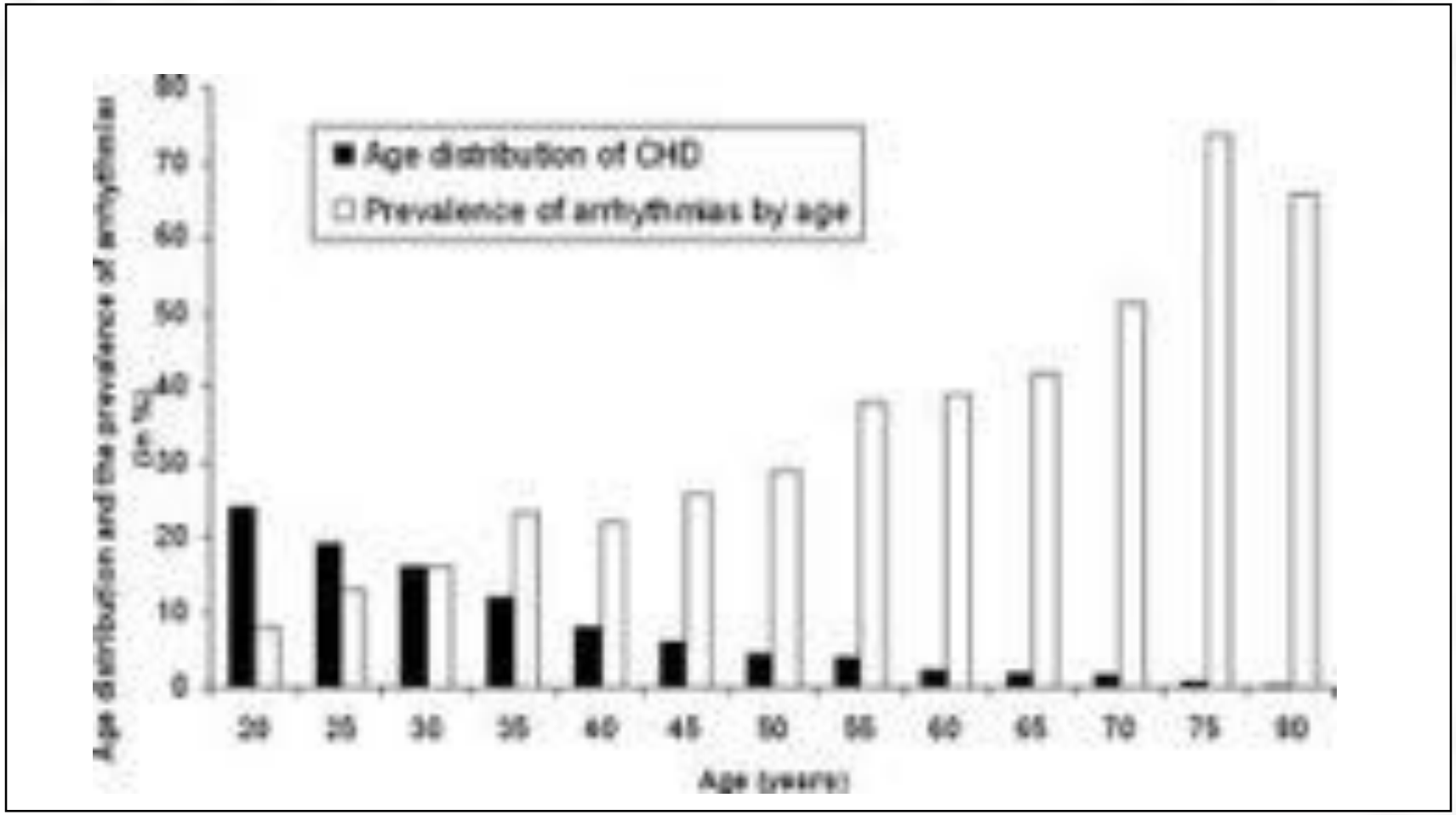
Troubles du Rythme post-opératoire

N Derval
CHU Bordeaux
LIRYC

GÉNÉRALITÉS

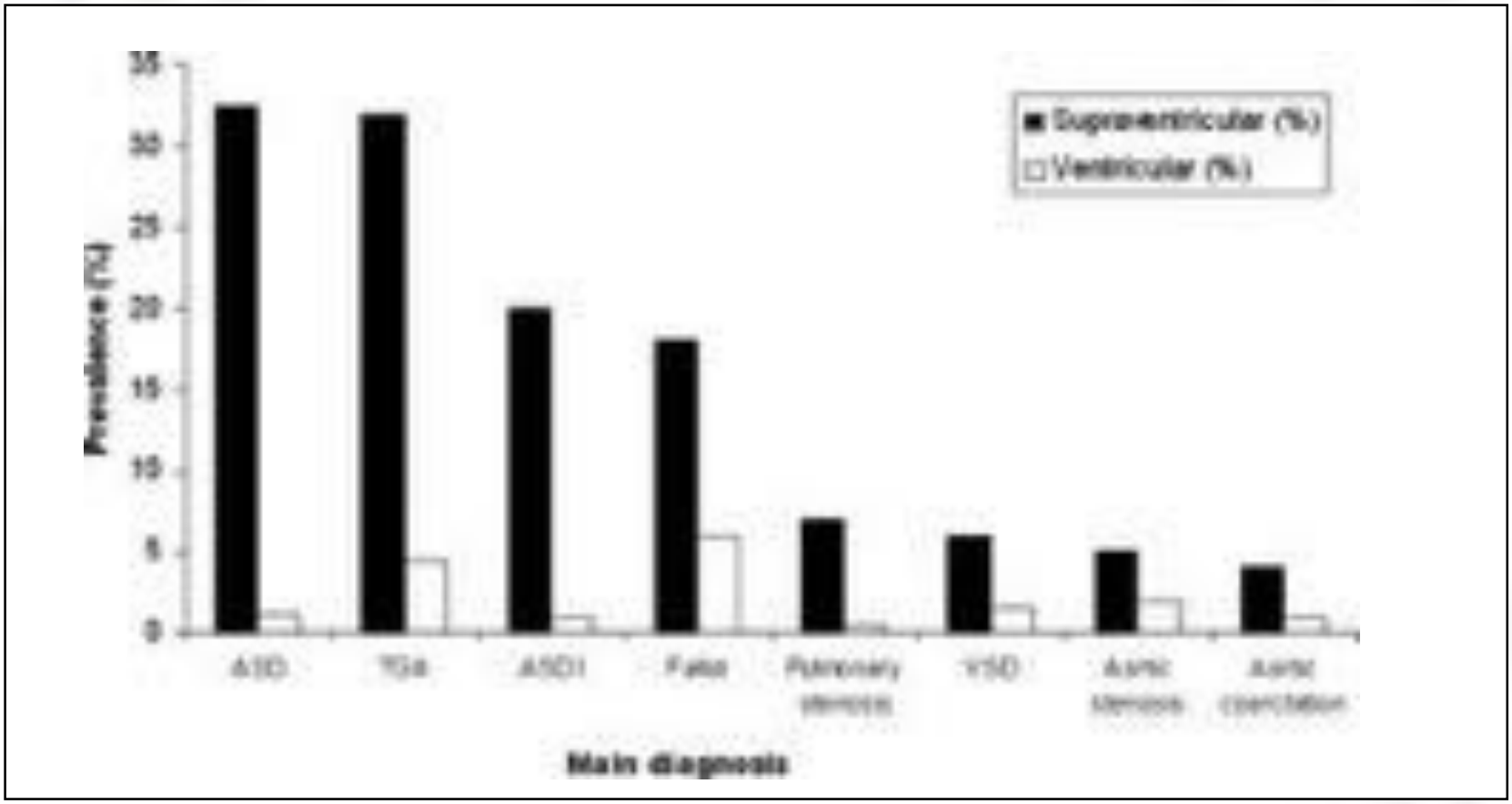
- Survie au-delà de la première année de vie est passée de 25% il y a environ 50 ans à >90% actuellement (atteinte de l'âge adulte).
- L'âge médian de décès des patients atteint de formes sévères de cardiopathie congénitale est passé de 2 à 23ans au cours de 30 dernières années.
- Apparition d'une **population de jeunes adultes** porteurs de cardiopathies congénitales complexes présentant des problèmes spécifiques dont des troubles du rythme.
- **troubles du rythme**: première cause d'hospitalisation et même de mortalité (en association avec l'insuffisance cardiaque) dans cette population [2].
- Tous les troubles du rythme peuvent être rencontrés dans le suivi.
- **Plus de 50%** des patients porteurs d'une cardiopathie congénitale, âgés de 20 ans, vont développer une tachycardie atriale.

EPIDÉMIOLOGIE



Roos Hesselink JW, PACE 2008

EPIDÉMIOLOGIE



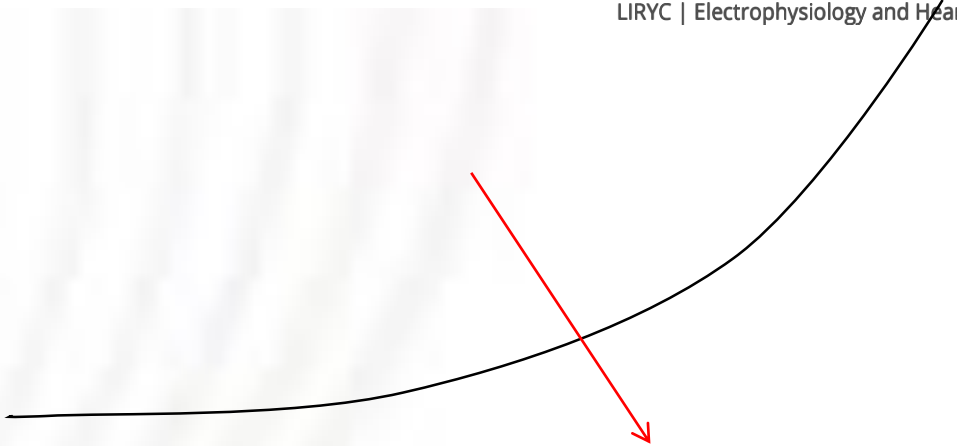
ASD: CIA; TGA: transposition des gros vaisseaux; ASDI: CIA Ostium primum, VSD: CIV

