, MD; Amir S. Jadidi, MD; Rukshen Weerasoorya, MBBS; Ashok Shah, MD; Nicolas Derval, MD; Hubert Cochet, MD; Sebastien Knecht, MD; Shinsuke Miyazaki, MD; Nick Linton, MEng, MRCP; Lena Rivard, MD; Matthew Wright, MBBS, PhD; Stephen B. Wilton, MD; Daniel Scherr, MD; Patrizio Pascale, MD; Laurent Roten, MD; Michala Pederson, MD; Pierre Bordachar, MD; François Laurent, MD; Steven J. Kim, MEng; Philippe Ritter, MD; Jacques Clementy, MD; Michel Haïssaguerre, MD

*Circulation.* 2012;125:2184-2196.





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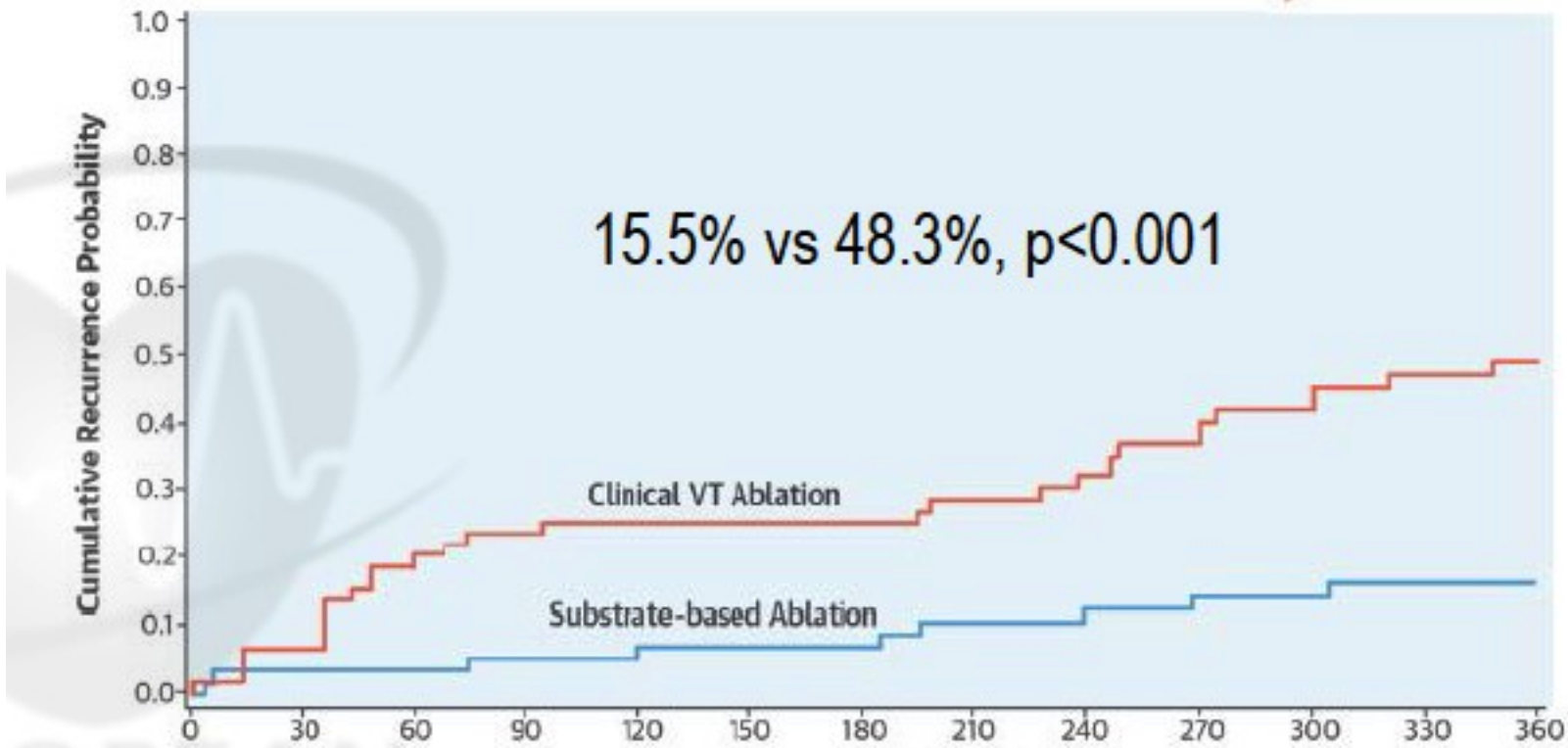
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Di Biase L et al. J Am Coll Cardiol 2015;66:2872-82

du plus excitant ....  
.... au plus réaliste

**OK ... mais besoin de définir (raffiner) ce qu'est une scar !**





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ESC

European Society  
of Cardiology

Europace (2019) 21, 1143–1144  
doi:10.1093/europace/euz132

### CONSENSUS STATEMENT

## 2019 HRS/EHRA/APHRS/LAHRs expert consensus statement on catheter ablation of ventricular arrhythmias

Edmond M. Cronin (Chair)<sup>1</sup>, Frank M. Bogun (Vice-Chair)<sup>2</sup>,  
Philippe Maury (EHRA Chair)<sup>3</sup>, Petr Peichl (EHRA Vice-Chair)<sup>4</sup>,  
Minglong Chen (APHRS Chair)<sup>5</sup>, Narayanan Namboodiri (APHRS Vice-Chair)<sup>6</sup>,  
Luis Aguinaga (LAHRS Chair)<sup>7</sup>, Luiz Roberto Leite (LAHRS Vice-Chair)<sup>8</sup>,  
Sana M. Al-Khatib<sup>9,§§</sup>, Elad Anter<sup>10,§§</sup>, Antonio Berruezo<sup>11,\*</sup>,  
David J. Callans<sup>12,§§</sup>, Mina K. Chung<sup>13,†</sup>, Phillip Cuculich<sup>14,§§</sup>,  
Andre d'Avila<sup>15,‡</sup>, Barbara J. Deal<sup>16,§</sup>, Paolo Della Bella<sup>17,\*</sup>, Thomas Deneke<sup>18,\*</sup>,  
Timm-Michael Dickfeld<sup>19,§§</sup>, Clau  
G. Neal Kay<sup>22,§§</sup>, Rakesh Latcham  
John M. Miller<sup>23,†</sup>, Akihiko Nogam  
Rajeev Kumar Pathak<sup>26,#</sup>, Luis C. S  
John L. Sapp Jr.<sup>28,§§</sup>, Andrea Sarko  
William G. Stevenson<sup>31,§§</sup>, Usha B  
Niraj Varma<sup>13,§§</sup>, and Katja Zepp

### Recommendations for substrate mapping in sinus rhythm

COR	LOE	Recommendations	References
I	B-NR	1. In patients with scar-related VT, substrate-guided ablation is useful for prevention of arrhythmia recurrences.	S8.5.2.1–S8.5.2.11
IIa	B-NR	2. High-density multielectrode mapping to obtain a more comprehensive characterization of the arrhythmogenic tissue during catheter ablation of scar-related VT can be useful.	S8.5.2.12–S8.5.2.14
IIa	B-NR	3. In patients with no or minimal endocardial bipolar electrogram abnormalities, reduced unipolar voltage can be useful for detection of epicardial or intramural scar.	S8.5.2.15–S8.5.2.19

# « historiquement »

## Valeurs de voltage de référence pour EGM normaux ou anormaux

*Carto™ and Navistar™ catheter*

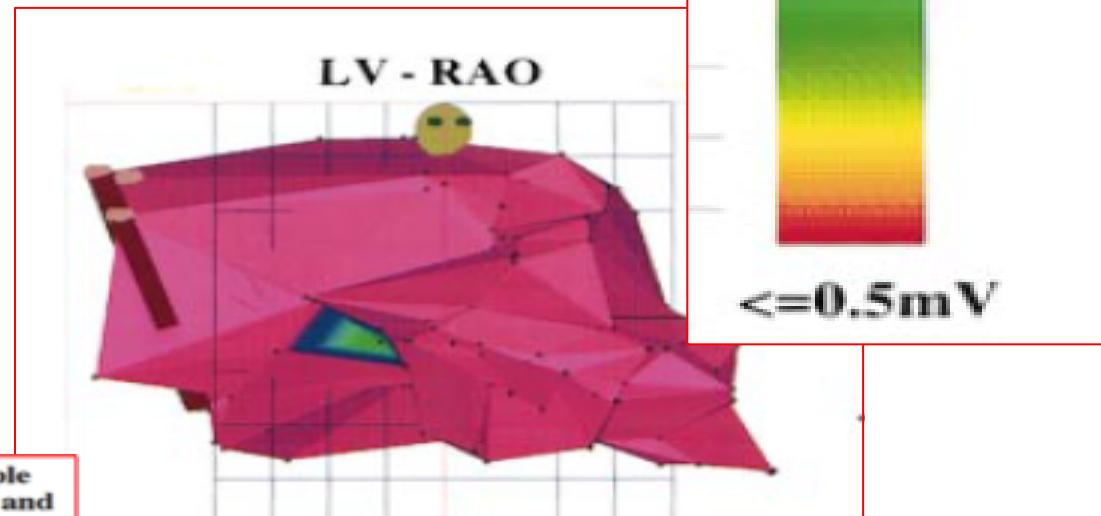
VD (4 patients) et/ou VG (4 patients) chez 6 patients sans cardiopathie  
71 to 168 endocardial sites/ventricule

Amplitude moyenne bipolaire VD  $3.76 \pm 1.7$  mV

95% > 1.44 mV

Amplitude moyenne bipolaire VG  $4.86 \pm 3.1$  mV

95% > 1.55 mV



**Linear Ablation Lesions for Control of Unmappable Ventricular Tachycardia in Patients With Ischemic and Nonischemic Cardiomyopathy**  
Francis E. Marchlinski, MD; David J. Callans, MD; Charles D. Gottlieb, MD; Erica Zado, PA-C  
(*Circulation*. 2000;101:1288-1296.)

= mean - 1 SD of abnormal EGM

**Linear Ablation Lesions for Control of Unmappable Ventricular Tachycardia in Patients With Ischemic and Nonischemic Cardiomyopathy**  
Francis E. Marchlinski, MD; David J. Callans, MD; Charles D. Gottlieb, MD; Erica Zado, PA-C  
(*Circulation*. 2000;101:1288-1296.)

**The value of catheter mapping during sinus rhythm to localize site of origin of ventricular tachycardia**  
DENNIS M. CASSIDY, M.D., JOSEPH A. VASSALLO, M.D., ALFRED E. BUXTON, M.D., JOHN U. DOHERTY, M.D., FRANCIS E. MARCHLINSKI, M.D., AND MARK E. JOSEPHSON, M.D.  
*Circulation* 69, No. 6, 1103-1110, 1984

On the basis of our previous experience with catheter and intraoperative mapping, we then arbitrarily designated a value of <0.5 mV as consistent with “densely scarred” endocardium



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## bipolar electrogram amplitude

- *amount of healthy tissue under electrode*
- *size of electrode and bipole*
- *hypertrophy of CM*
- *orientation of the dipole vs activation direction*
- *anisotropy*
- *cardiac rate and conduction velocity*
- *synchronization of cells*
- *contact, oedema, fat*
- *filtering*
- *impedance mismatch, curvature*
- *amplification*
- *animal model*

**Une seule échelle de voltage est incorrect  
doit être réadapté à chaque cas**

### FACTORS AFFECTING SIZE AND SHAPE OF EGM

- Electrode size and interelectrode spacing
- Angle and force of contact
- Wavefront of activation
- Conduction velocity influenced by:
  - reduced sodium channel activity
  - axial resistivity
  - impedance mismatch
  - curvature
- Gap Junction (Connexin-43) disarray
- Insulating tissue: scar, fat, inflammation and edema

Anter E, Josephson, ME. JACC Clin Electrophysiol. 2015;1:341–352.



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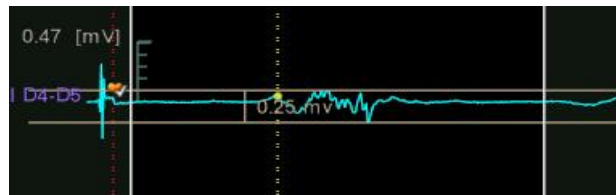
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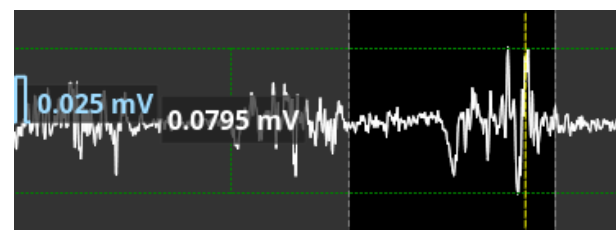
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Et dépend de chaque système !

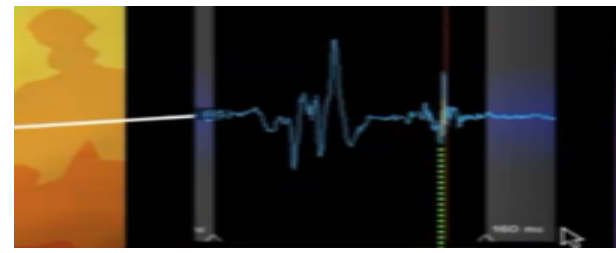
Amplitude max (Biosense)



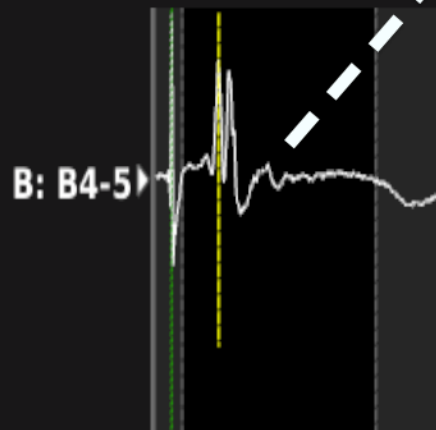
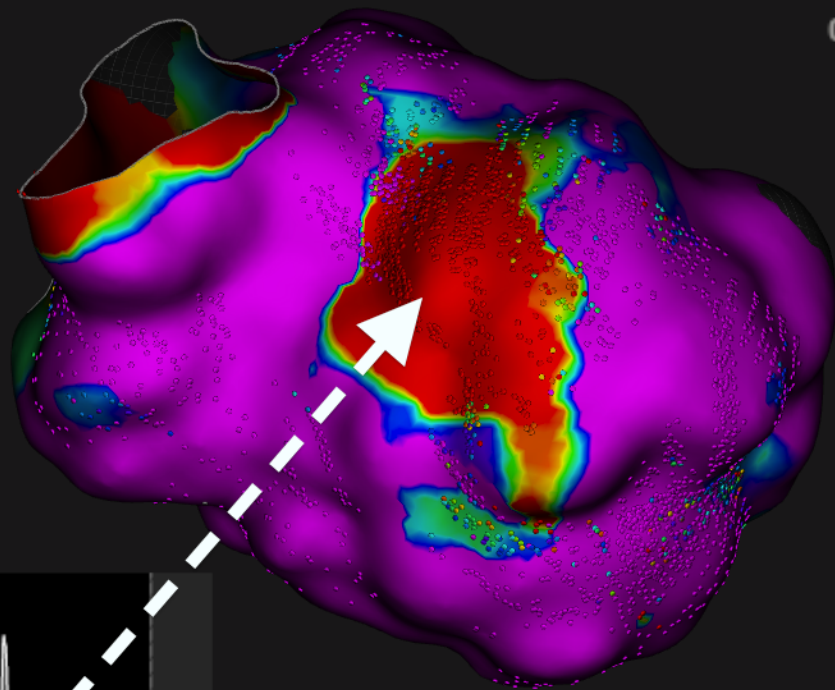
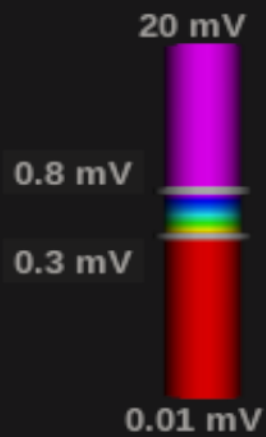
Amplitude max (Boston)



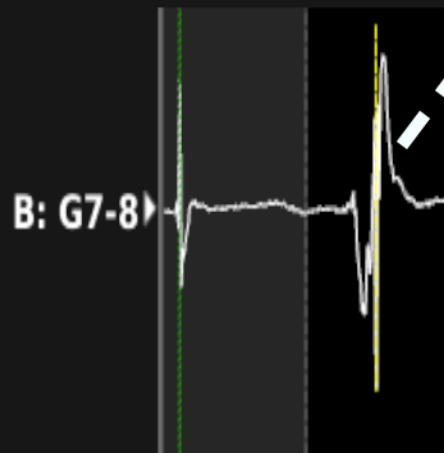
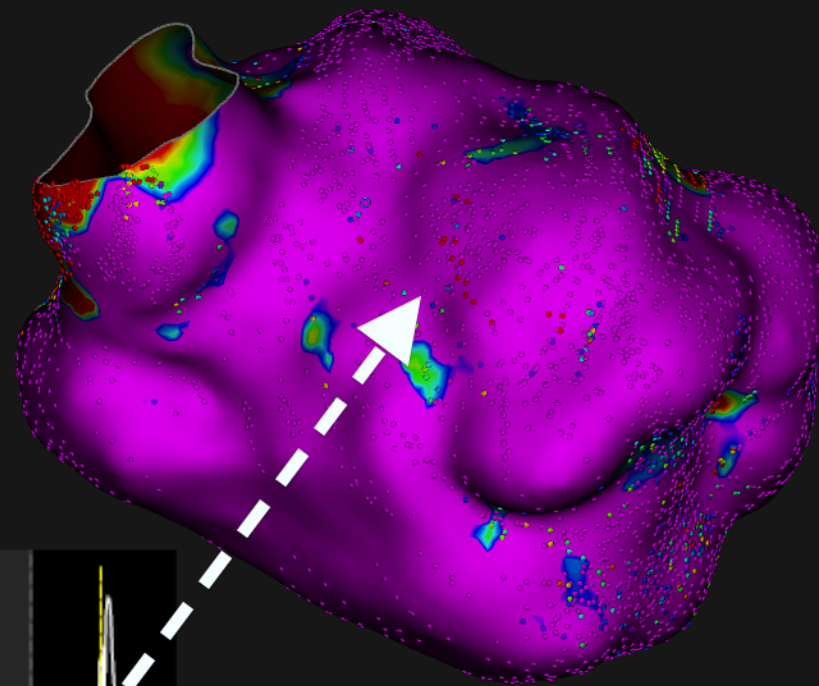
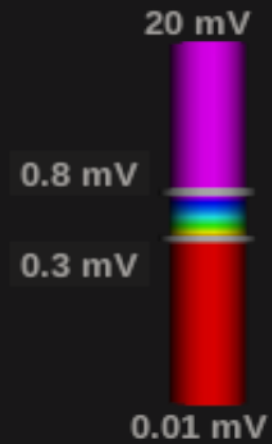
Peak frequency +  
Omnidirectionel (Abbott)



# RV pacing



# atrial pacing



# Directional Influences of Ventricular Activation on Myocardial Scar Characterization

## Voltage Mapping With Multiple Wavefronts During Ventricular Tachycardia Ablation

Roderick Tung, MD; Mark E. Josephson, MD; Jason S. Bradfield, MD; Kalyanam Shivkumar, MD, PhD

29 patients (ICM et NICM)

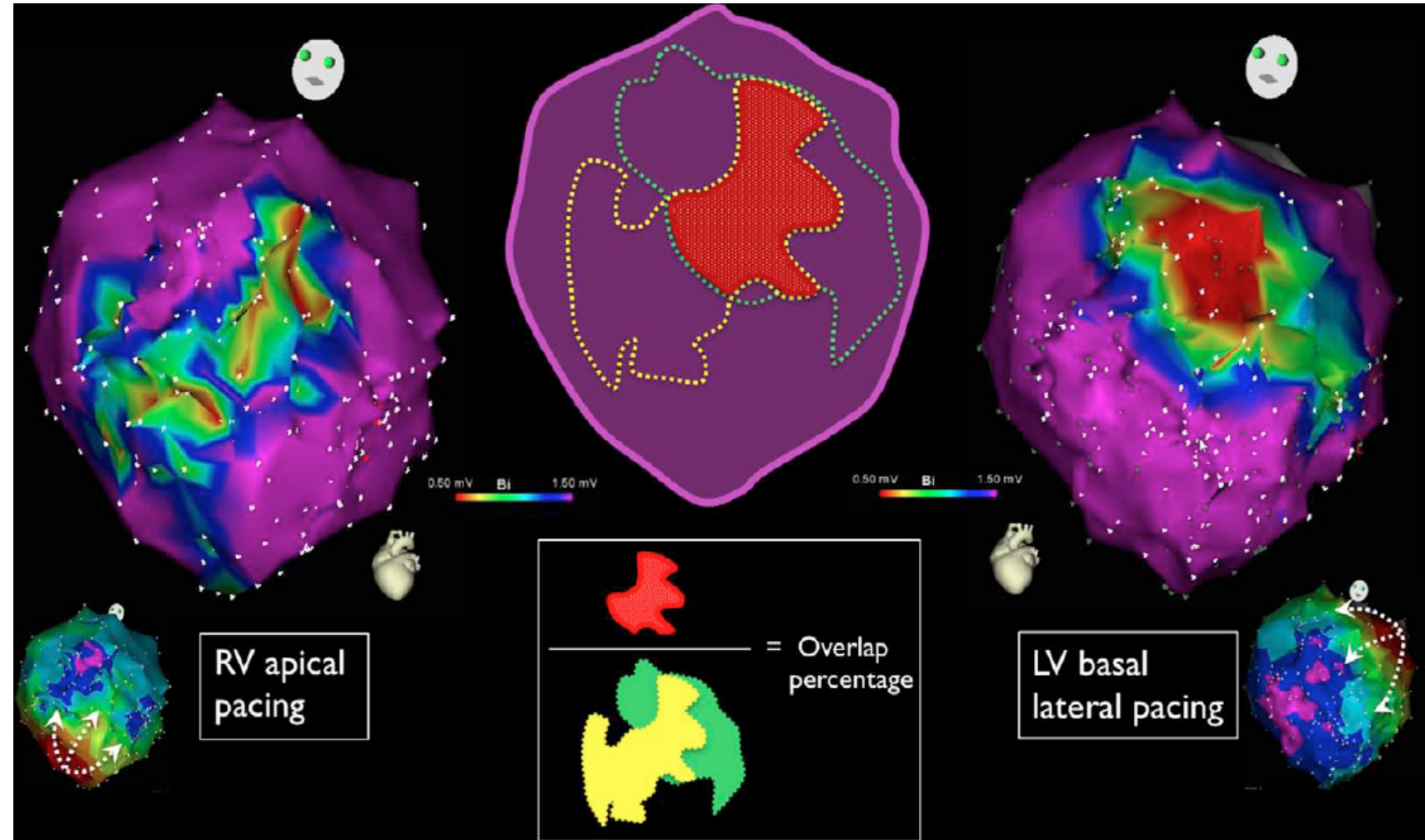
22% variabilité surface scar

Surface low voltage < 1.5 mV  
généralement atrial et VG > VD

Surtout scars septales  
Surtout scars hétérogènes  
Idem en unipolaire

Moins marqué dense scars

Pacing atrial vs VD vs VG  
Carte avec 4 mm tip catheter

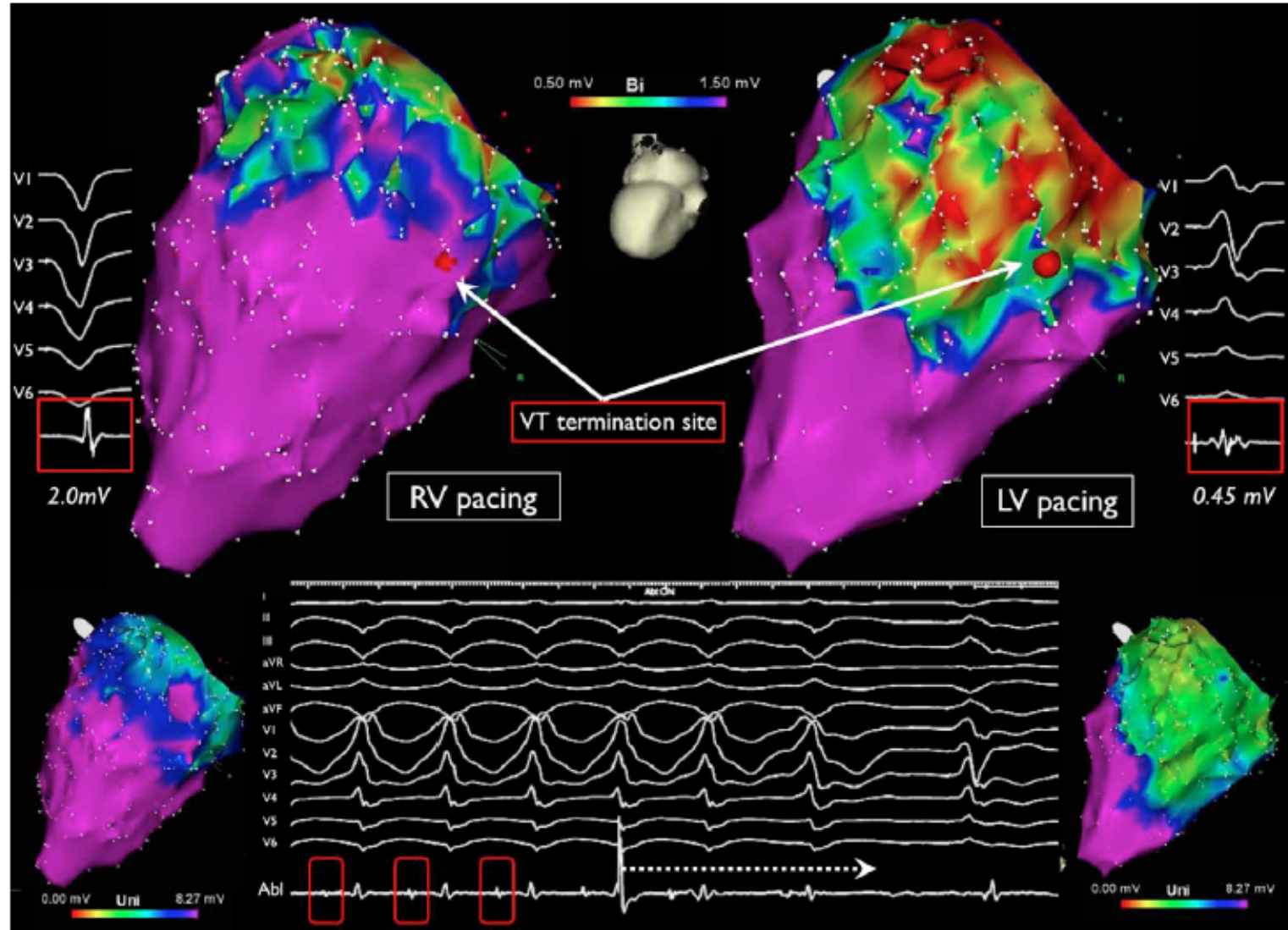


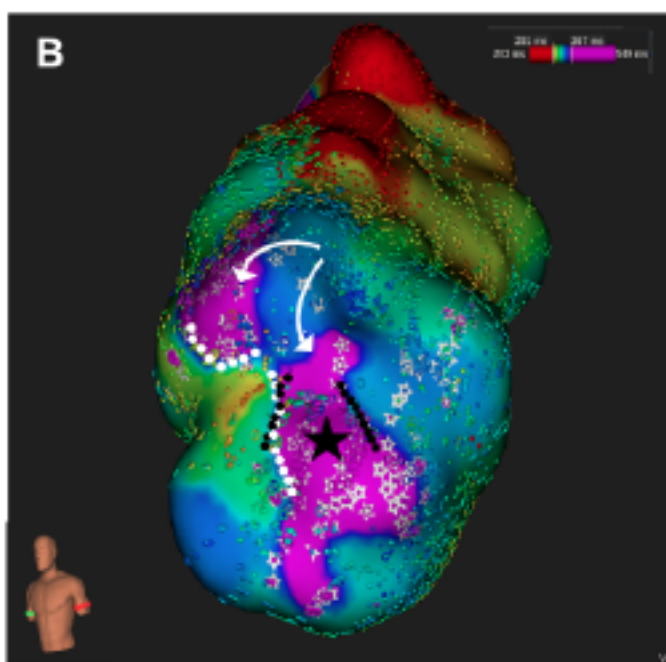
# Directional Influences of Ventricular Activation on Myocardial Scar Characterization