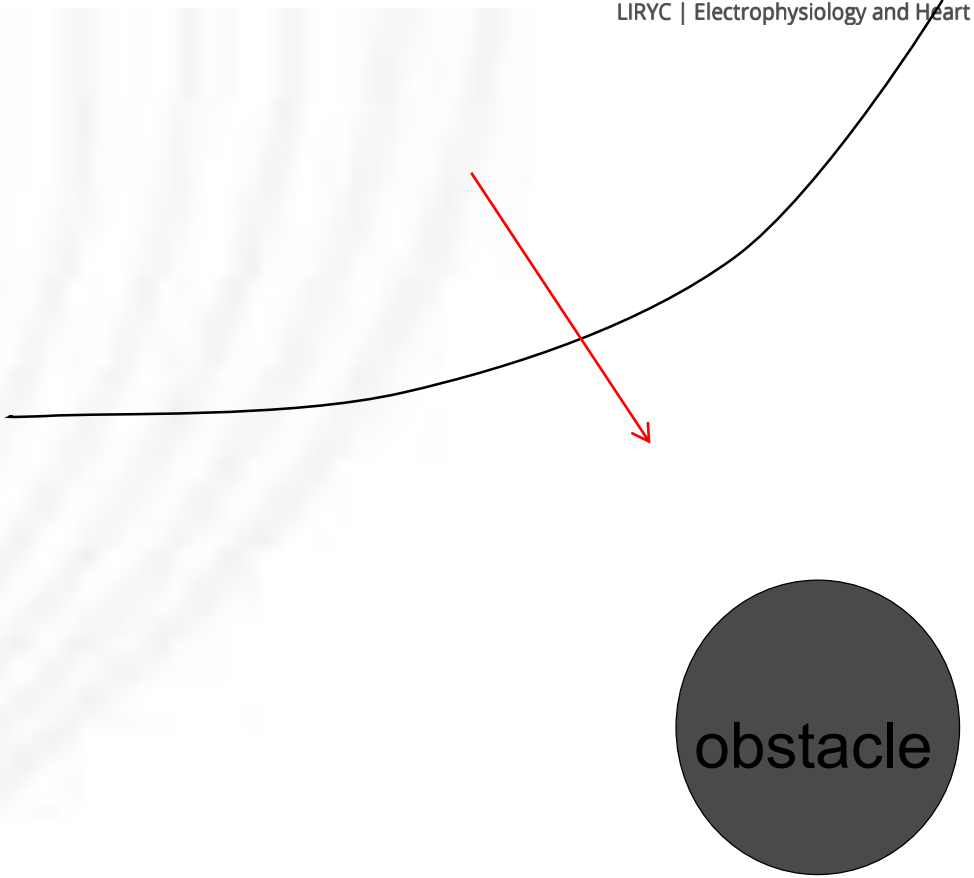
Roos Hesselink JW, PACE 2008

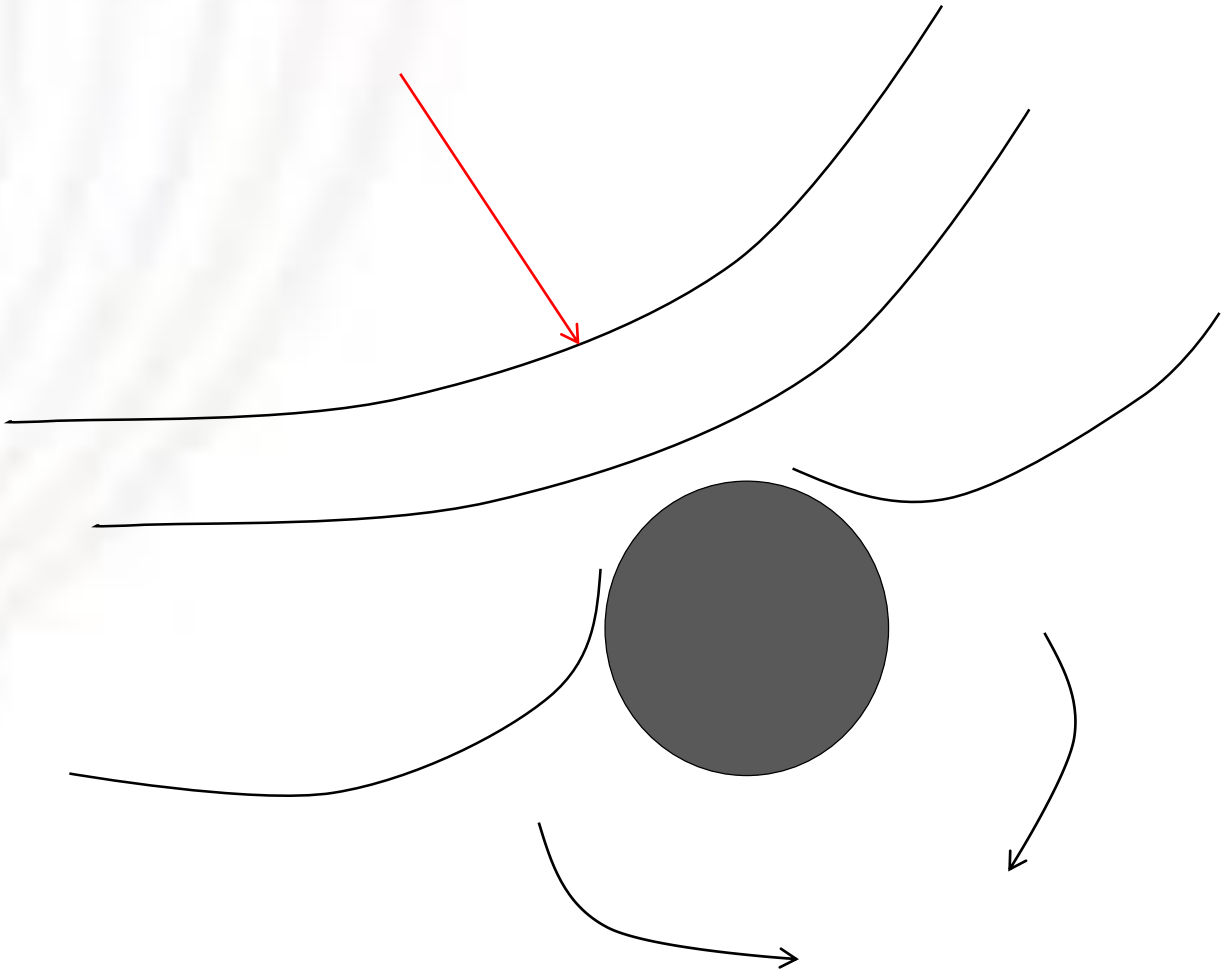
PHYSIOPATHOLOGIE

- ***la cardiopathie sous-jacente***: Elle entraîne la persistance pendant plusieurs décennies de conditions hémodynamiques défavorables, responsables d'une surcharge diastolique chronique atriale et ventriculaire, d'une dyssynchronie atrio-ventriculaire, d'altérations du couplage intercellulaire, de fibrose interstitielle etc… Ces différents phénomènes peuvent se conjuguer et aboutir à la constitution d'un substrat pro-arythmogène.

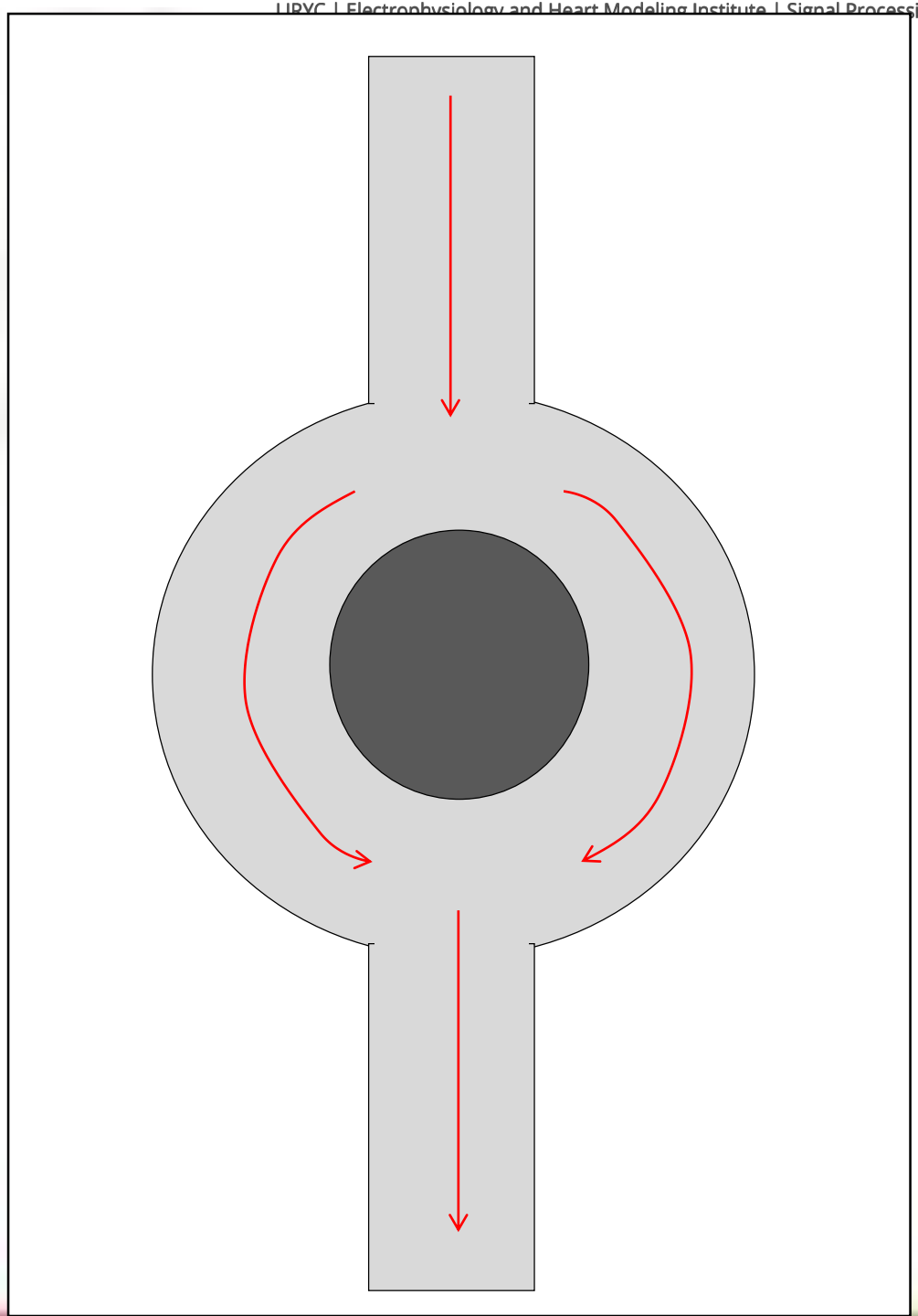
- ***La réparation chirurgicale***: pour réparer les anomalies cardiaques le chirurgien va devoir inciser une ou plusieurs cavités cardiaques. Ces incisions créent des lignes de bloc de conduction électrique et redéfinissent le mode d'activation de ces cavités pouvant ainsi aboutir à la création de circuits d'arythmies potentiels.



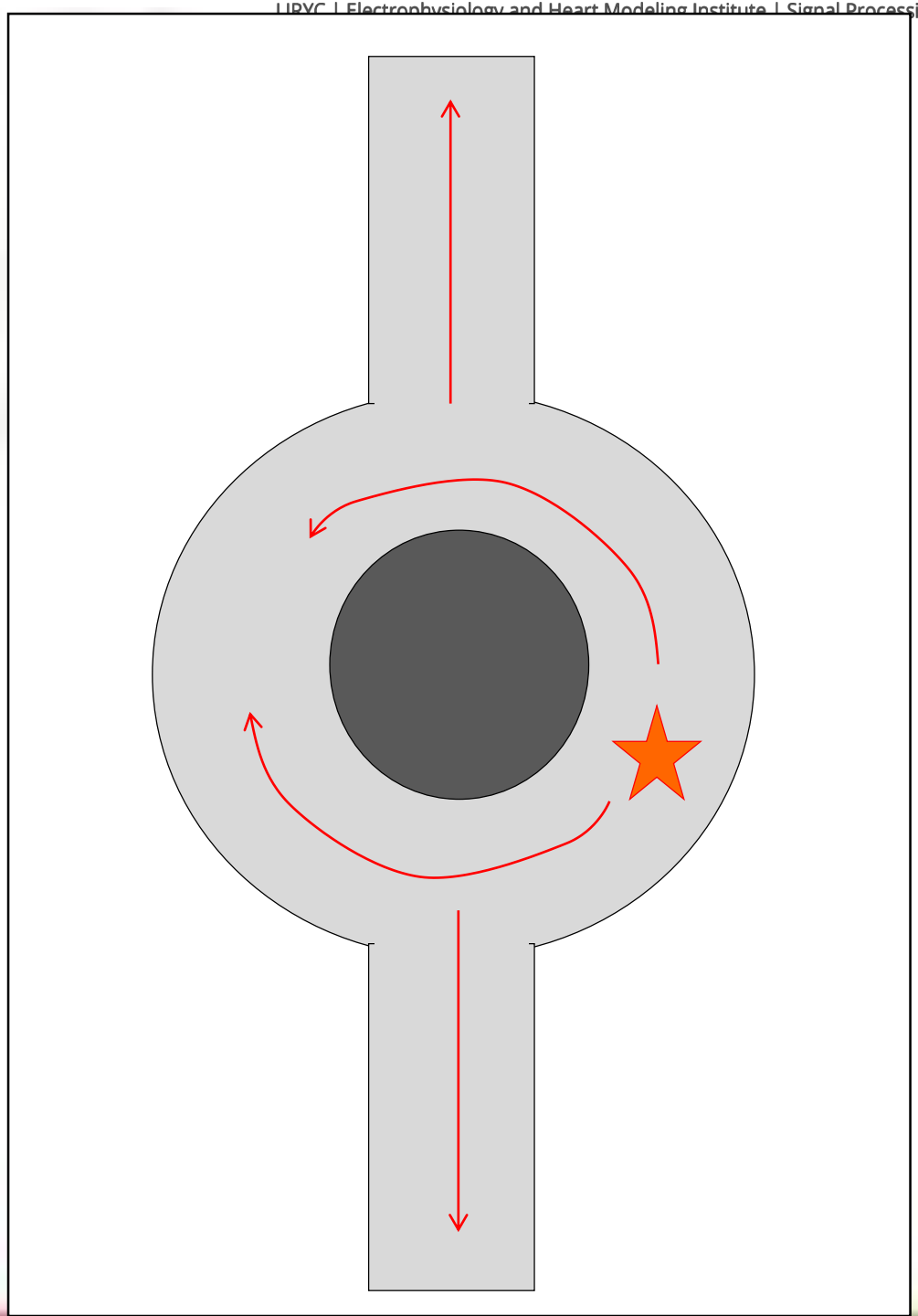

obstacle

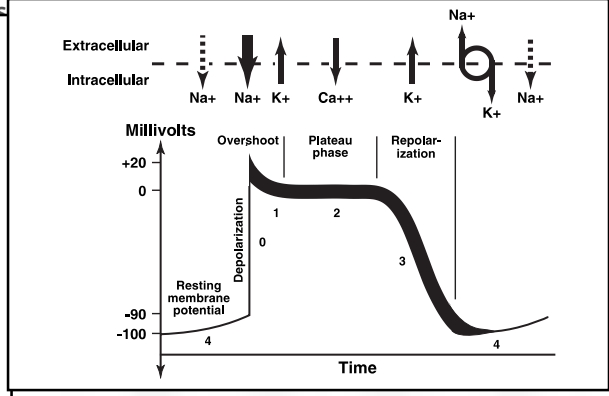


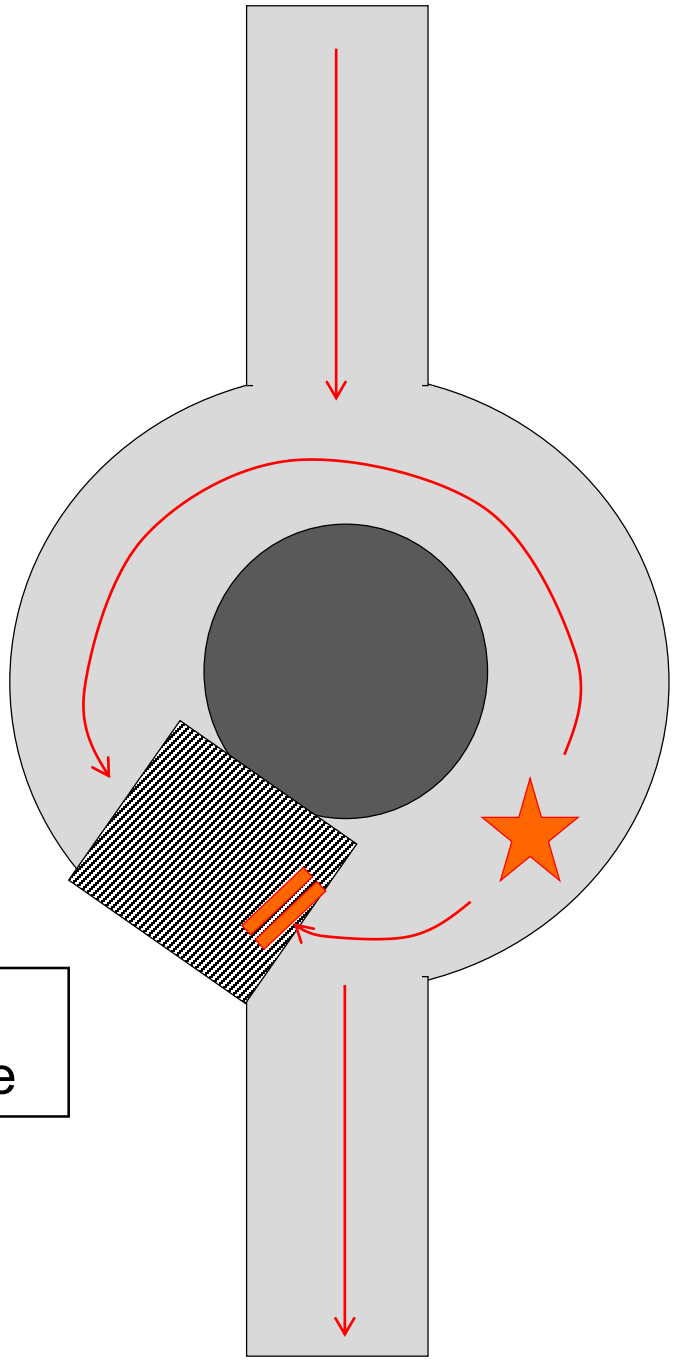
Rythme sinusal



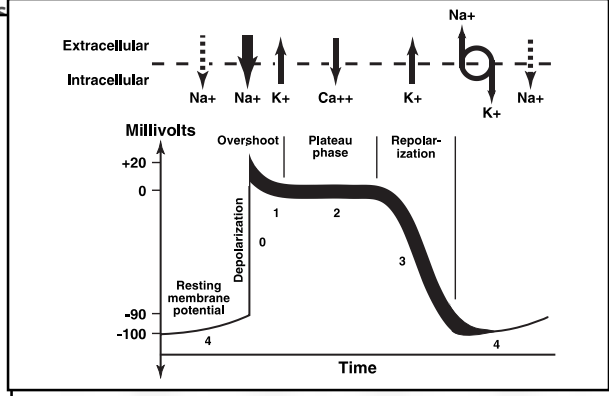
Extrasystole

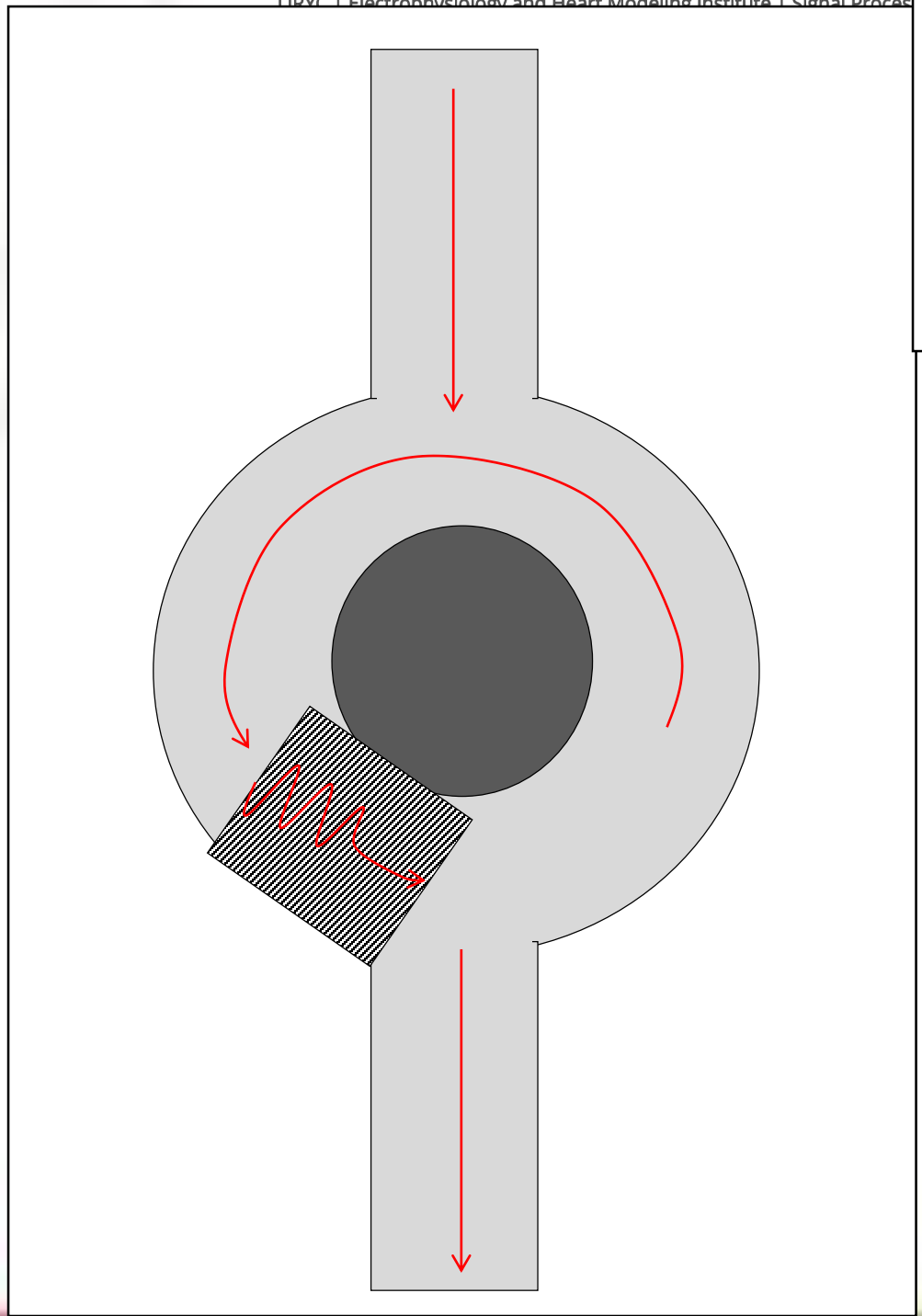




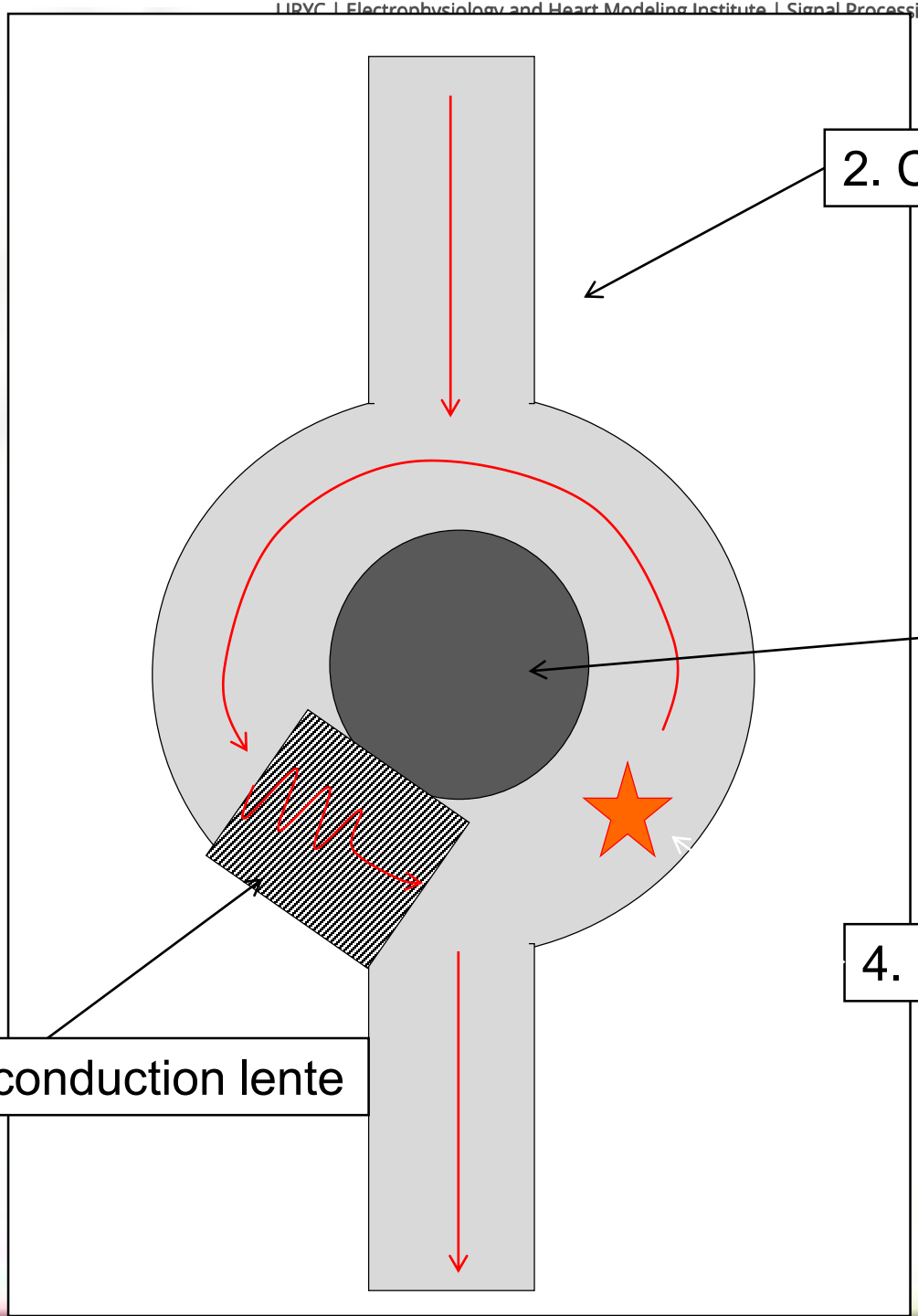


Zone de conduction lente

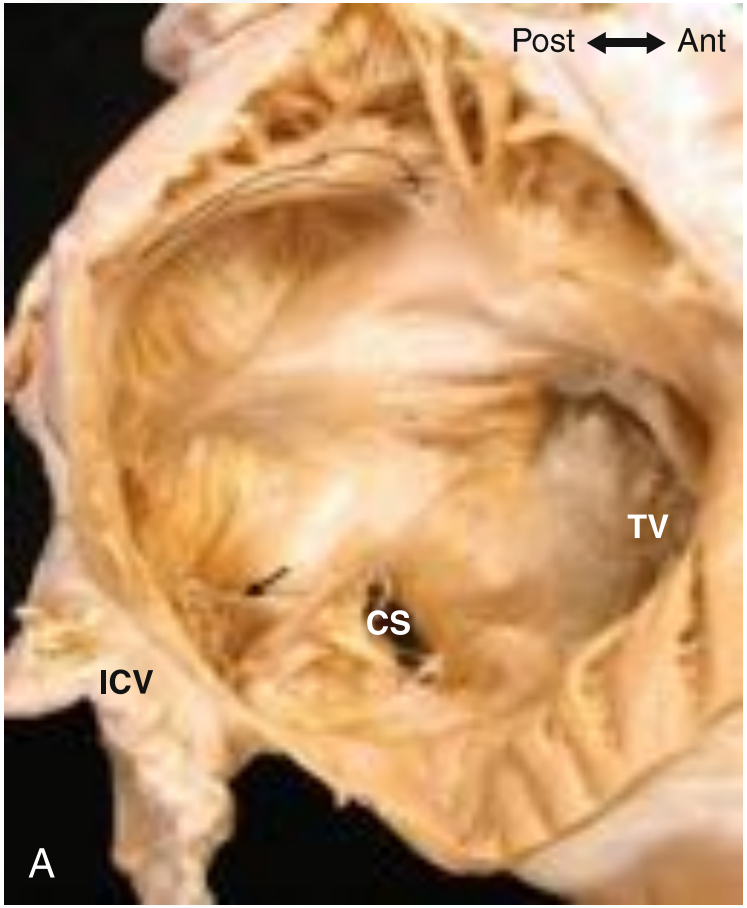


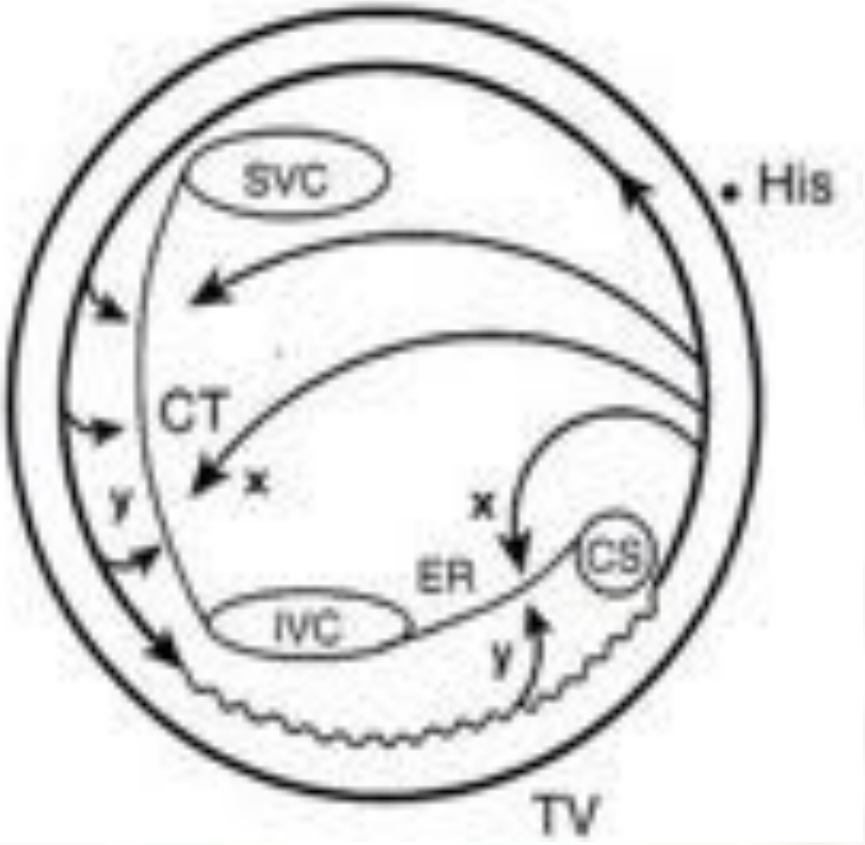


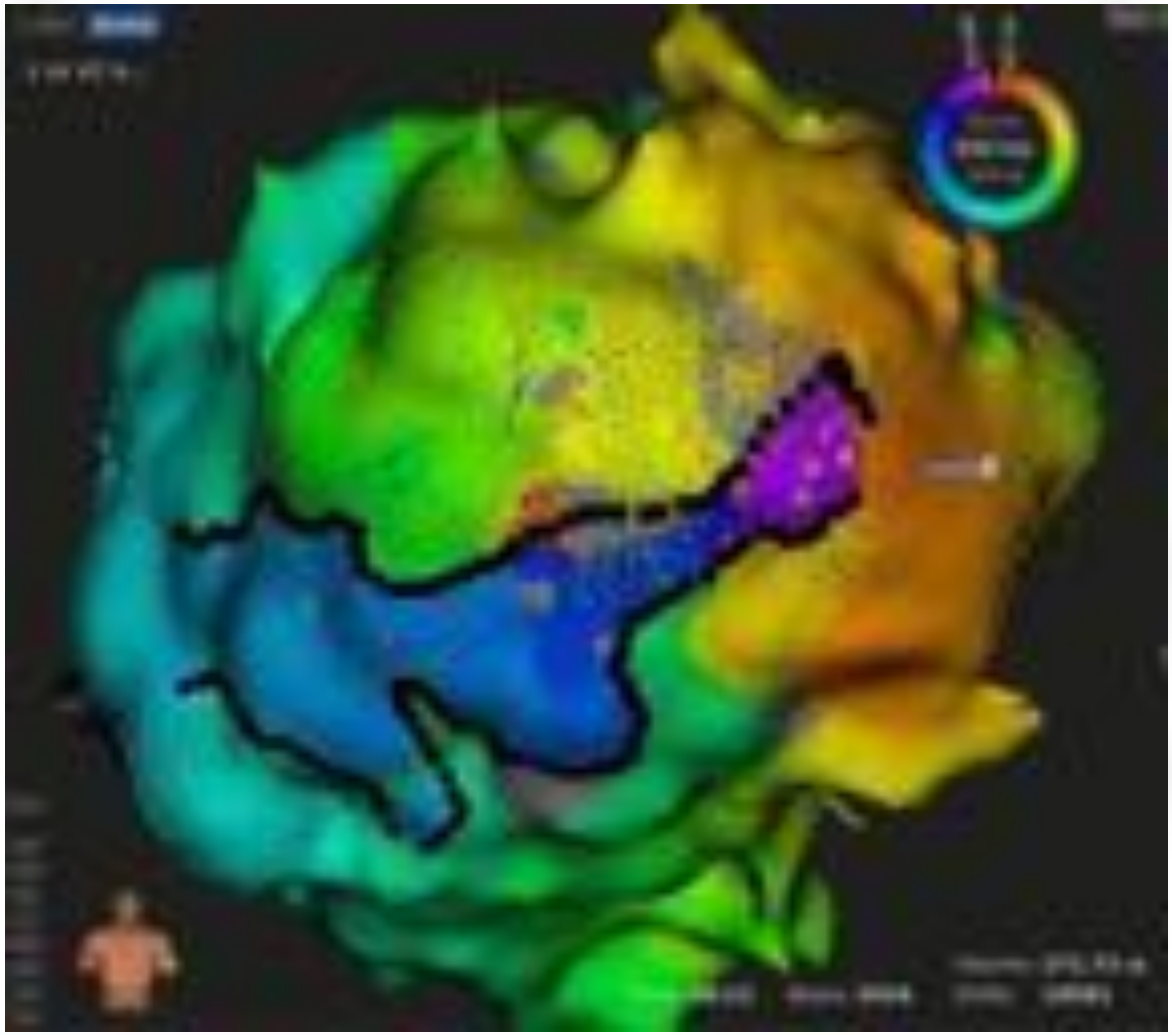
Déclenchement de la tachycardie par réentrée


2. Conduction "encadrée"
1. obstacle
4. Extrasystole initiatrice
3. Zone de conduction lente

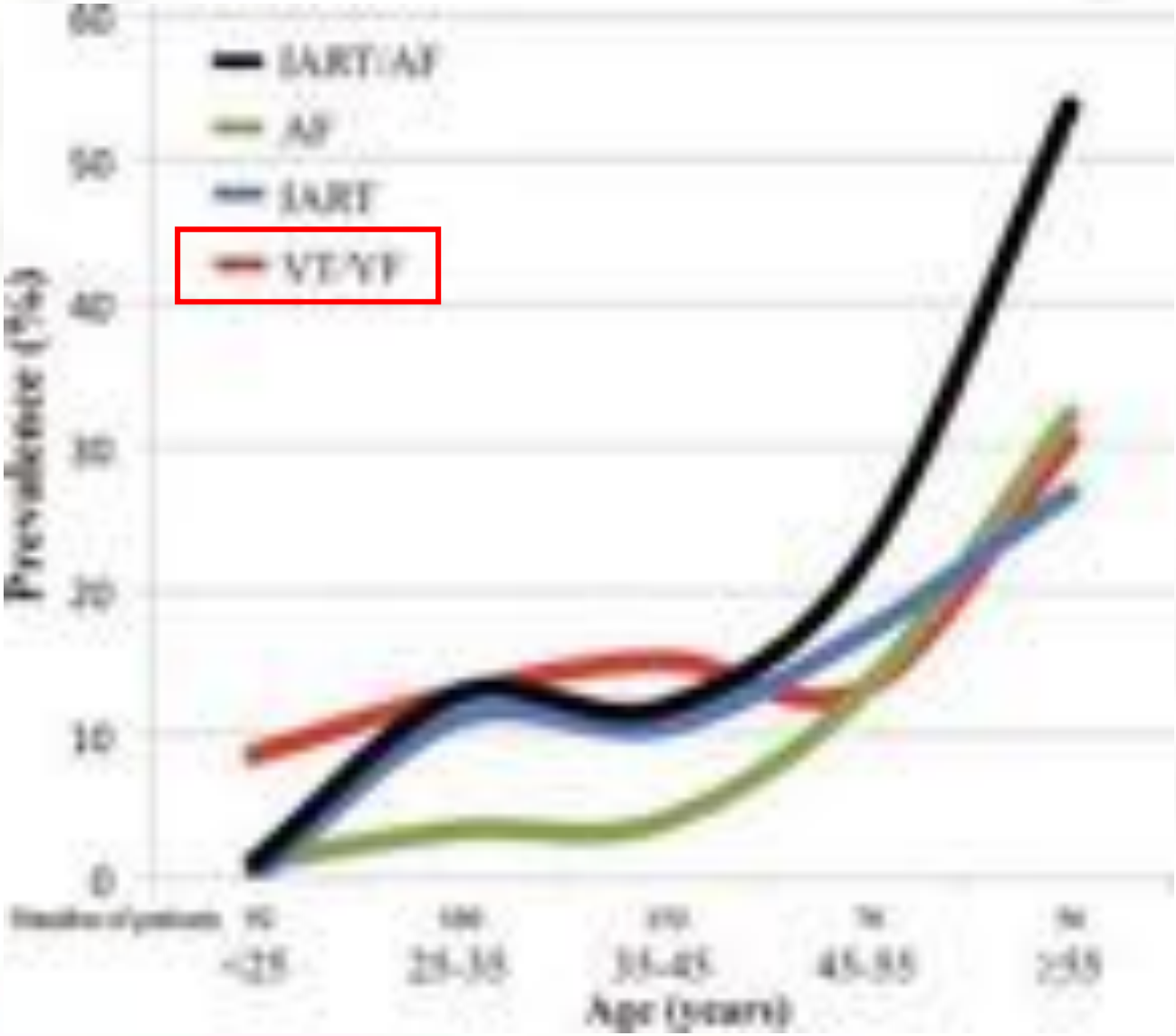
RÉENTRÉE : FLUTTER COMMUN