## Voltage Mapping With Multiple Wavefronts During Ventricular Tachycardia Ablation

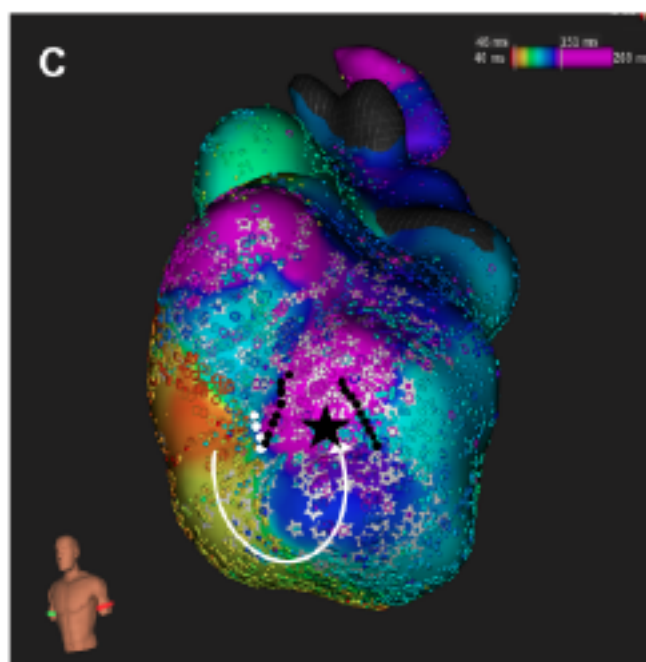
Roderick Tung, MD; Mark E. Josephson, MD; Jason S. Bradfield, MD; Kalyanam Shivkumar, MD, PhD

**18% des  
sites  
critiques  
dans des  
zones  
discordantes**

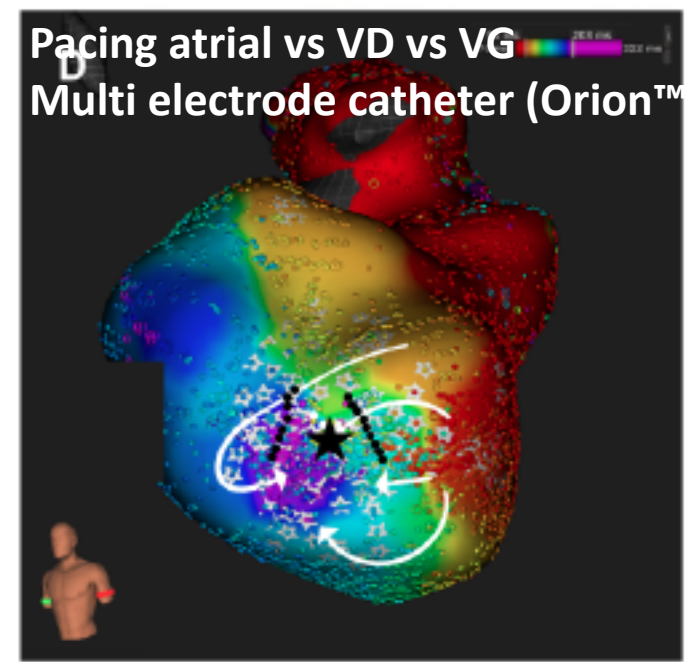




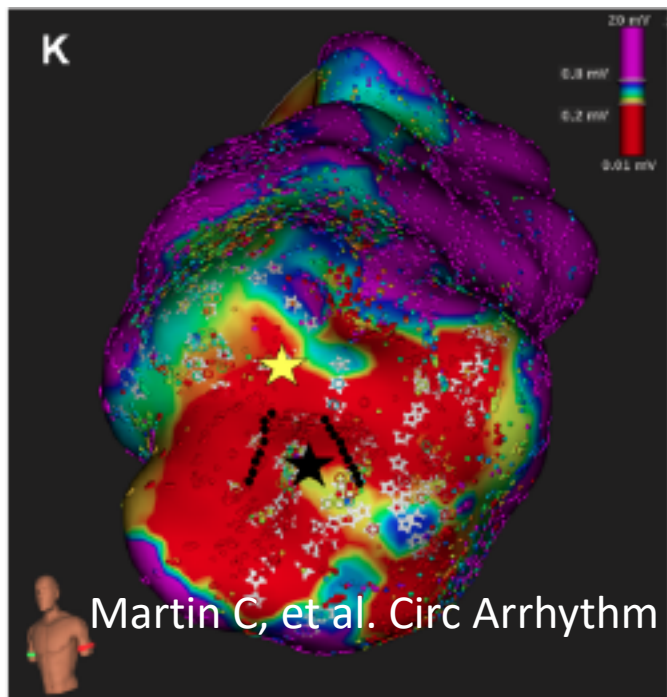
Atrial pacing



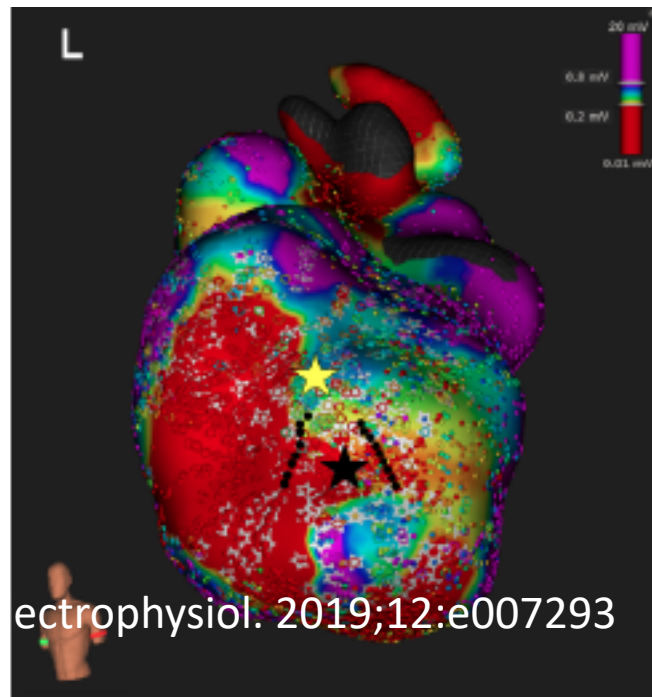
RV pacing



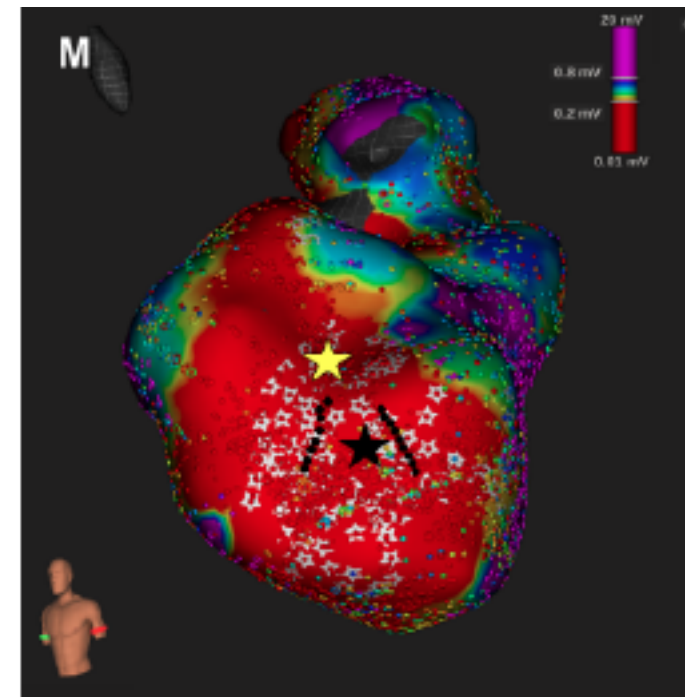
LV pacing



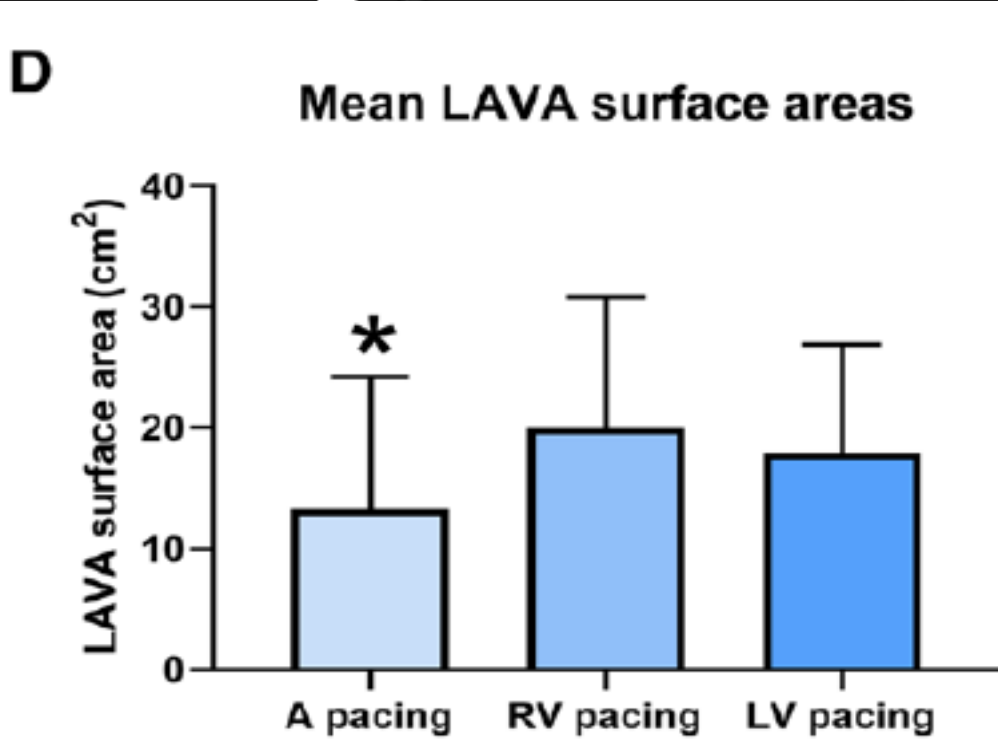
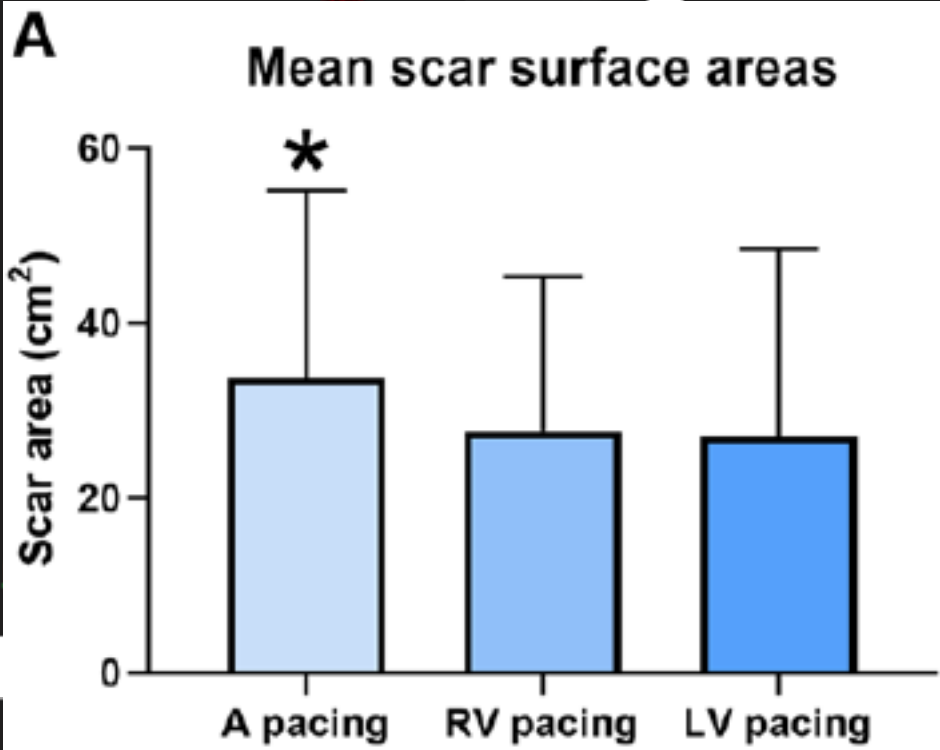
Martin C, et al. Circ Arrhythm



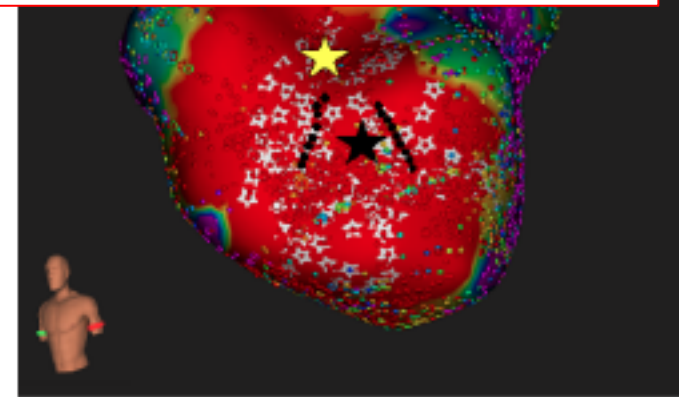
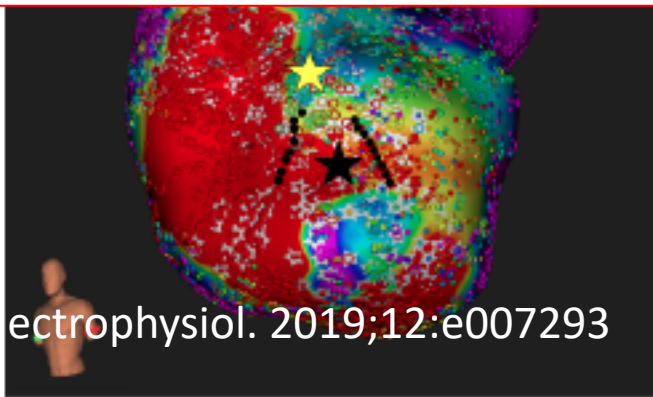
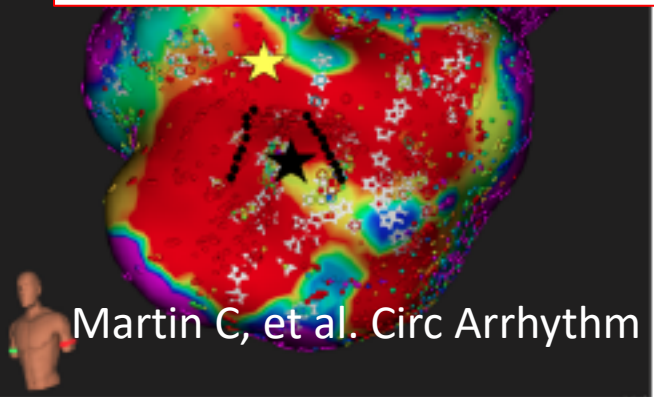
ectrophysiol. 2019;12:e007293







Scar area overlap  $45 \pm 18 \%$   
 LAVA area overlap  $45 \pm 18 \%$   
 LAVA area plus large si activation perpendiculaire / ligne de bloc





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## Comparisons entre cartes multiples

- long

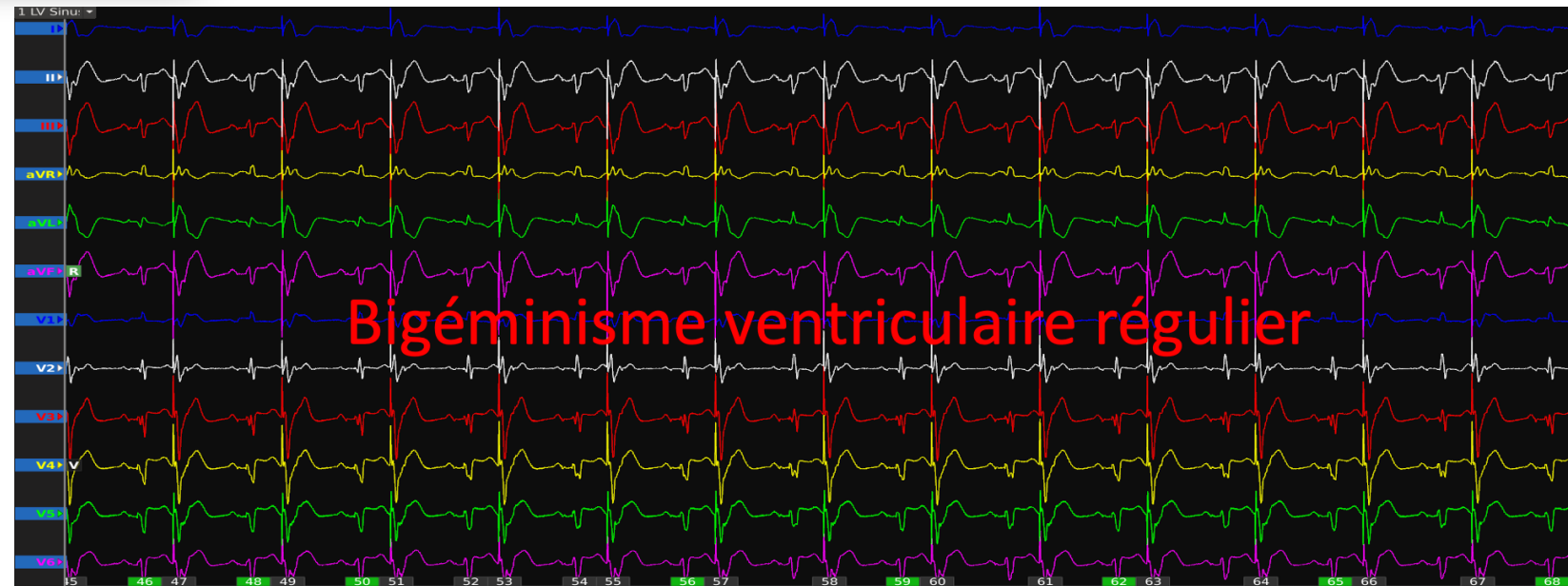
- parasité par positions différentes du cathéter entre chaque carte

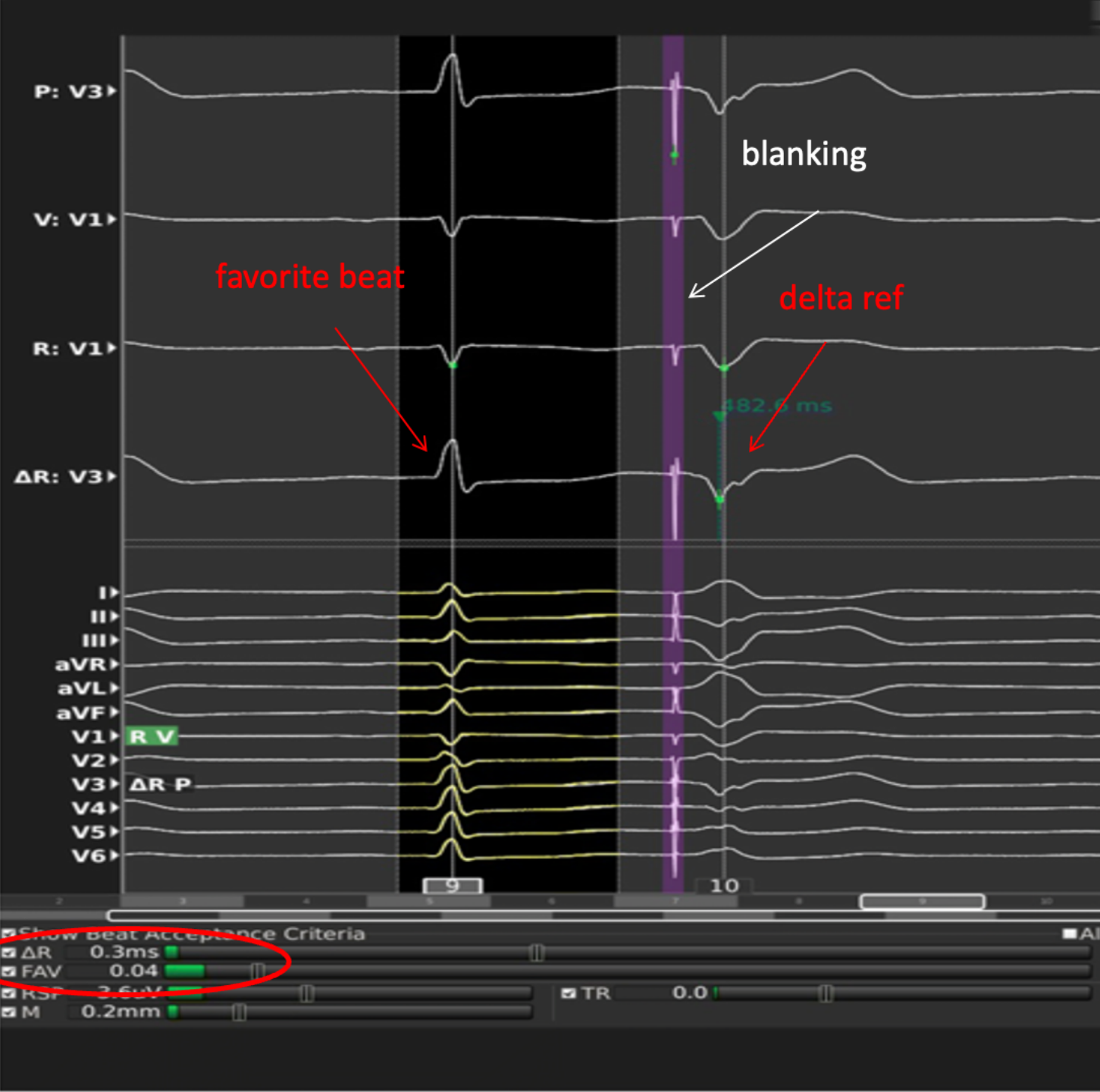
Creation of sinus rhythm and paced maps using a single acquisition step: the “one acquisition-two maps” technique—a feasibility study

Voglimacci-Stephanopoli Q, Maury P, et al.  
J Interv Card Electrophysiol. 2021 Aug;61(2):235-243

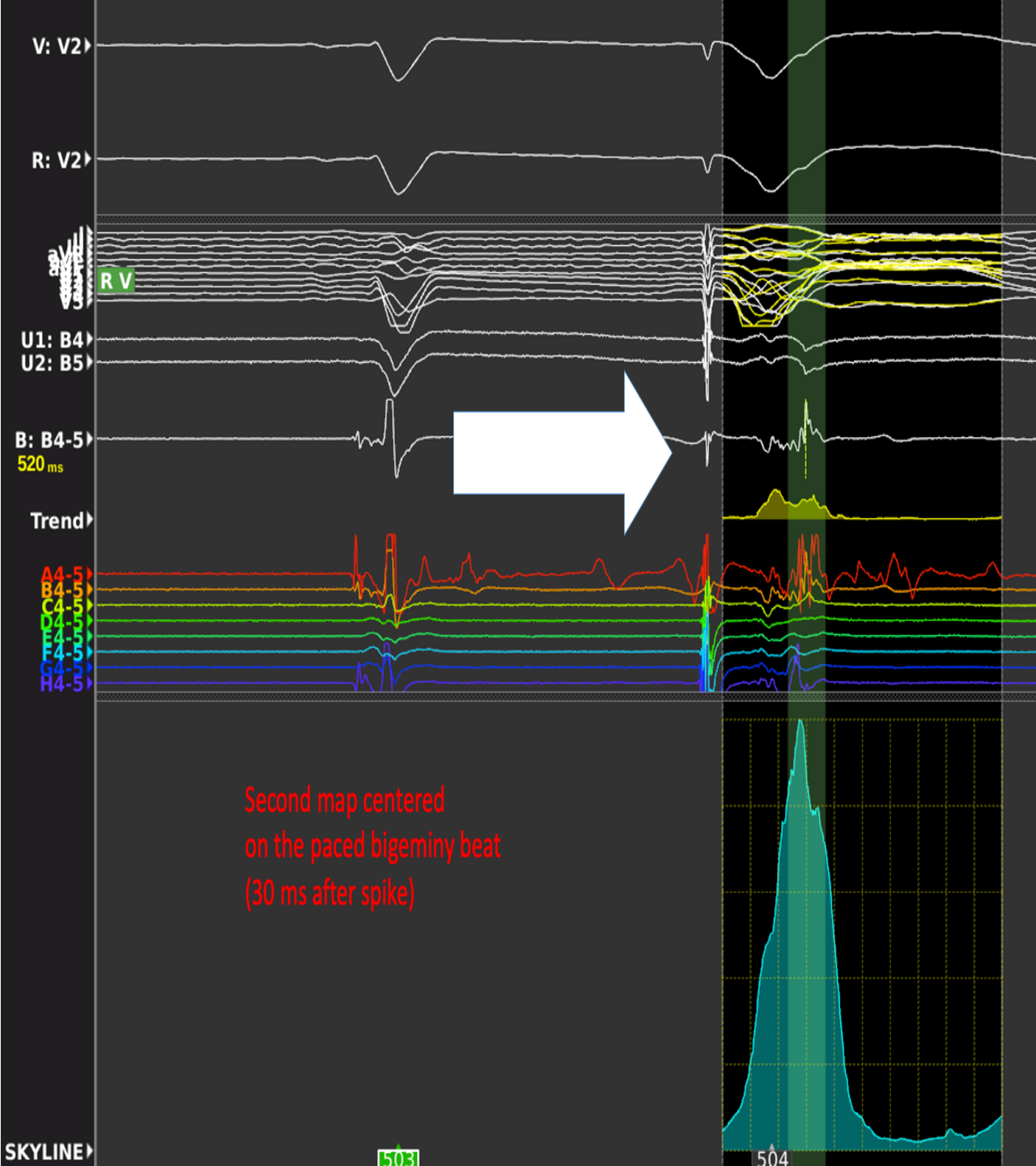
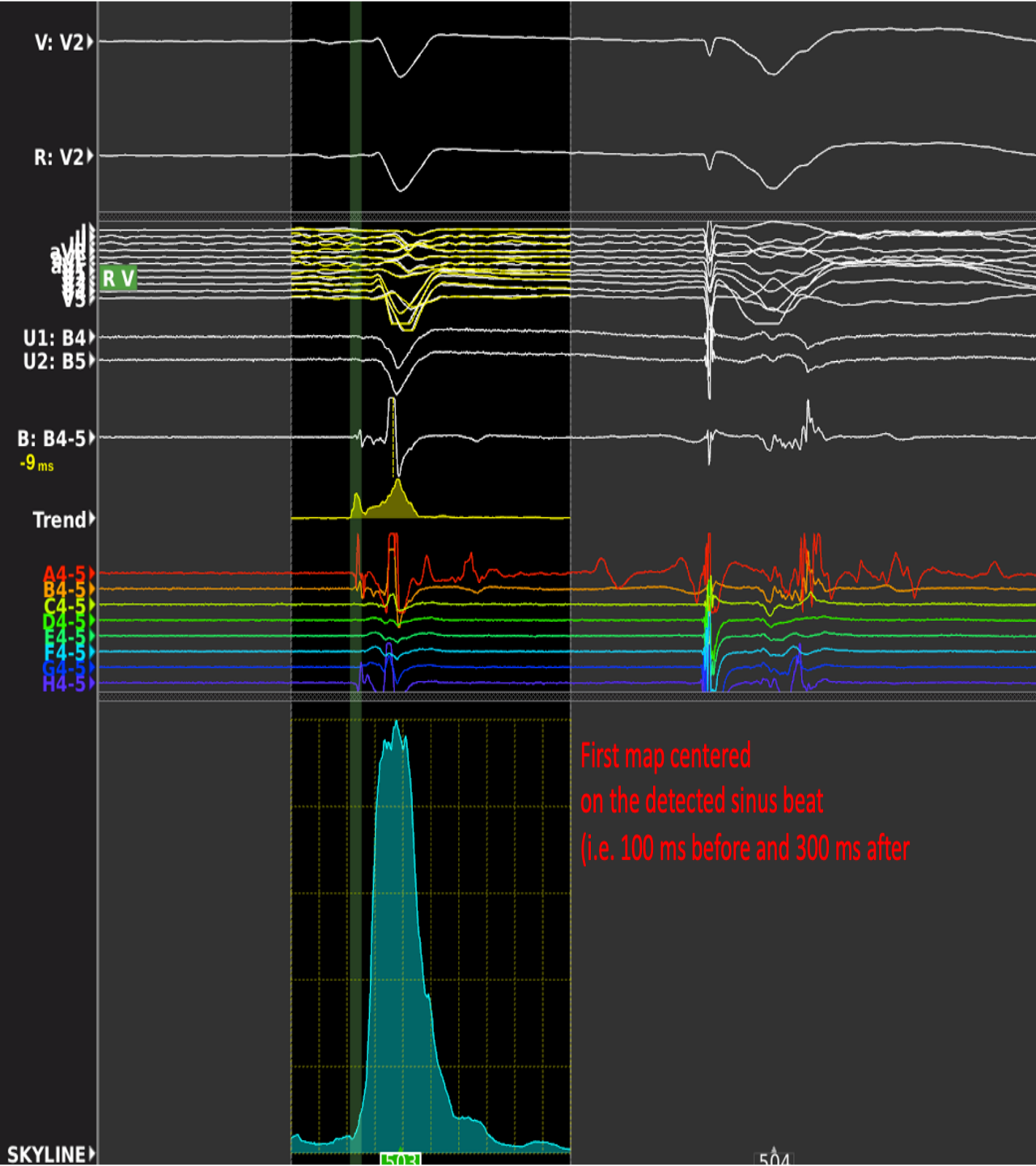
## Programmation speciale du stimulateur