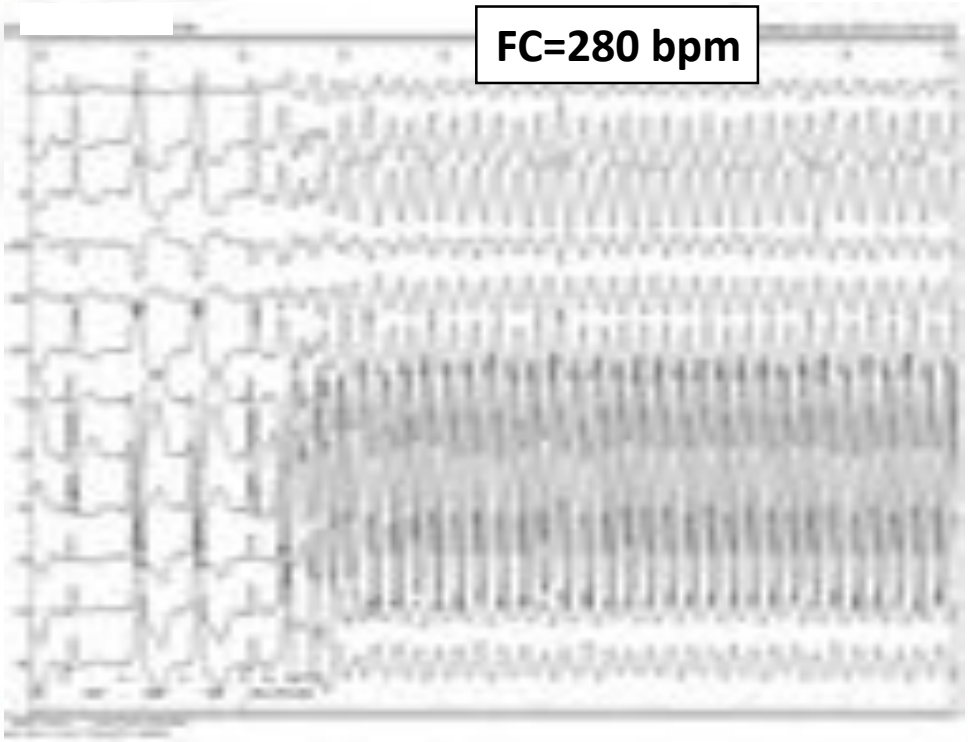
ARYTHMIES VENTRICULAIRES: TDF



Khairy , P Circulation 2010

ARRHYTHMIA IN TOF

Authors	patients	Mean follow-up	SCD	SCD incidence per decade
Murphy et al.[2]	163	30years	6%	2.0%
Nollert et al.[3]	490	25years	3%	1.2%
Silka et al.[7]	445	22years	2.6%	1.8%
Norrgaard et al.[4]	125	25years	5.6%	2.2%
Gatzoulis et al.[8]	793	21years	6%	3.0%



- SCD is reported in 1–6% of cases
  - in most instances due to **VT**/VF
  - 1/3 to 50% of late deaths

Gatzoulis MA, et al. Lancet 2000;

ARRHYTHMIA IN TOF

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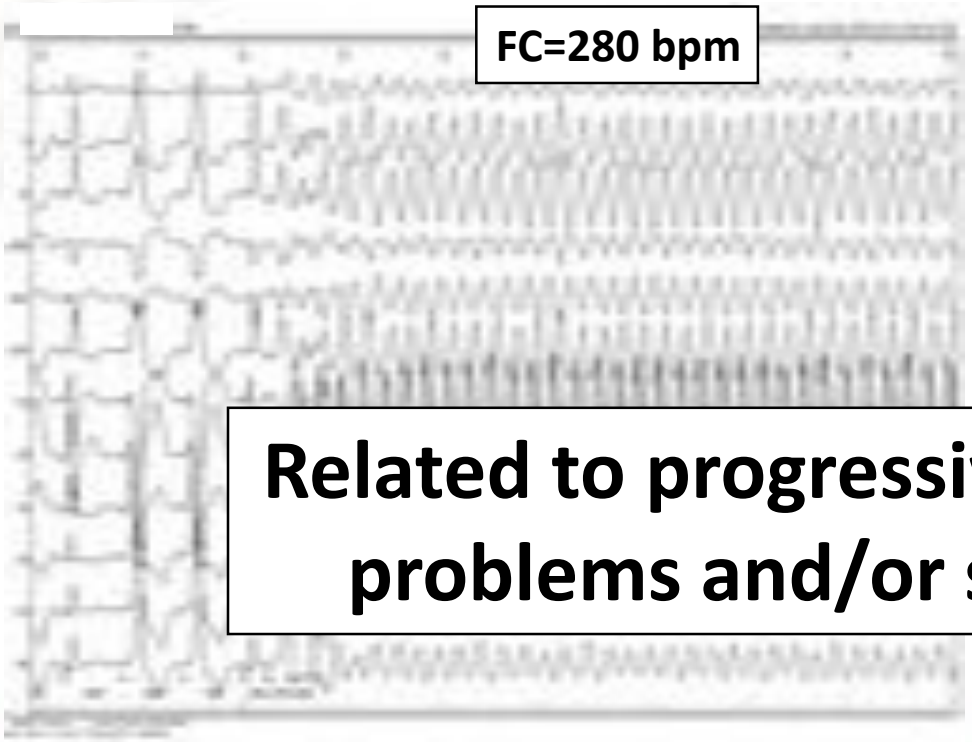