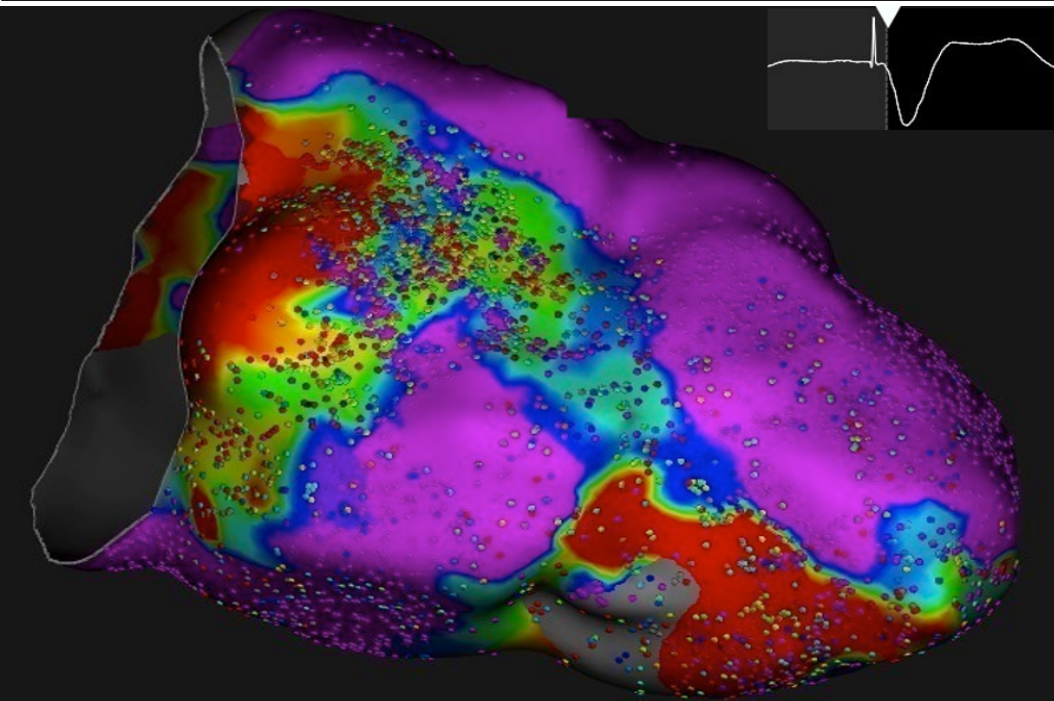
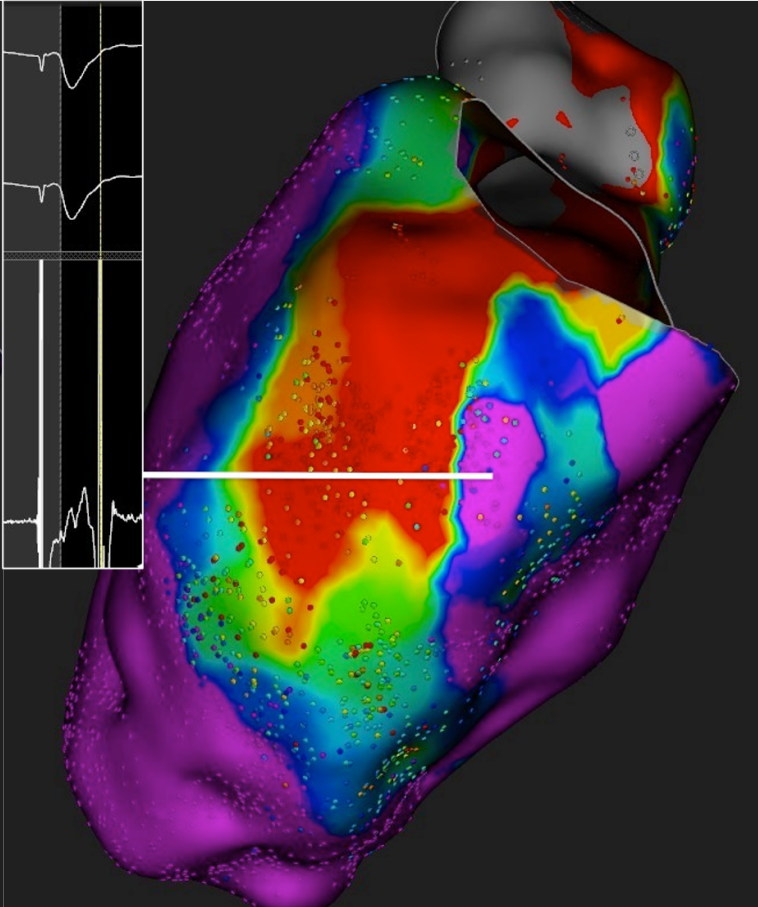
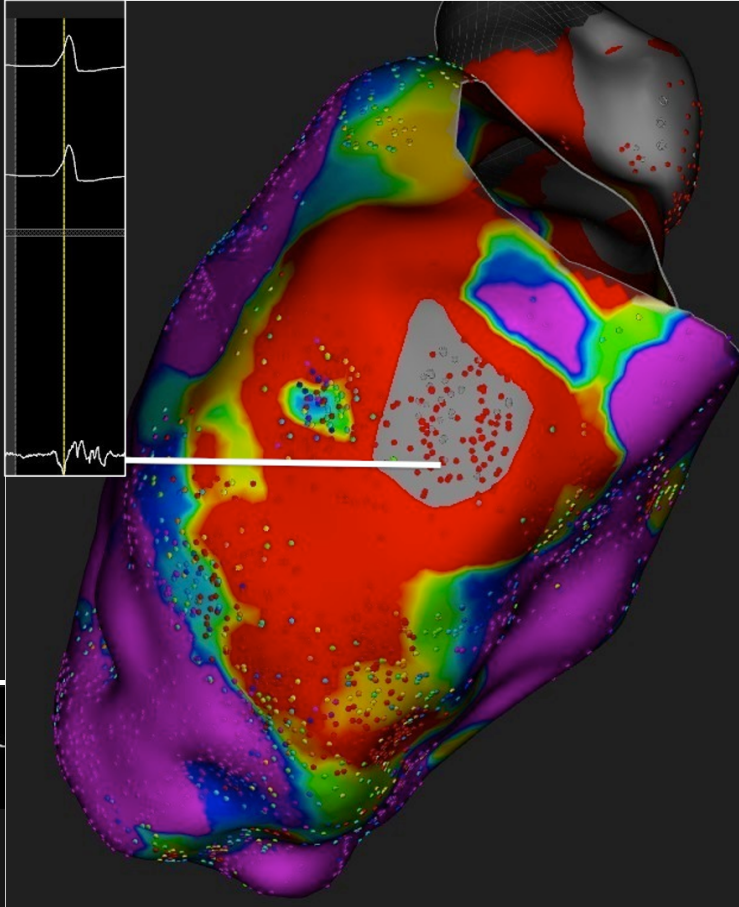
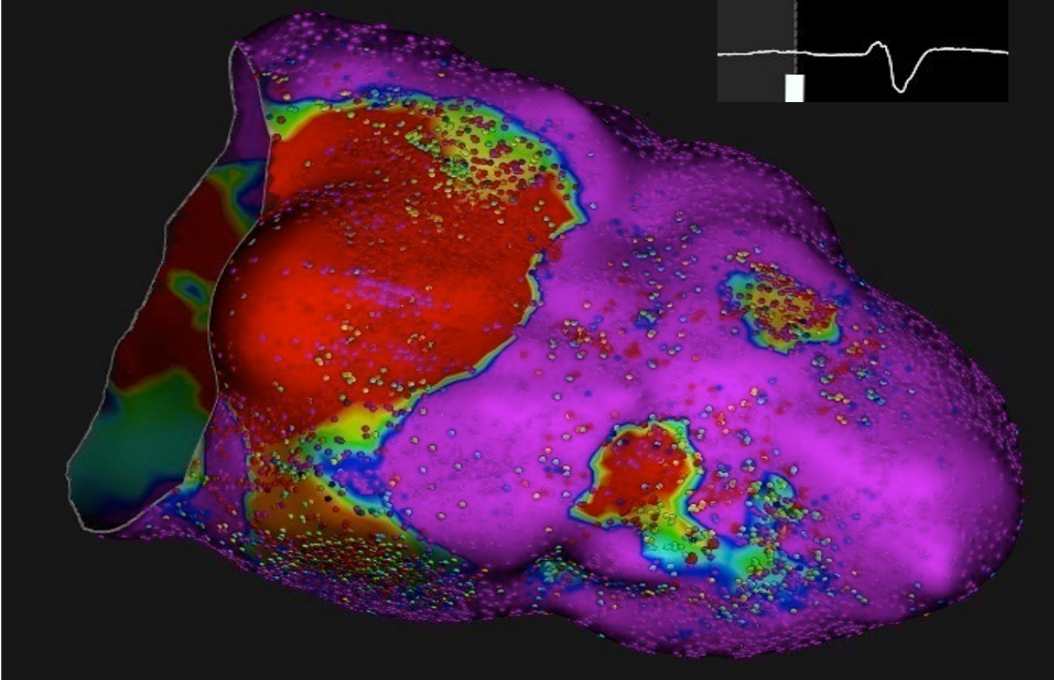
- ➔ « detection mode »
- ➔ un seul ES
- ➔ couplage fixe 400 ms
- ➔ « pause » réglée sur 0
- ➔ Nb battement entre chaque evenement déclenchant réglé sur 0





1. Exactly même nombre de battements
2. Environ même nombre de points
3. Localisation des points similaire ++++

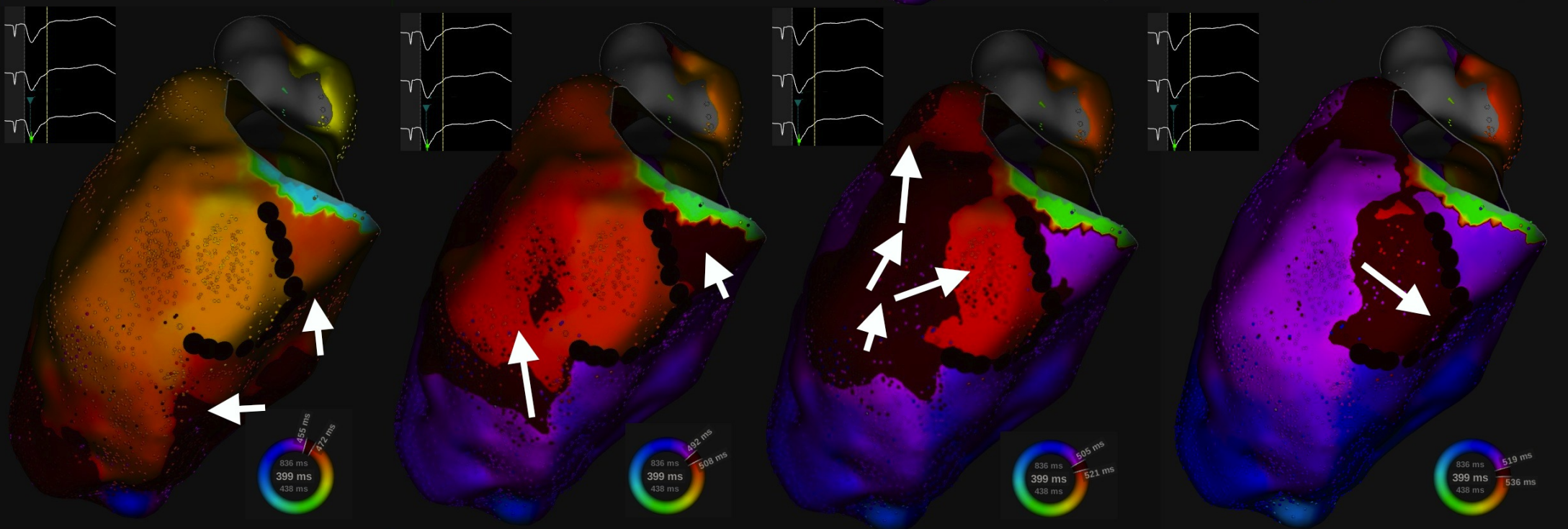
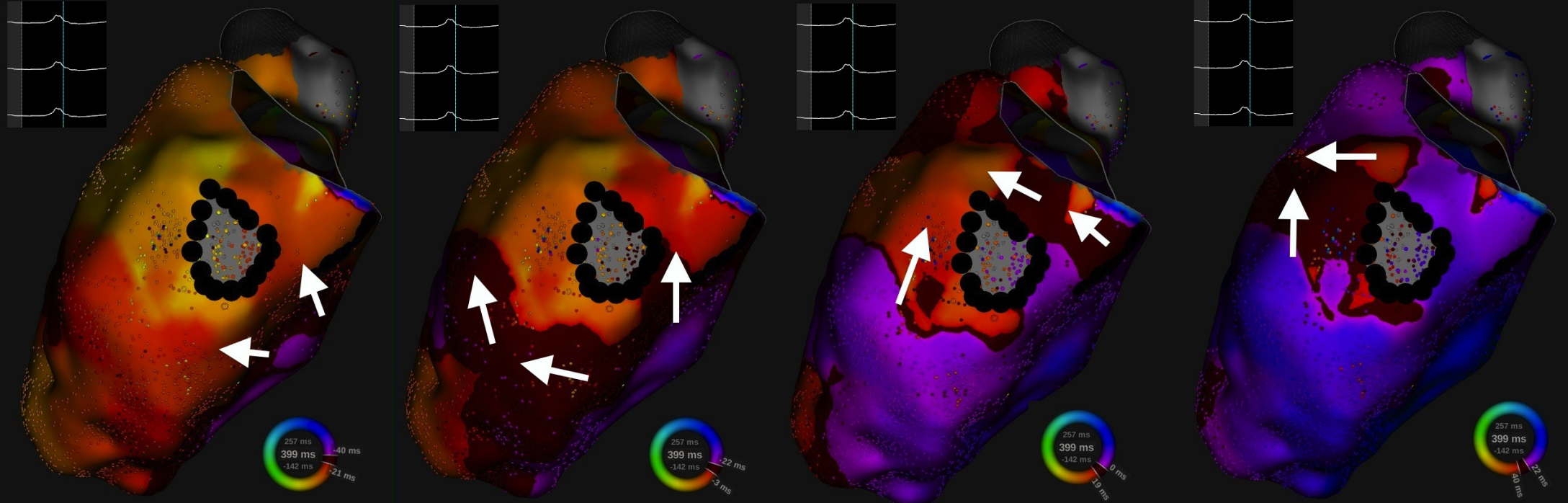