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  - in most instances due to VT/VF

Related to progressive haemodynamic problems and/or surgical scarring

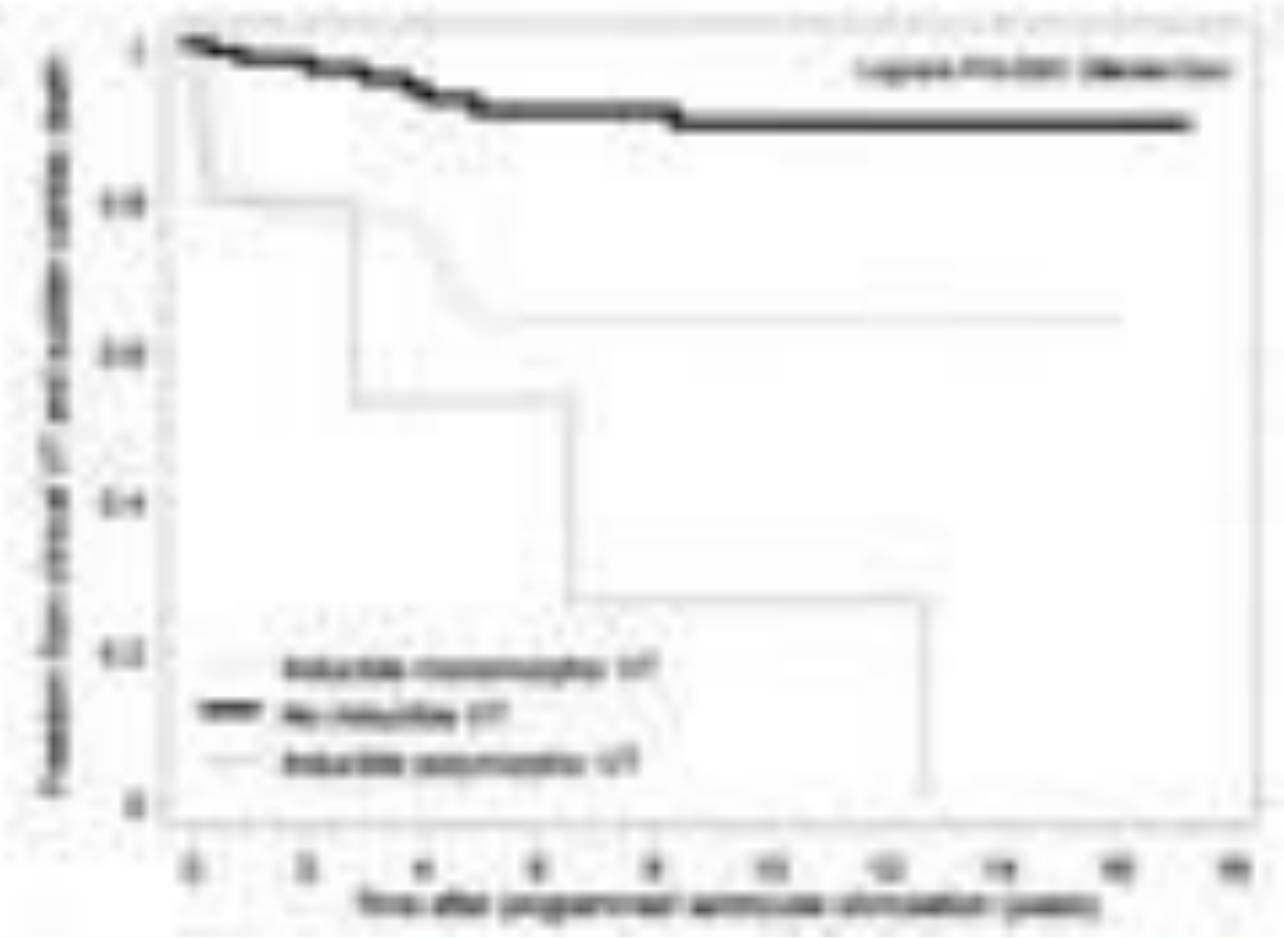
Gatzoulis MA, et al. Lancet 2000;

ARRHYTHMIA IN TOF

- Risk factor of arrhythmia remains controversial
  - Right and/or left ventricular dysfunction
  - Extensive ventricular fibrosis (on CMR)
  - QRS ≥180 ms
  - Significant PR
  - Non-sustained VT on Holter monitoring
  - Inducible VT at EP testing
  - Long-lasting palliative shunts
  - Older age at time of repair.

ESC guidelines for GUCH. European Heart Journal 2010

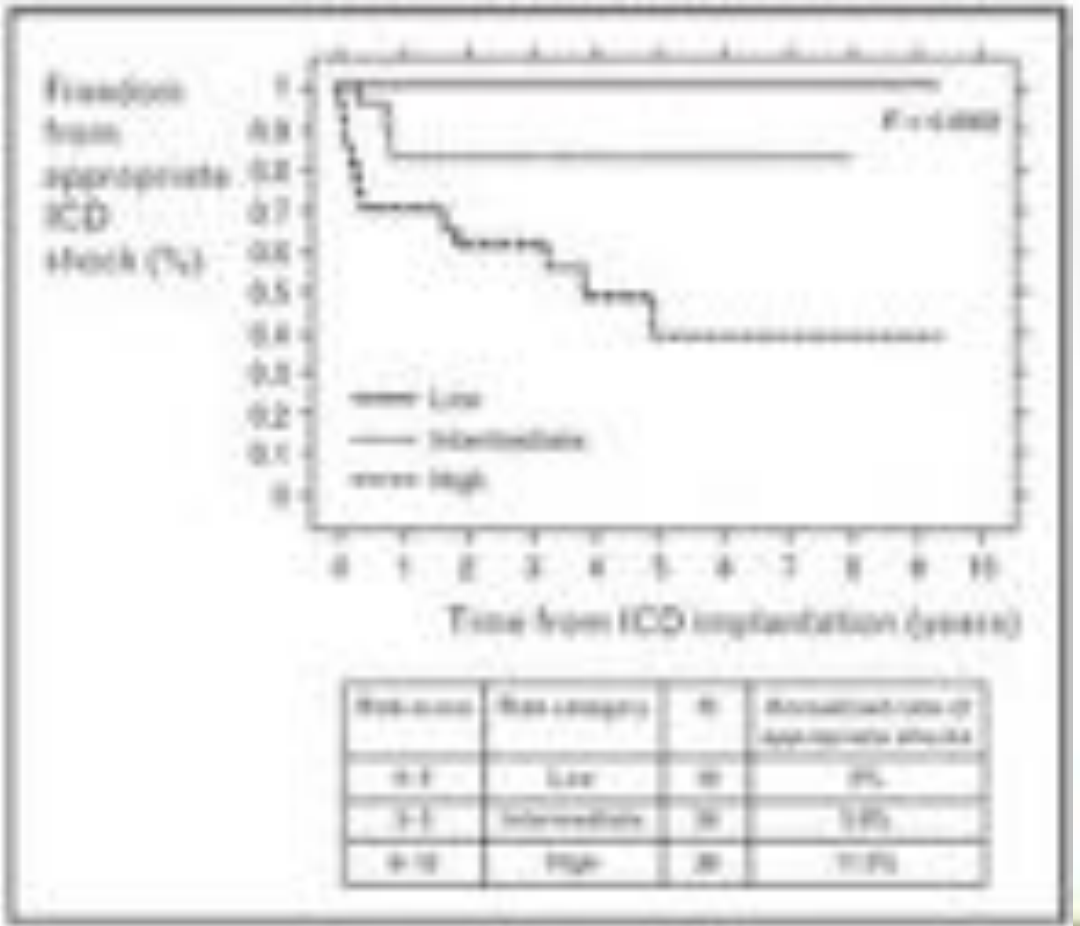
INDUCIBILITY



- 252 patients
- Median corrective surgery: 4.5years
- f/u after EP study: 6.5+/- 4.5 years

Khairy et al. circulation 2004

Variable	Exp(β)	Points attributed
Prior palliative shunt	3.2	2
Inducible sustained ventricular tachycardia	2.6	2
QRS ≥180 ms	1.4	1
Ventriculotomy incision	3.4	2
Nonsustained ventricular tachycardia	3.7	2
Left ventricular end-diastolic pressure >12 mmHg	4.9	3
TOTAL POINTS		0–12



Le Gloan et Khairy.
Curr op in Cardiology 2011

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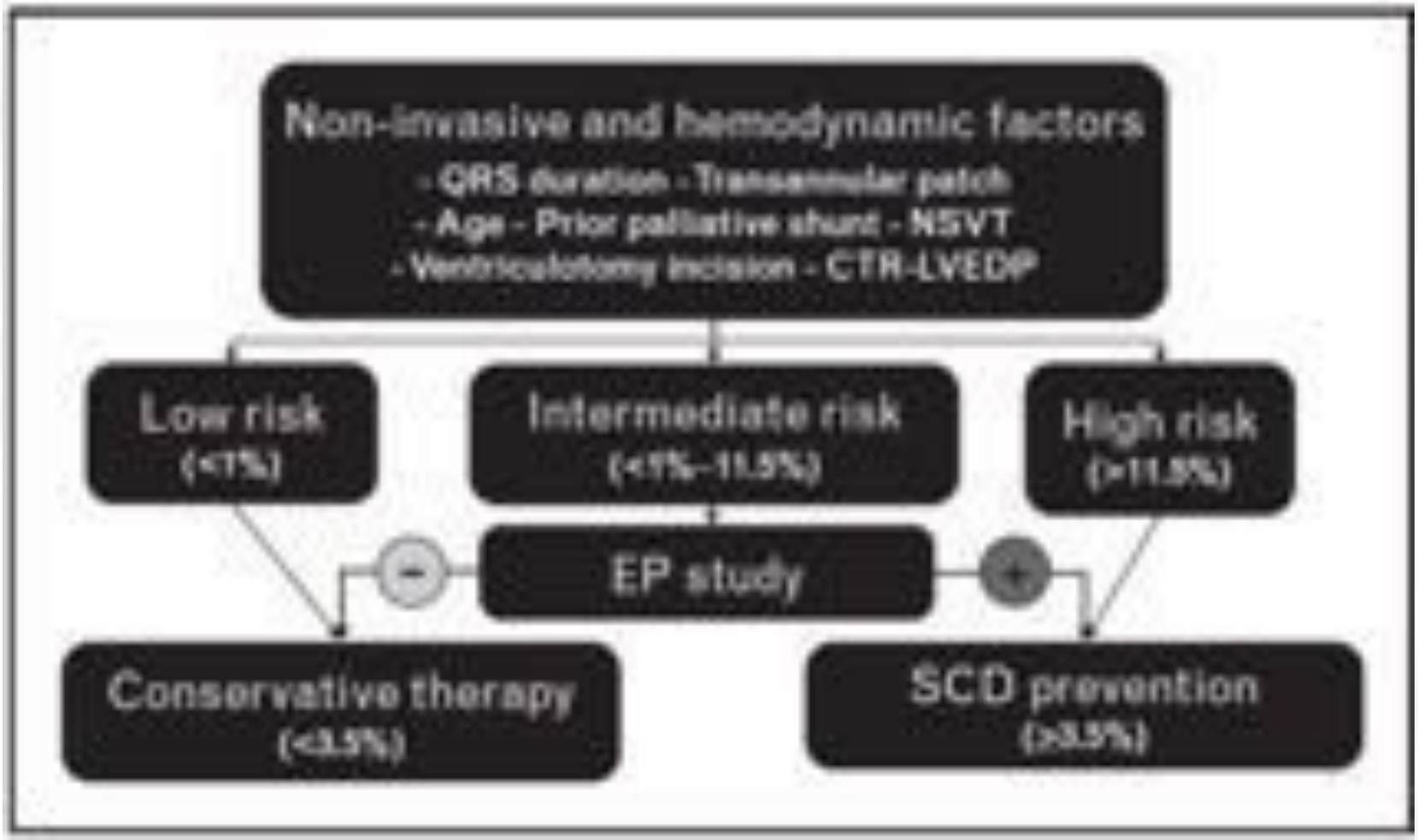
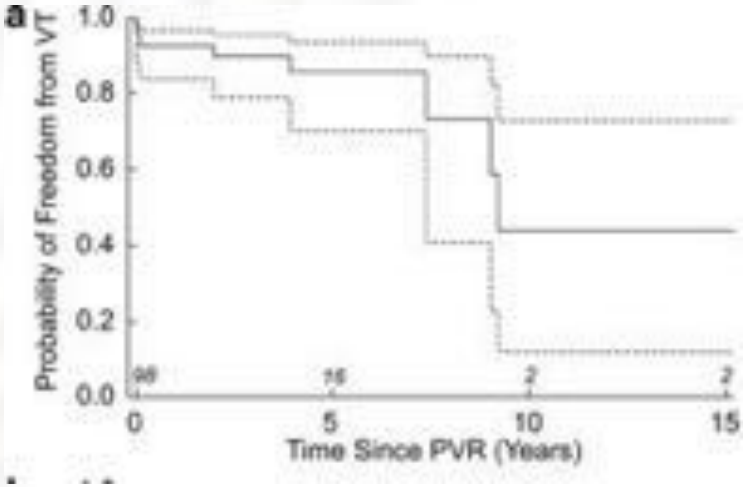
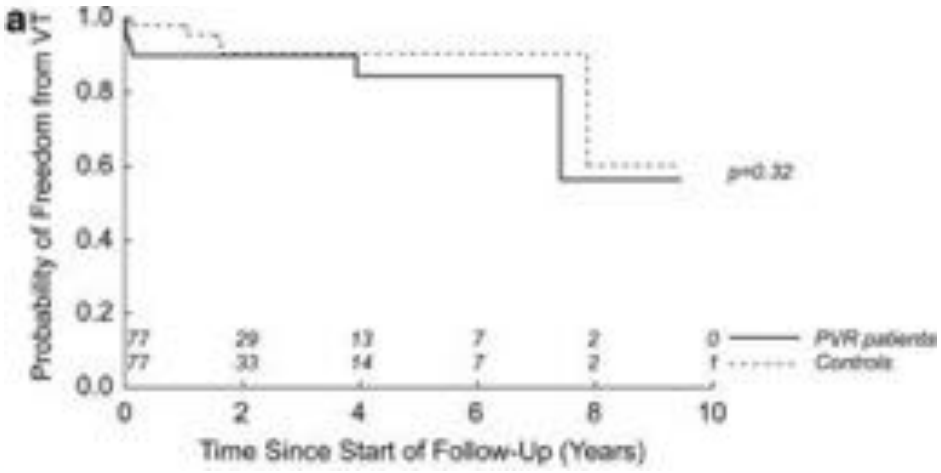


Le Gloan et Khairy.
Curr op in Cardiology 2011

PULMONARY VALVE REPLACEMENT





- 98 patients with TOF and late pulmonary valve replacement for RV dilation
- 77 matched control patients (no PVR)
- Conclusion:

"…incidence of death or sustained VT after PVR is considerable at 1 event per 20 patient-years. QRS duration did not change significantly after PVR over the course of the study. Compared with a group of similar control subjects, PVR did not result in improved survival or decreased incidence of VT…"

Harrild et al. circulation 2009

WHAT ABOUT TREATMENT?

Current guidelines for the prevention of SCD

- ***Class I indication***
  - ICD therapy is indicated in adults with CHD who are survivors of cardiac arrest due to VF or hemodynamically unstable VT after evaluation to define the cause of the event and exclude any completely reversible etiology (Level of evidence: B).
  - ICD therapy is indicated in adults with CHD and spontaneous sustained ventricular tachycardia who have undergone hemodynamic and electrophysiologic evaluation (Level of evidence: B). Catheter ablation or surgery may offer a reasonable alternative or adjunct to ICD therapy in carefully selected patients (Level of evidence: C).
  - ICD therapy is indicated in adults with CHD and a systemic left ventricular ejection fractionr35%, biventricular physiology, and New York Heart Association (NYHA) class II or III symptoms (Level of evidence: B).

PACES/HRS expert consensus arrhythmia and GUCH. Heart Rhythm. 2014

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PACES/HRS expert consensus arrhythmia and GUCH. Heart Rhythm. 2014

- ***Class IIa***
  - ICD therapy is reasonable in selected adults with tetralogy of Fallot and multiple risk factors for sudden cardiac death, such as
    - Left ventricular systolic or diastolic dysfunction,
    - Nonsustained ventricular tachycardia,
    - QRS duration >180 ms,
    - Extensive right ventricular scarring, or
    - Inducible sustained ventricular tachycardia at electrophysiologic study

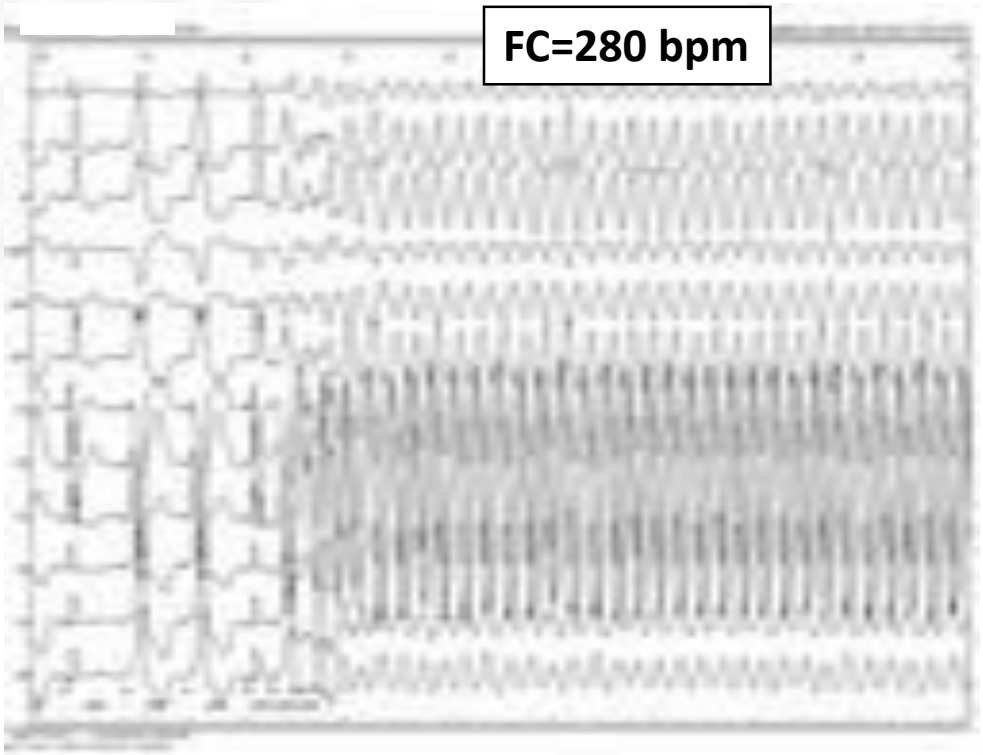
- ***Class IIb***
  - ICD therapy may be considered in adults with CHD and a systemic ventricular ejection fraction of 35% in the absence of overt symptoms (NYHA class I) or other known risk factors (Level of evidence of: C).
  - ICD therapy may be considered in adults with CHD and syncope of unknown origin with hemodynamically significant sustained ventricular tachycardia or fibrillation inducible at electrophysiologic study (Level of evidence: B)

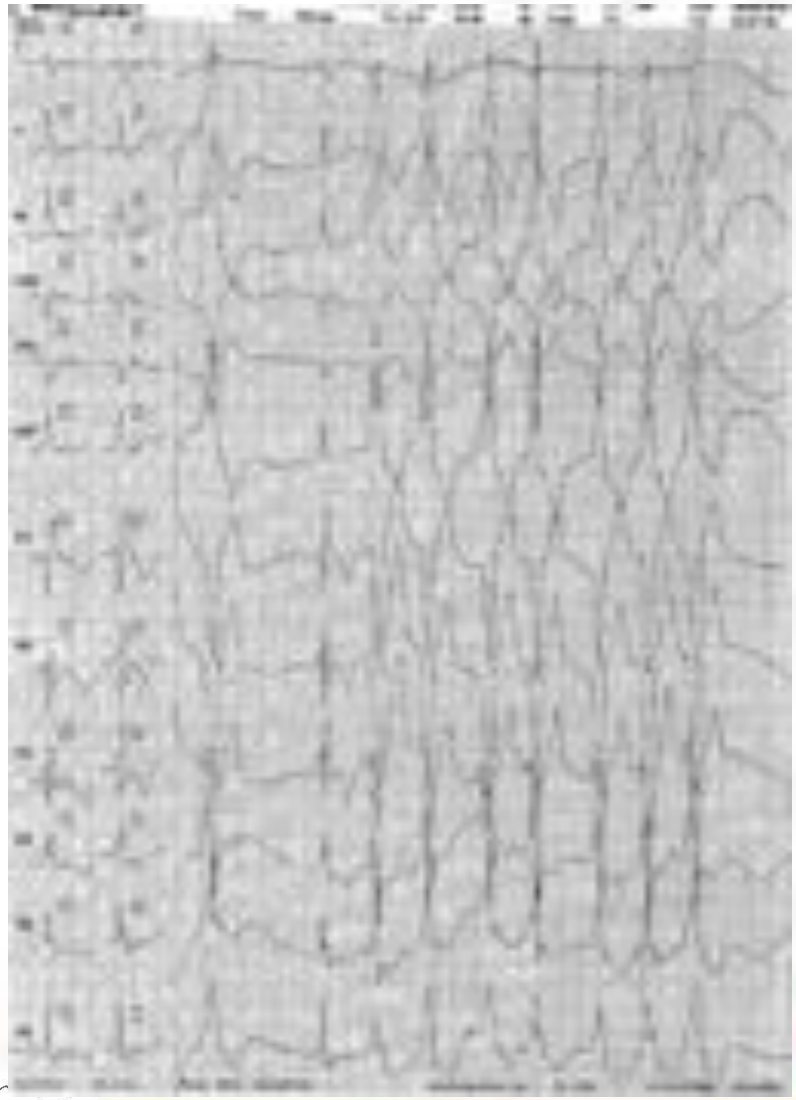
- ***Prophylactic antiarrhythmic therapy*** is not indicated for asymptomatic patients with isolated premature ventricular beats (IIIC)

PACES/HRS expert consensus arrhythmia and GUCH. Heart Rhythm. 2014

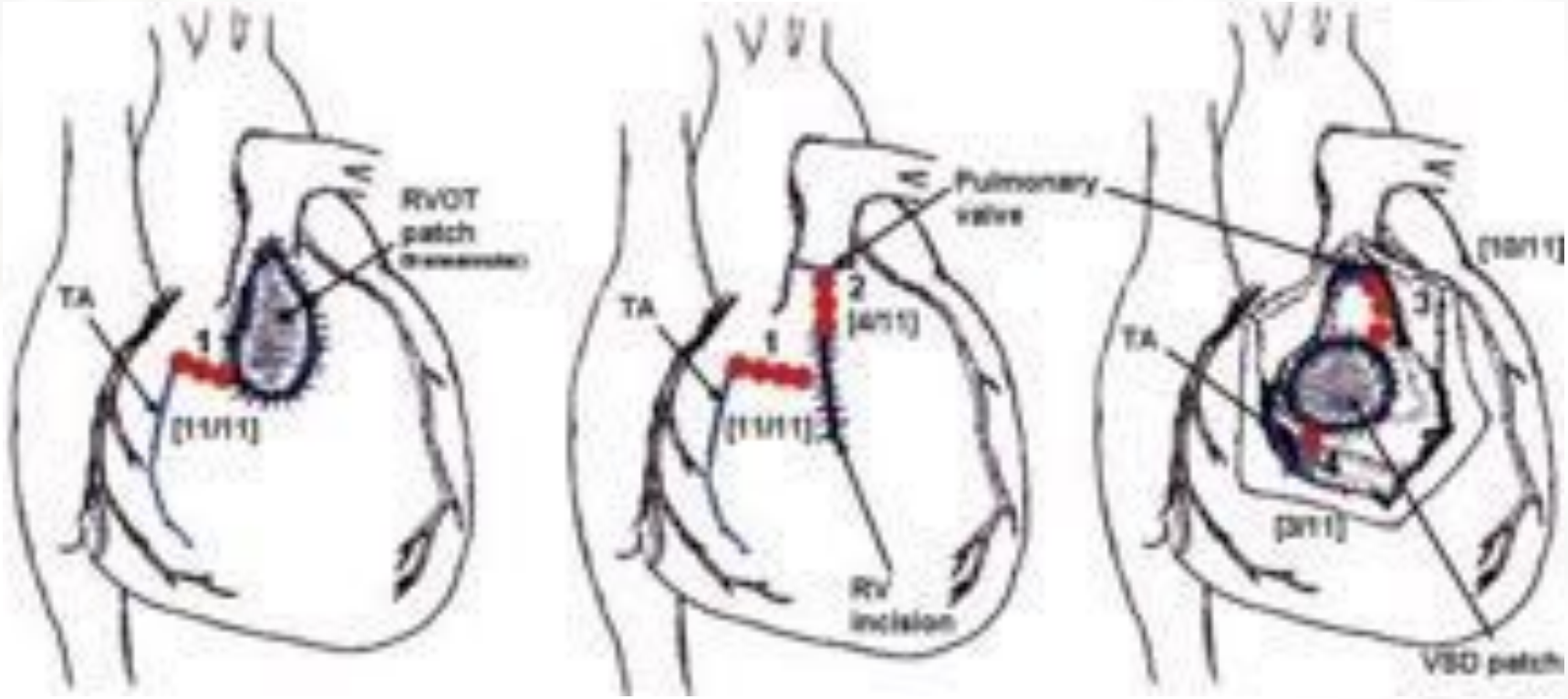
VENTRICULAR TACHYCARDIA

Are all VT the same ?