30 nouveaux patients successifs. 58% modification scar

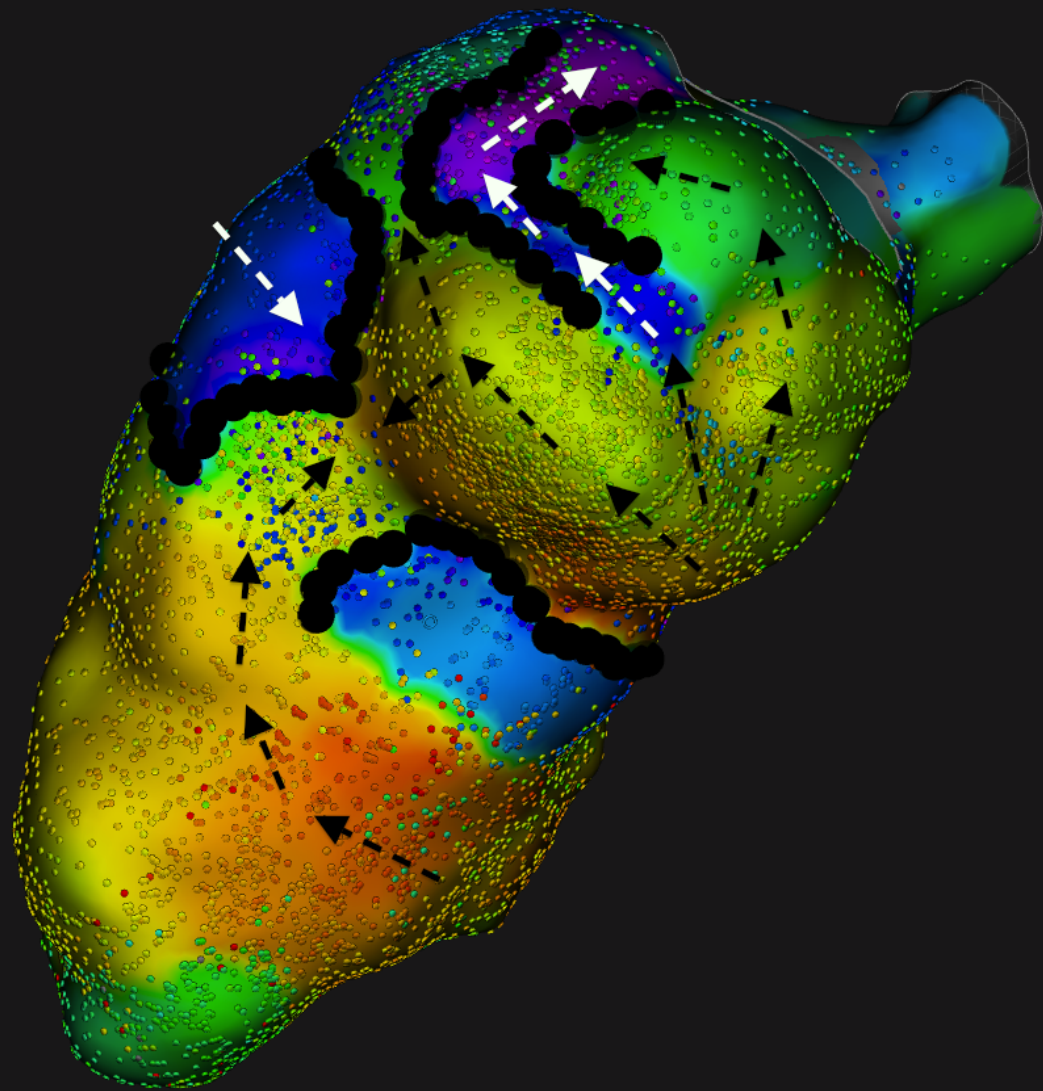
	Sinus rhythm map	Paced map	p=
Healthy surface (>0.8 mV)	69±20 cm <sup>2</sup>	92±22 cm <sup>2</sup>	<0.0001
Border zone surface (0.2-0.8 mV)	71±26 cm <sup>2</sup>	53±33 cm <sup>2</sup>	<0.0001
Dense scar surface (<0.2 mV)	26±27 cm <sup>2</sup>	20±25 cm <sup>2</sup>	0.0003
Late Potentials area	6.6±9.1 cm <sup>2</sup>	4.5±5 cm <sup>2</sup>	0.05
Fragmented potentials area	10.5±10.7 cm <sup>2</sup>	6.9±10.1 cm <sup>2</sup>	0.0027

*Foltran, Maury, review JCE*



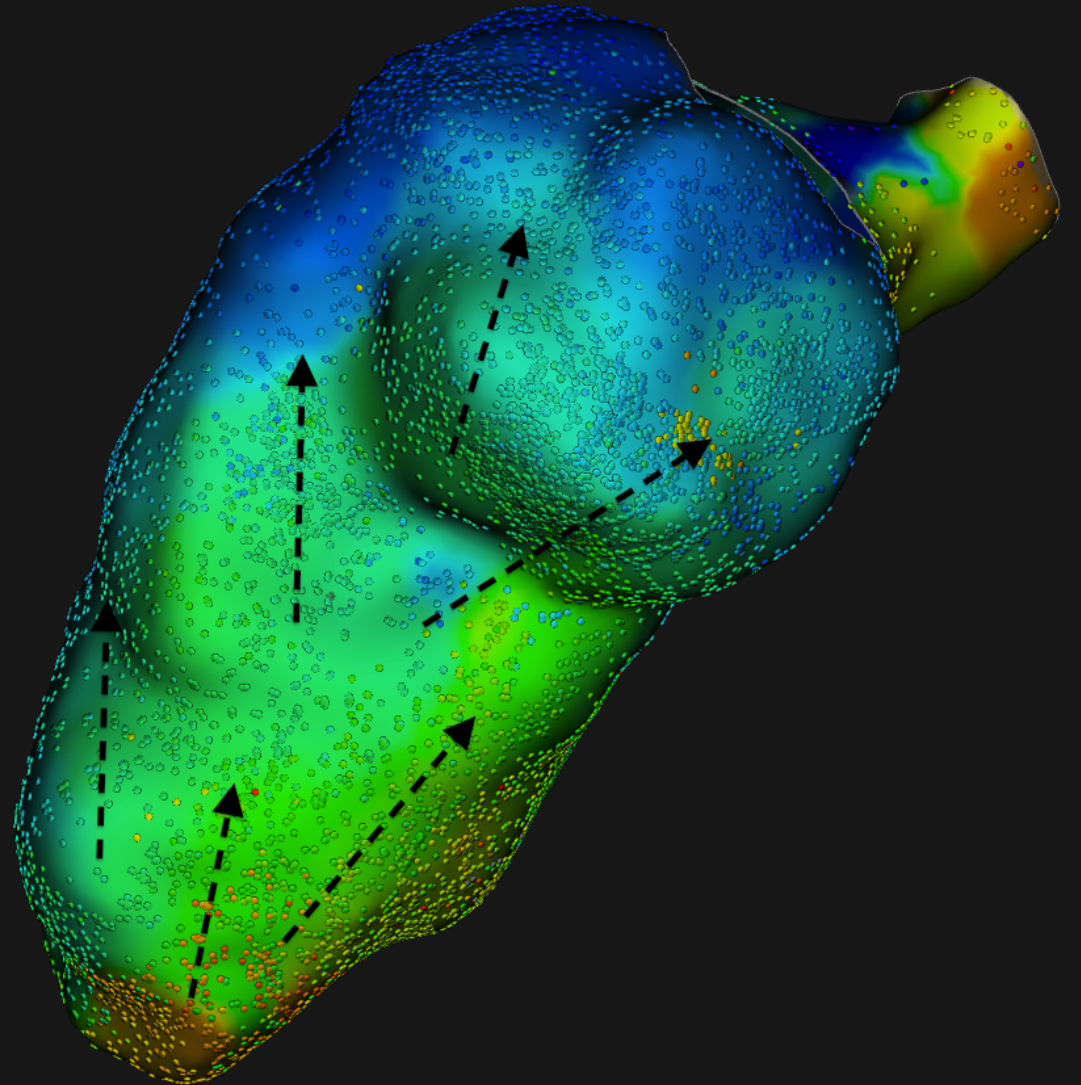
# sinus rhythm

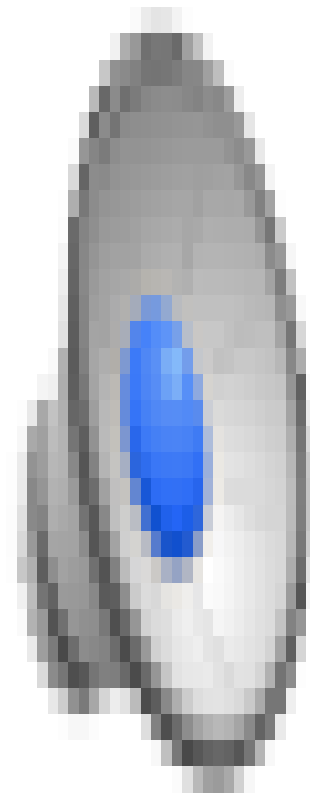
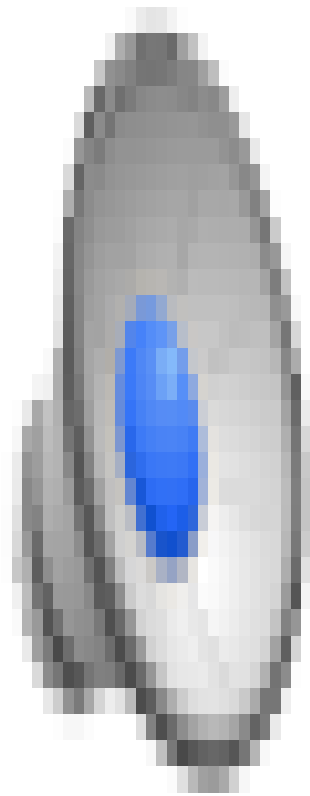
-405 ms -269 ms  
-435 ms -261 ms



# RV pacing

31 ms 180 ms  
26 ms 199 ms









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# 20

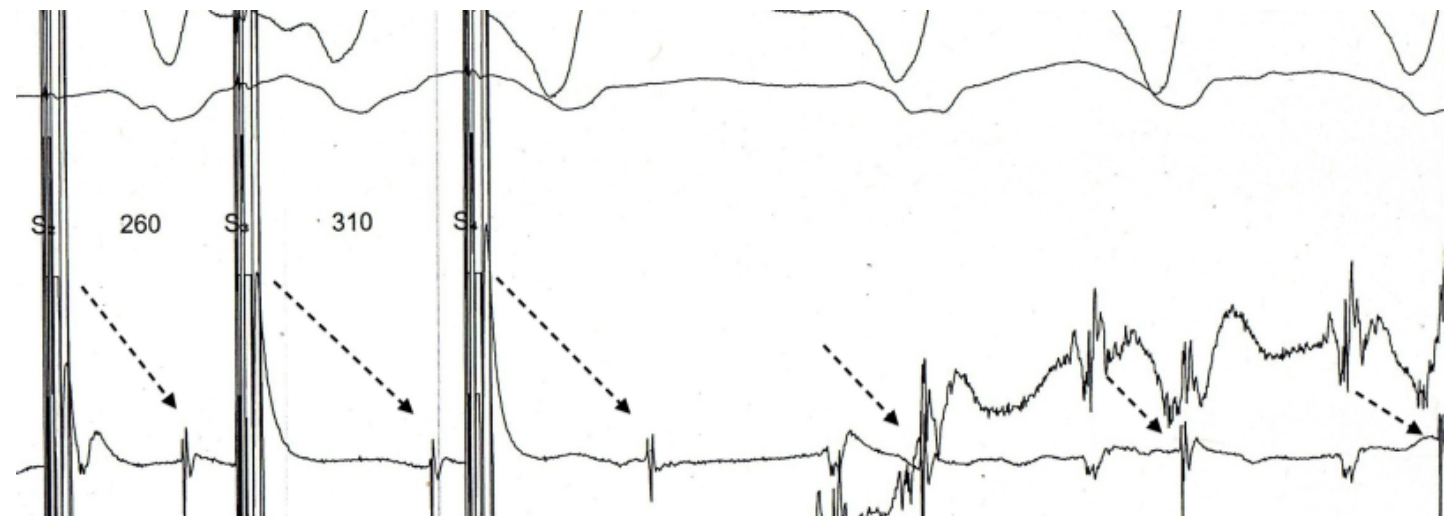
ans

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## OK pour ablation « substrat » mais ...

1. Pas de réelle comparaison entre toutes ces « techniques »
2. Plus efficace si homogénéisation large versus substrat « ciblé »
3. Plus rapide (et moins complications ?) si RF ciblée
4. *Aussi efficace et plus rapide si on cible substrat réellement impliqué ?*

Di Biase L, et al. *J Am Coll Cardiol.* 2012;60:132–141  
Gökoğlan Y, et al. *J Am Coll Cardiol.* 2016;68:1990–1998.



# Le substrat « fonctionnel »

« decrement evoked potentials » (DEEPs)

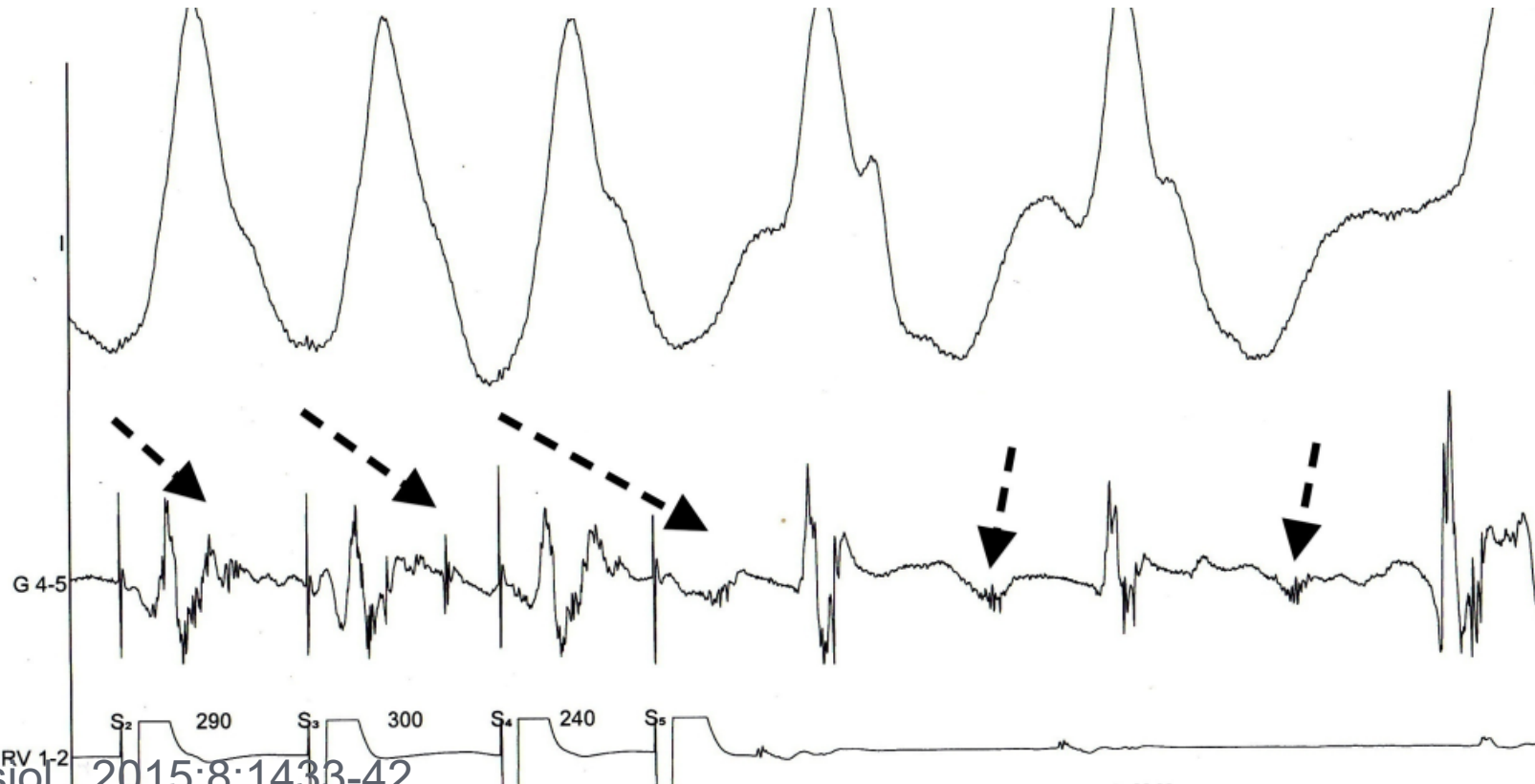
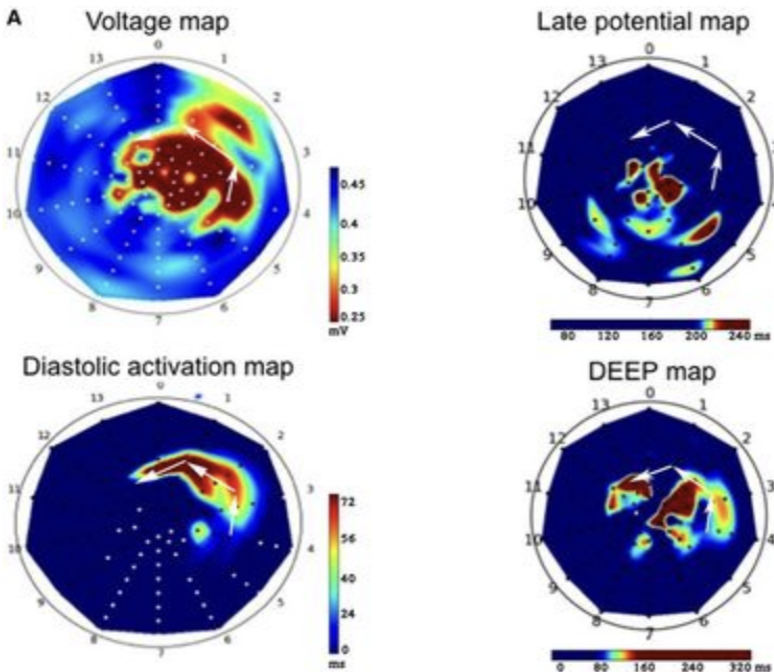
## Pour la détection d'un isthme de TV

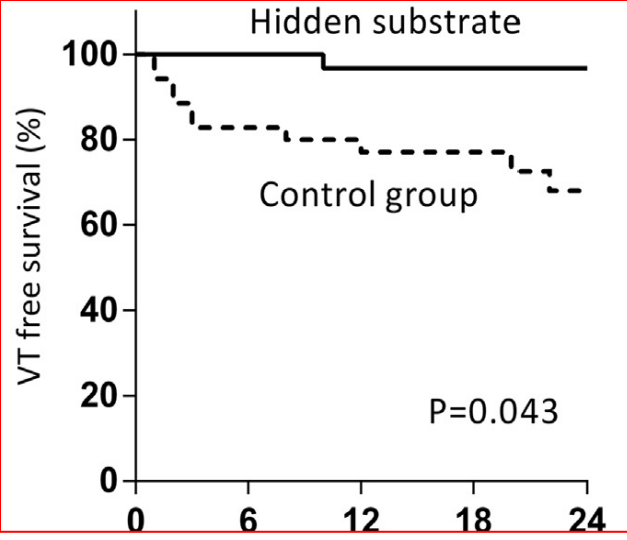
Sensibilité 50%

Spécificité 43% (95% pour les plus décrémentiels)

Meilleures que LP tout venant

**Tous les LAVAs sont impliqués ?**

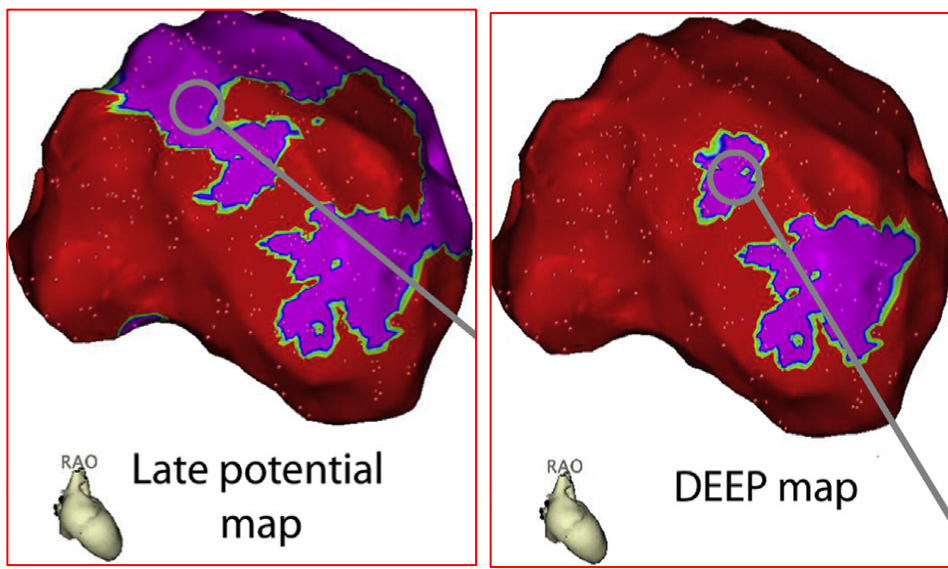
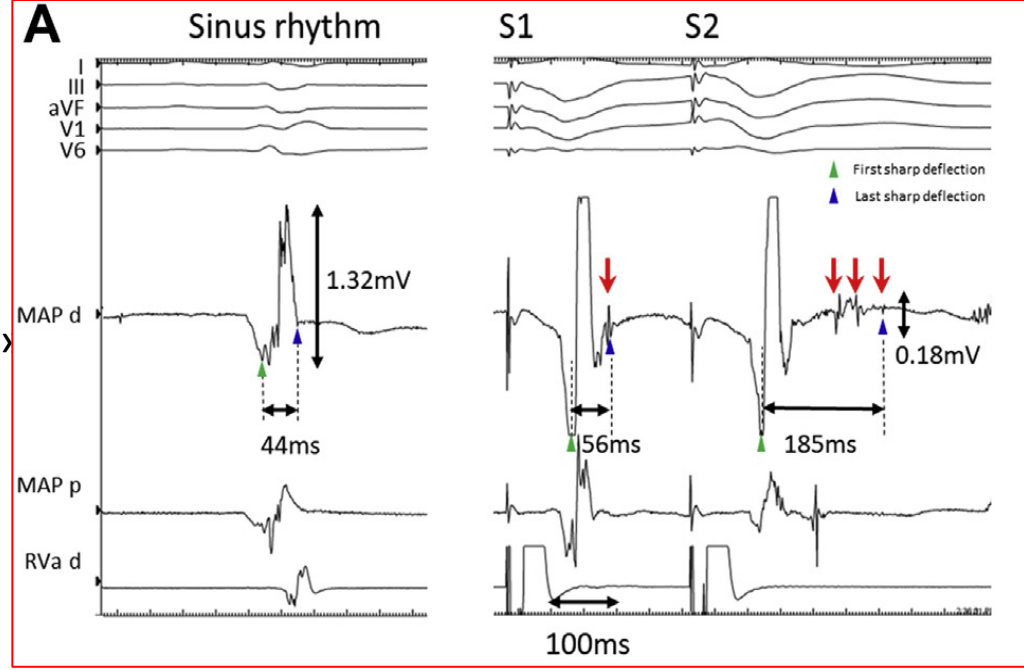




Scar plus petites si existence LAVAs « cachés »

Moins de récurrences si LAVAS « cachés » ablatés vs conventionnel

De Riva M, et al. JACC Clin Electrophysiol. 2018;4:316-327



DEEP focused ablation  
(LAVAs décrementiels post ESV)

Meilleure spécificité pour isthme VT  
75% succès long terme si ablatés

Porta Sanchez A, et al. JACC Clin Electrophysiol. 2018;4:307-315



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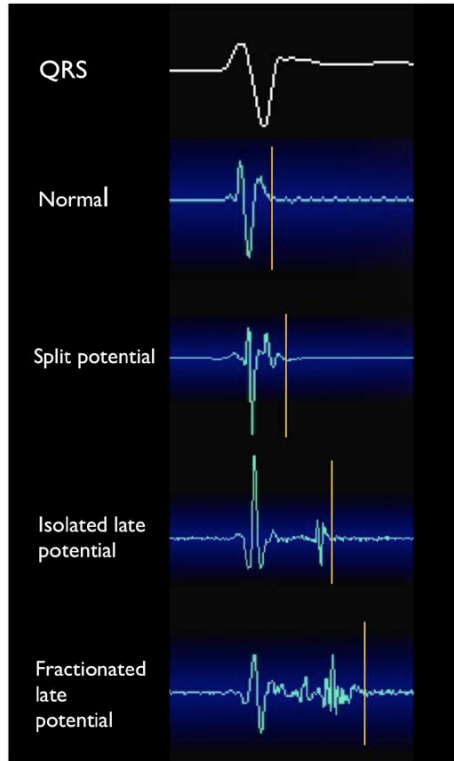
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# 20

ans  
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### Deceleration zone, isochronal late activation mapping (ILAM)

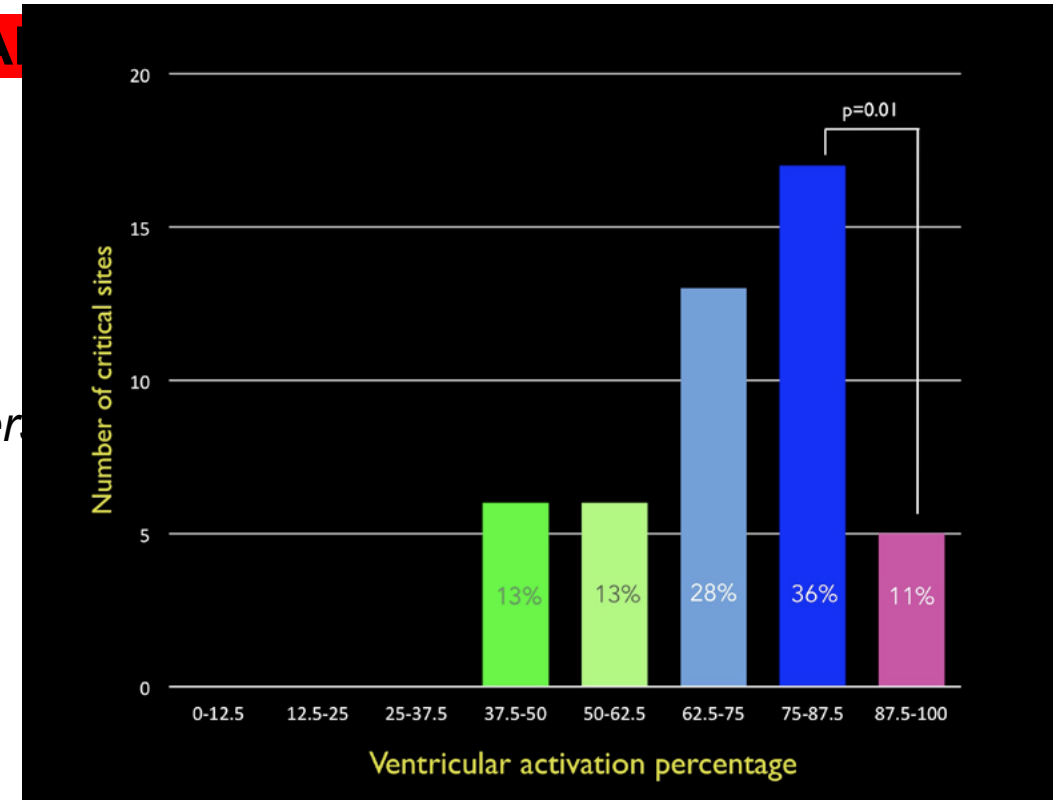
3 isochrones sur 1 cm = 0.6 cm/sec



*isthmes TV pas nécessairement corrélés  
aux pot les plus tardifs en sinusal*

*Isochrones de conduction lente qui arrivent vers  
la zone la plus tardive sont plus spécifiques*

*Mais pas d'ES ici (sinusal ou pacing)*



Irie T, et al. *Circ Arrhythm. Electrophysiol.* 2015;8:390–399



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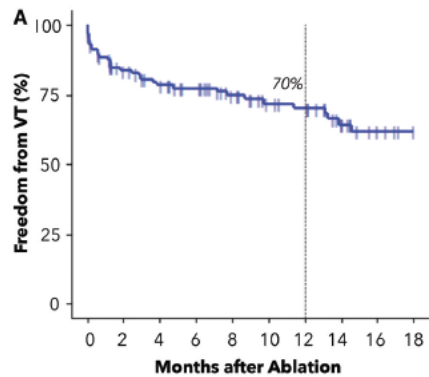
Registre rétrospectif de 120 patients successifs (Chicago)