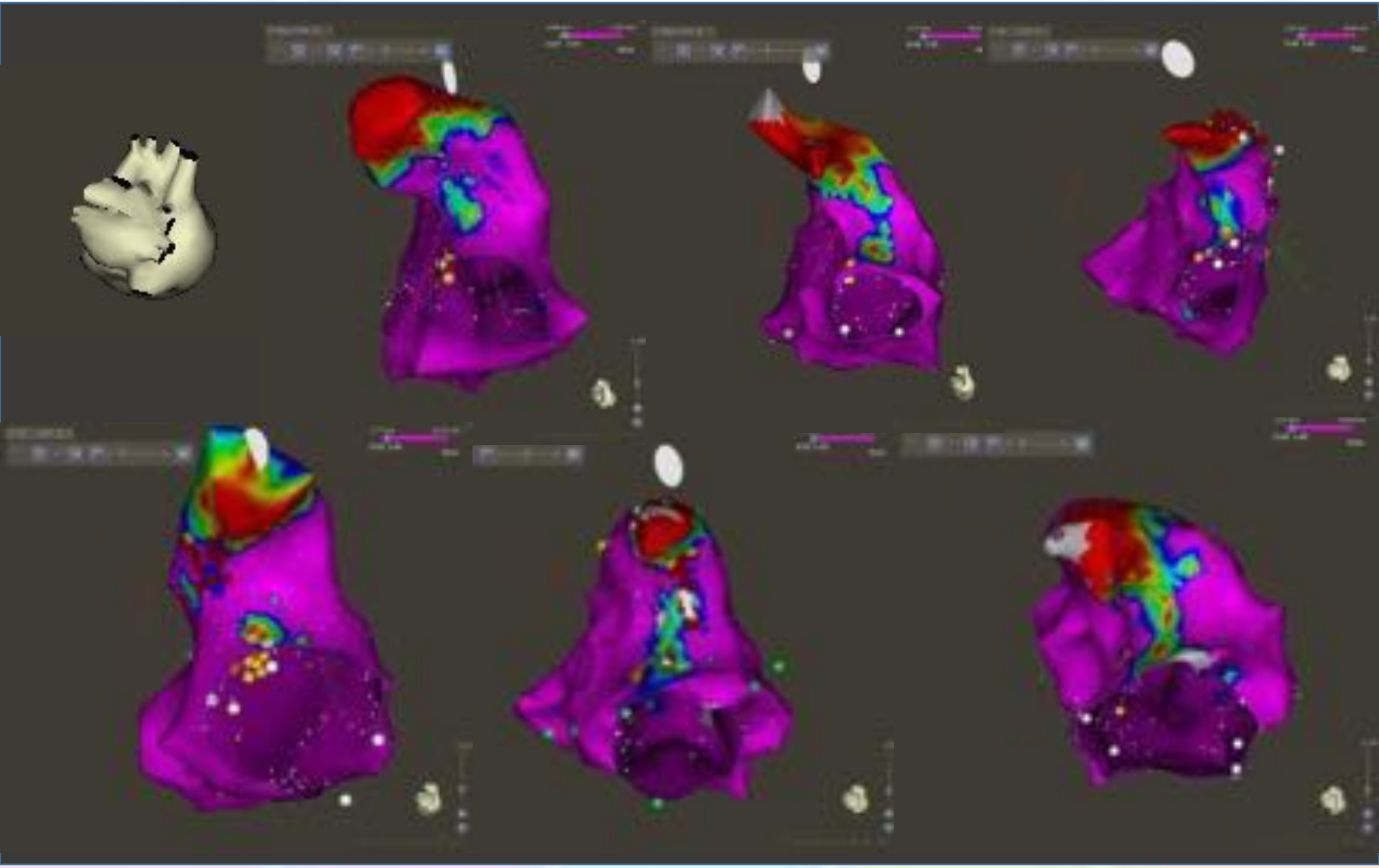
SURGICAL SCARRING



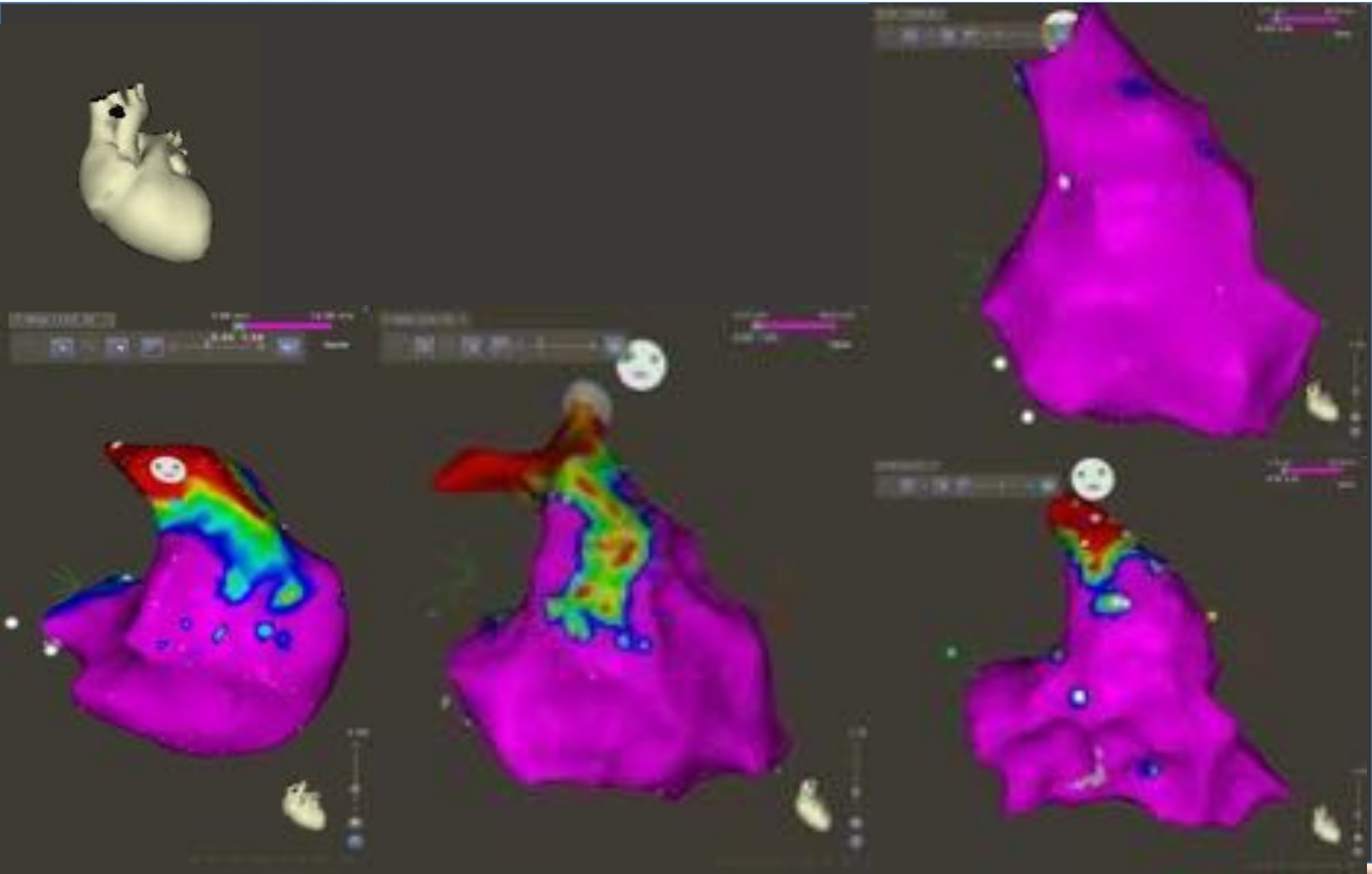
9 ToF patients with VT ablation

Zeppenfeld K et al. Circulation 2007

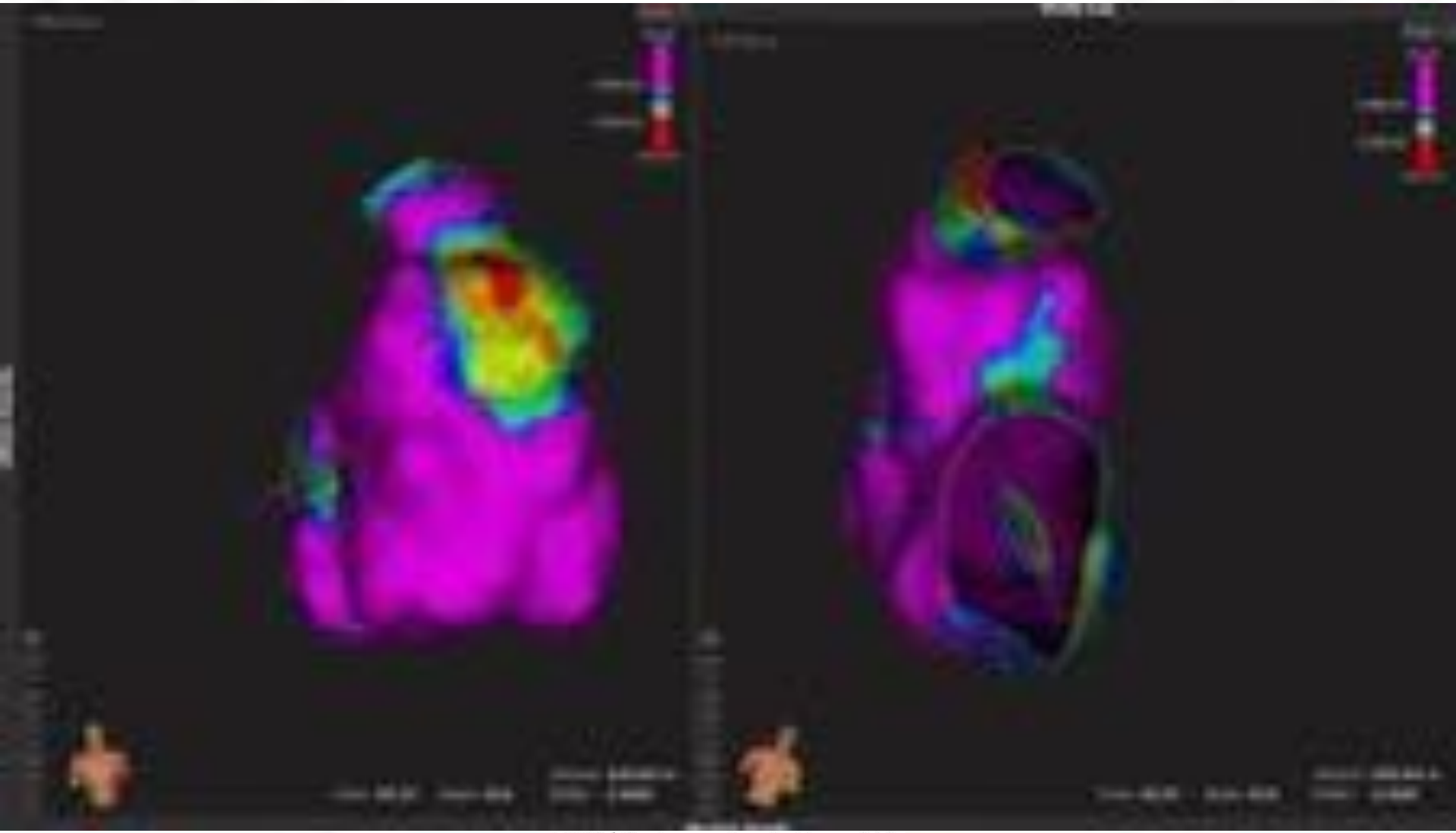
DIFFERENT SCAR DISTRIBUTION



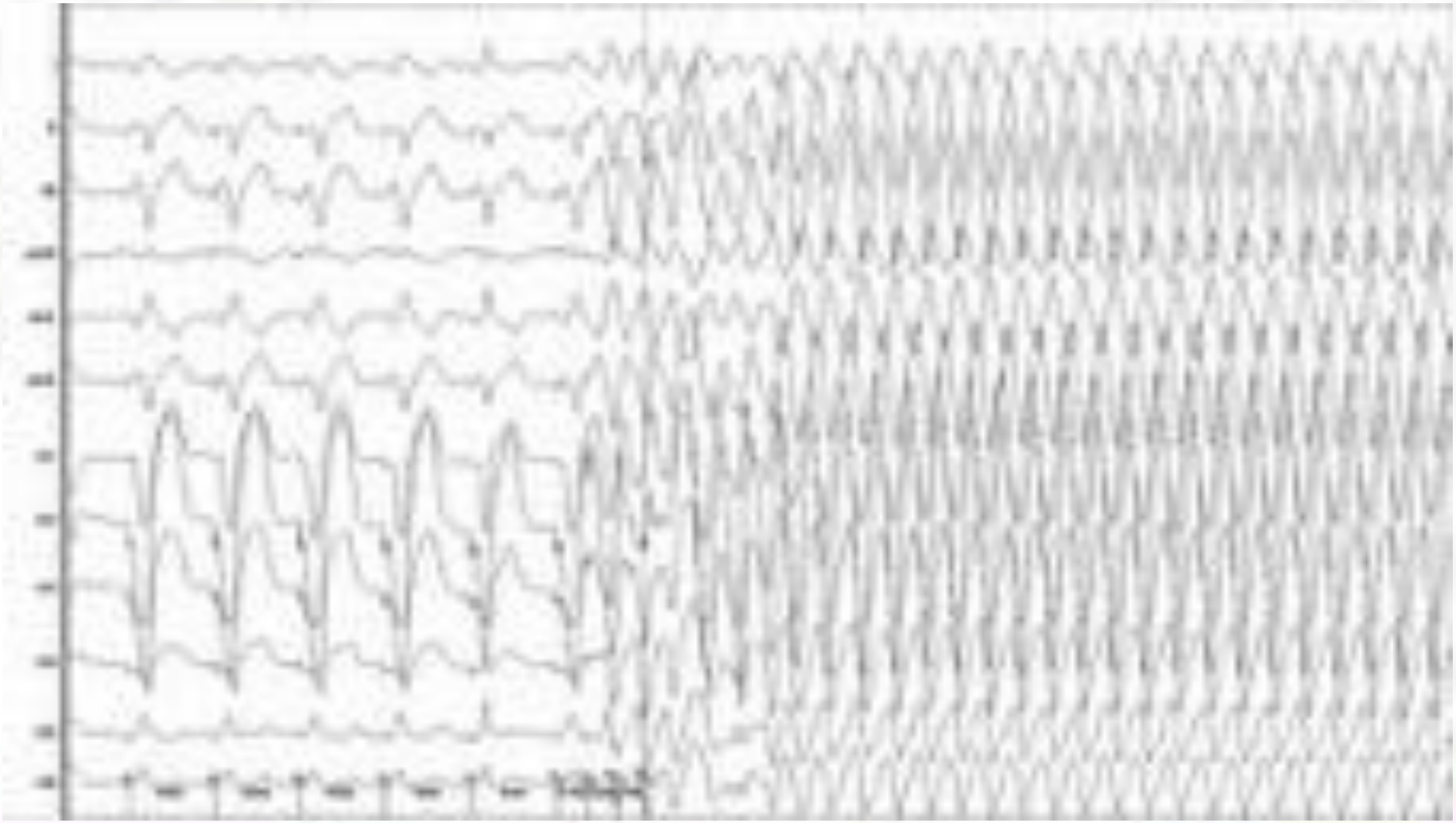
DIFFERENT SCAR DISTRIBUTION



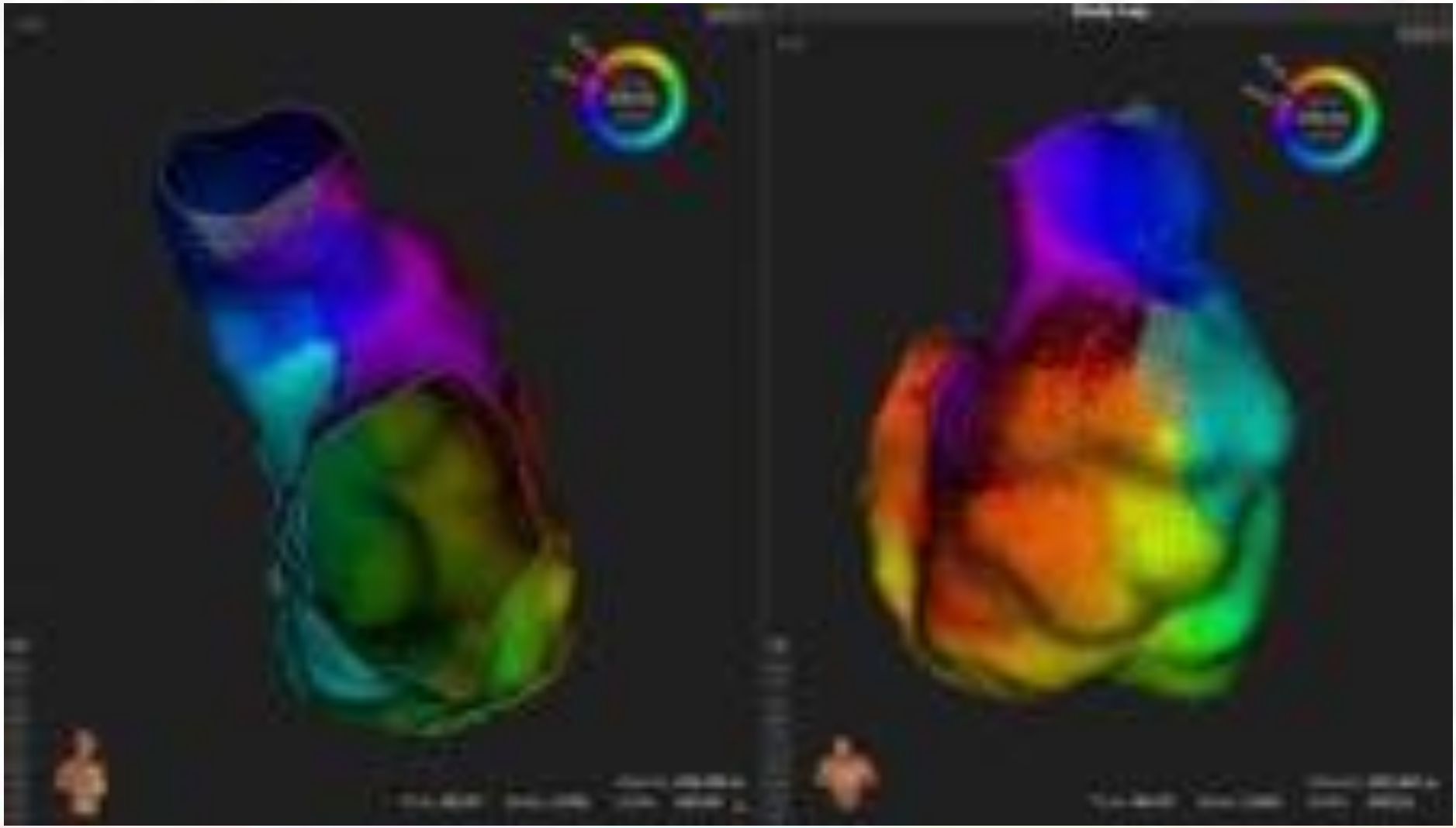
27 yo **patients** with ToF



VT induced by programmed pacing
BP 120/76

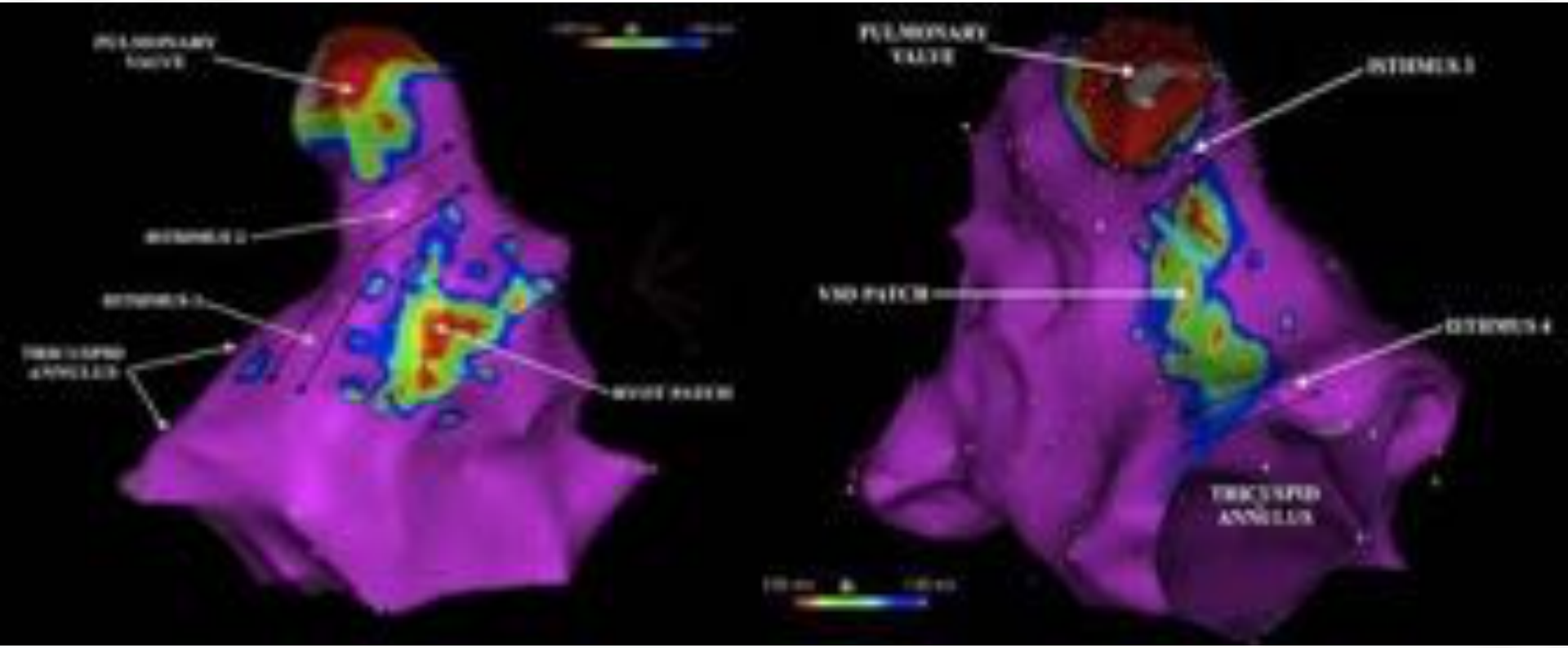


ACTIVATION MAP



How to assess the risk of VT

- **Critical Isthmuses for VT circuit have conduction velocity <0.5 m/sec**



Collaborative study with Katja Zeppenfeld, Leiden, NL

Arrhythmogenic anatomical isthmuses identified by electroanatomical mapping are the substrate for ventricular tachycardia in repaired Tetralogy of Fallot