## Zones de décélération corrélées

- isthme TV
- zone de bon pacemap

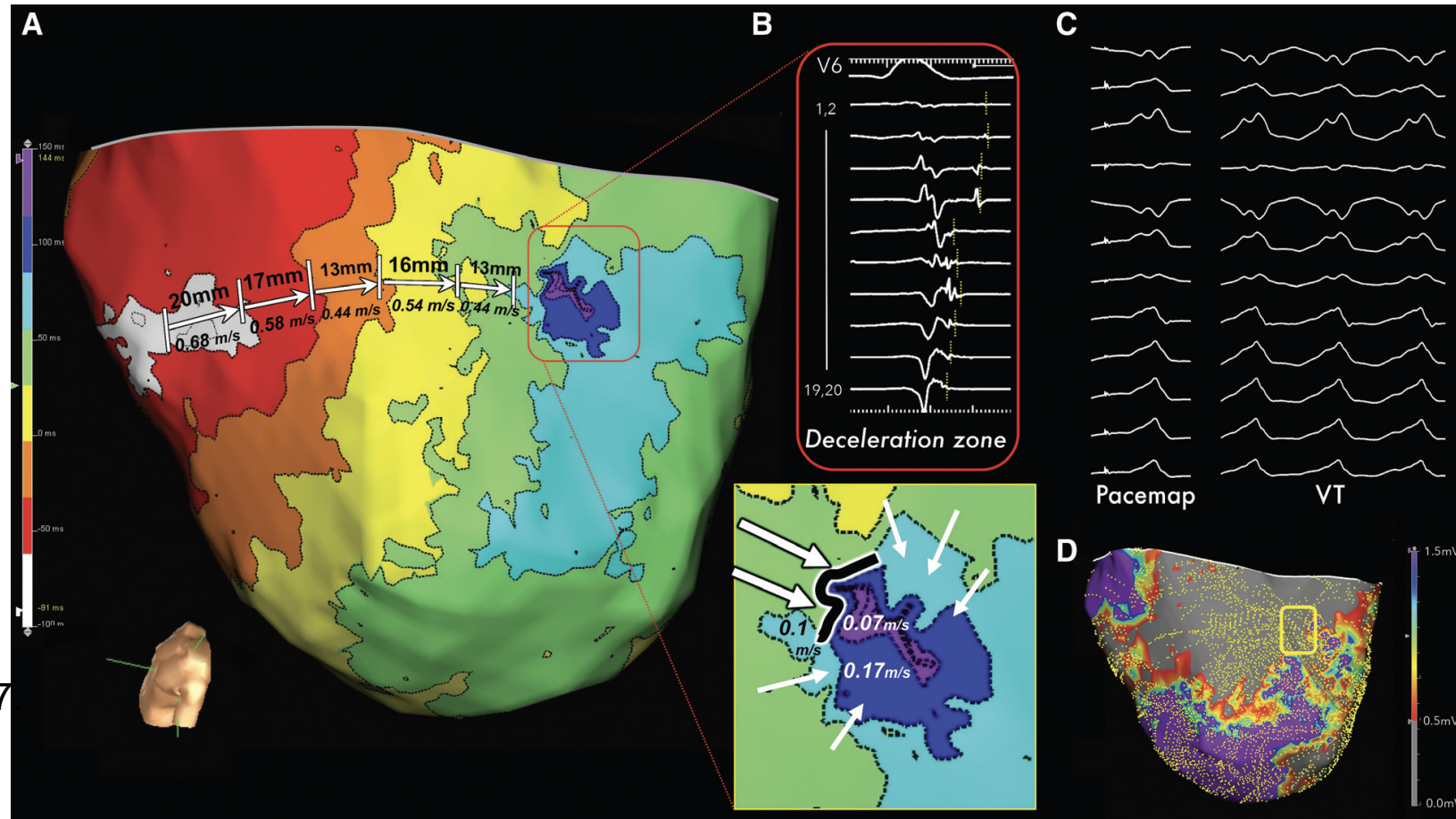
median zones décélération 2

- 18% une seule
- 35% deux
- 45%  $\geq 3$



Succès  
long terme 70%

AZIZ Z, et al. Circulation. 2019;140:1383–1397





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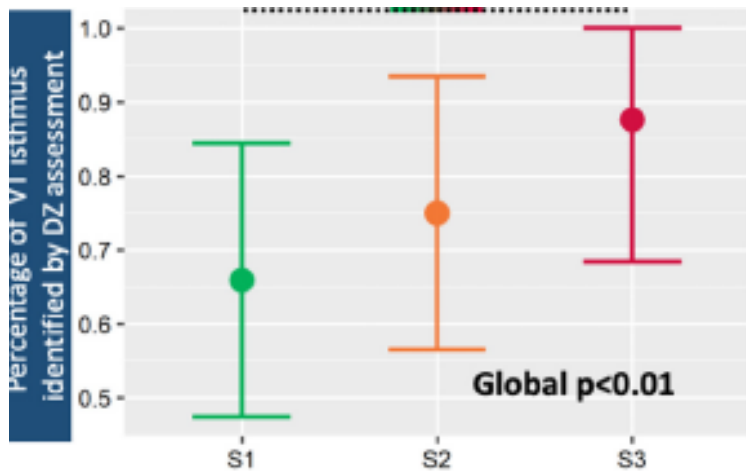
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20 ans

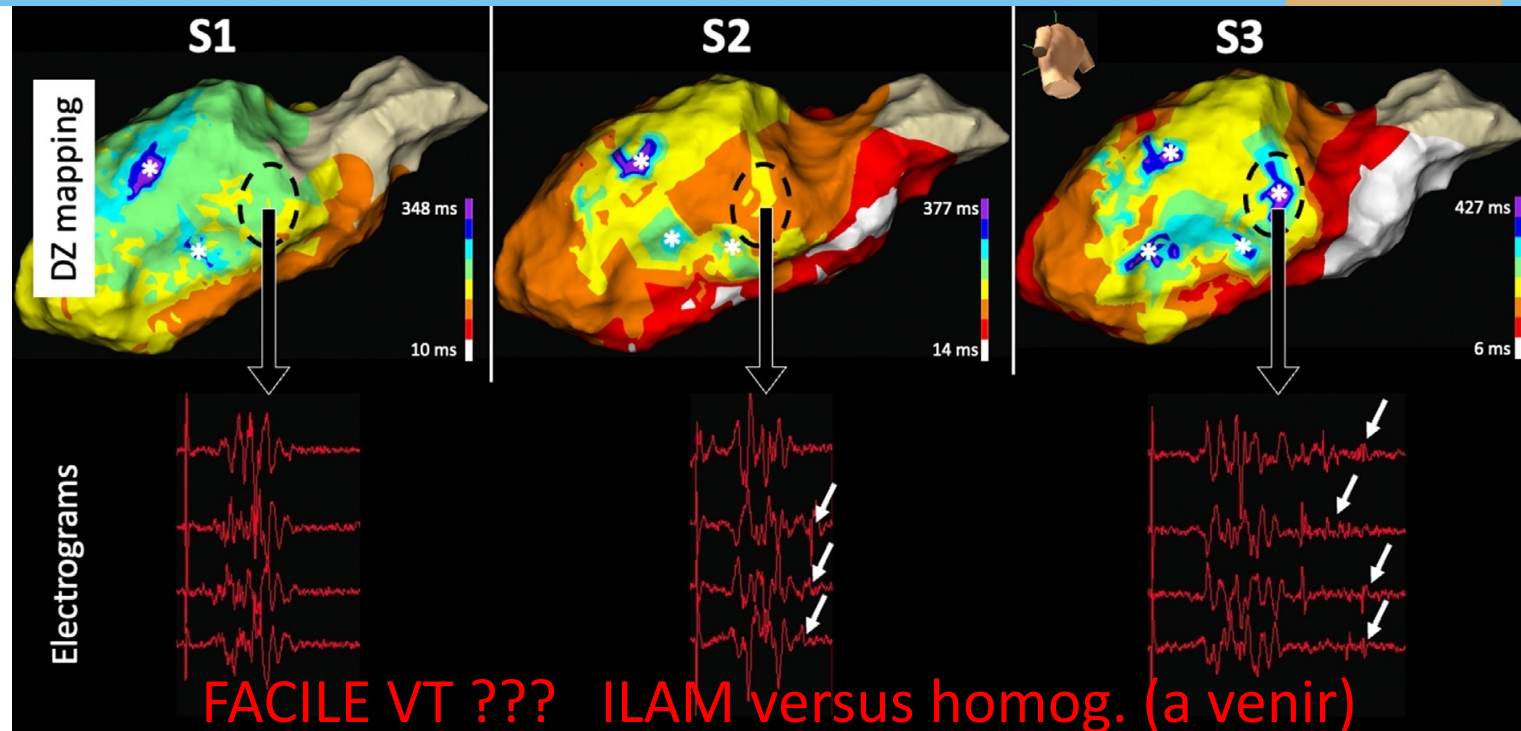
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## Procotole S3 ?

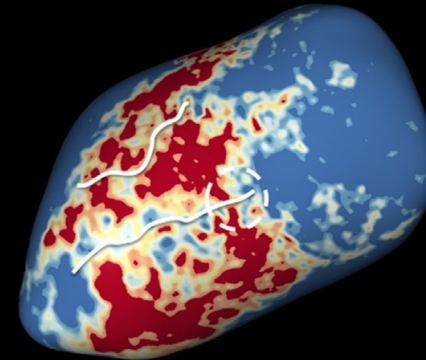
- plus de LAVAS, LP
- plus de channels
- plus de zones de décélération

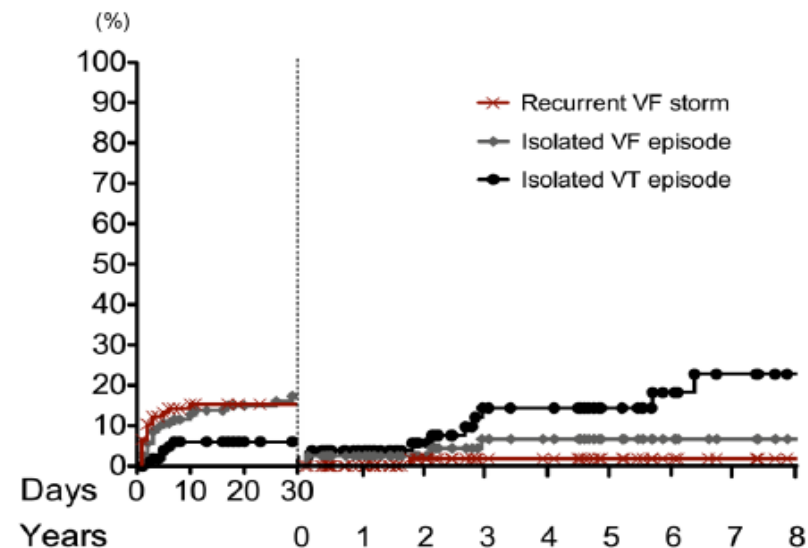
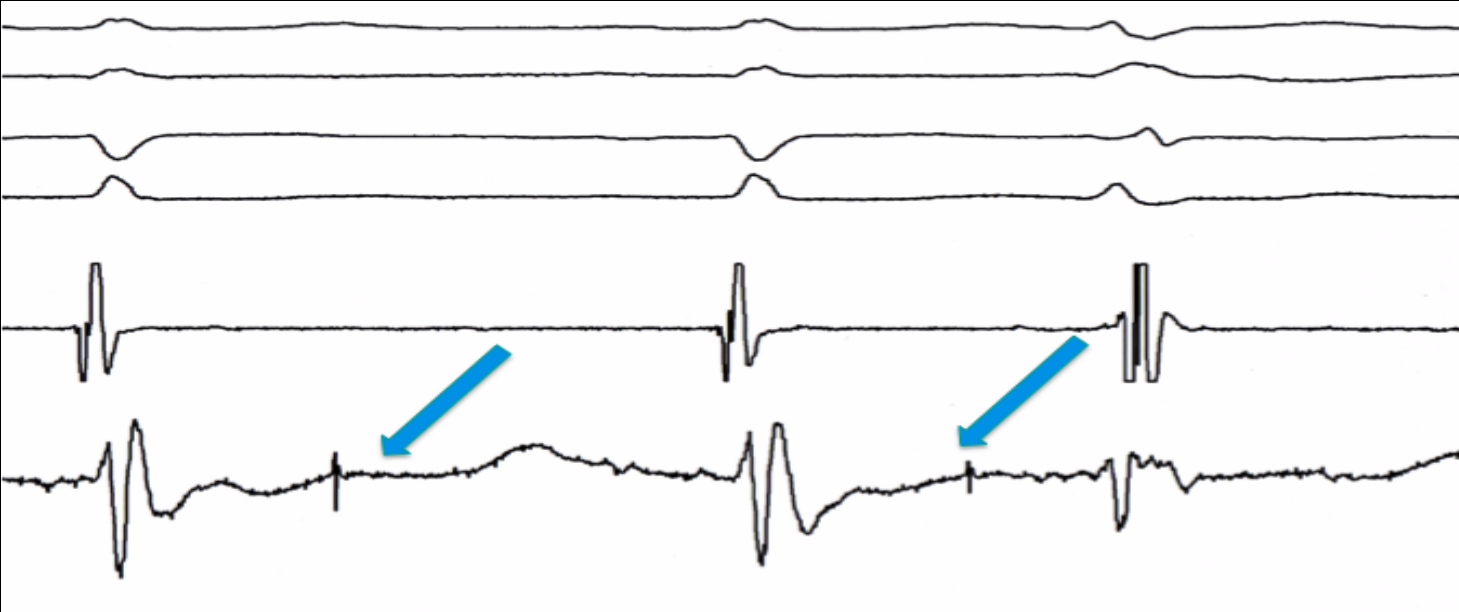


inclusion of extrastimulus increases sensitivity  
negative and positive predictive value  
while maintaining specificity



LGE-MRI





## ESV

spontanées	86%
scar/territoire infarctus	100%
septum	86%
Purkinje	90%



Catheter Ablation of Refractory Ventricular Fibrillation Storm  
After Myocardial Infarction: A Multicenter Study

Komatsu, et al. Circulation. 2019 May 14;139(20):2315-2325

# intégration de l'imagerie

Live Review

3 LV TV1

1 VTK

B.Time Live Review

188 ms  
194 ms  
209 ms  
430 ms  
-221 ms

Volume: 169.97 cc  
EGMs: 6912

Time: 16:56 Beats: 1322

Statistics: multiple maps are visible

Beat Review Graph

Auto \* NF SUP RL LL LAO PA AP

Auto \* INF SUP RL LL RAO LAO PA AP

MFI Orion

MFI Orion

3 LV TV1

1 VTK

B.Time Live Review

Volume: 169.97 cc  
EGMs: 6912

Time: 16:56 Beats: 1322

Statistics: multiple maps are visible

Beat Review Graph

Auto \* NF SUP RL LL LAO PA AP

Auto \* INF SUP RL LL RAO LAO PA AP

MFI Orion

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## Conclusions et messages

- ✓ ablation substrat « électrique » devenue incontournable
- ✓ nécessité de mieux définir ce substrat et la scar
- ✓ nécessité de définir le substrat réellement coupable
- ✓ nécessité de comparer les stratégies
- ✓ nécessité de personnaliser l'ablation en fonction d'un substrat donné