Gijsbert F.L. Kapel[1], Frédéric Sacher[2], Olaf M. Dekkers[3,4,5], Masaya Watanabe[1], Nico A. Blom[1], Jean-Benoît Thambo[2], Nicolas Derval[2], Martin J. Schalij[1], Zakaria Jalal[2], Adrianus P. Wijnmaalen[1], and Katja Zeppenfeld[1*]

EUROPEAN SOCIETY OF CARDIOLOGY

74 ToF patients

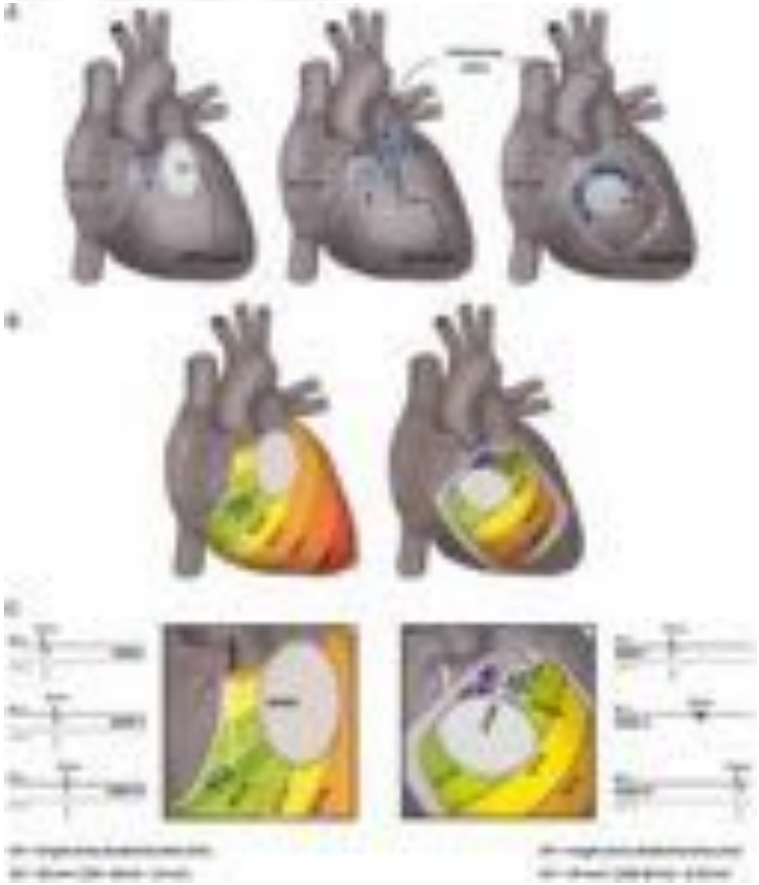
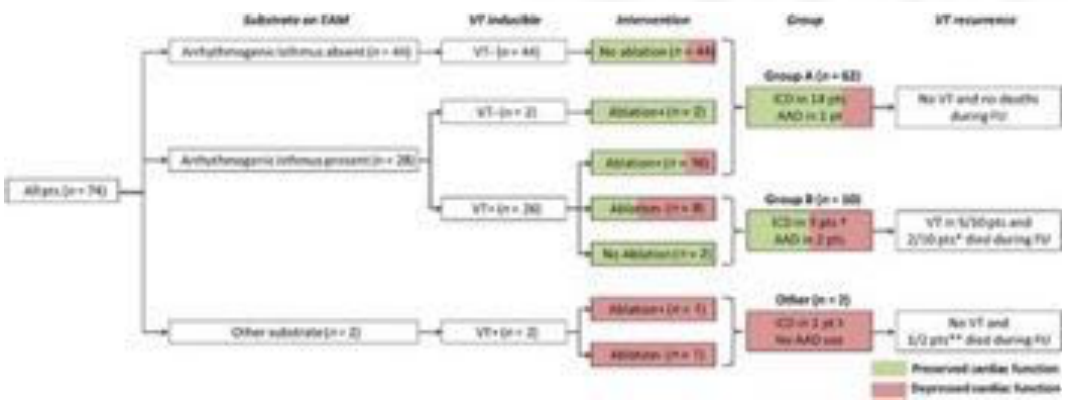


Table 2 Presence and characteristics of anatomical isthmuses according to ventricular tachycardia profile

Characteristics	No VT (n = 46)	VT inducible (n = 15)	VT spontaneous and inducible (n = 13)	Overall P
Isthmus, n	2.0 (1.0–2.0)	2.0 (2.0–3.0)	2.0 (2.0–3.0)	0.111
Minimal width (mm)	28 ± 11	22 ± 10	18 ± 5*	0.005
Maximal length (mm)	16 ± 7	20 ± 7	25 ± 7*	0.001
EA abnormal isthmus, n pts	5	13*	13*	<0.001
Lowest CVi (m/s)	0.78 ± 0.24	0.44 ± 0.44*	0.27 ± 0.09*	<0.001



F/U: 50months+/-22months

28 pts with indication for ablation
26 attempted ablation
- 18/26 success (69%)
- 8/26 failed (31%)

CONCLUSION TDR VENTRICULAIRE

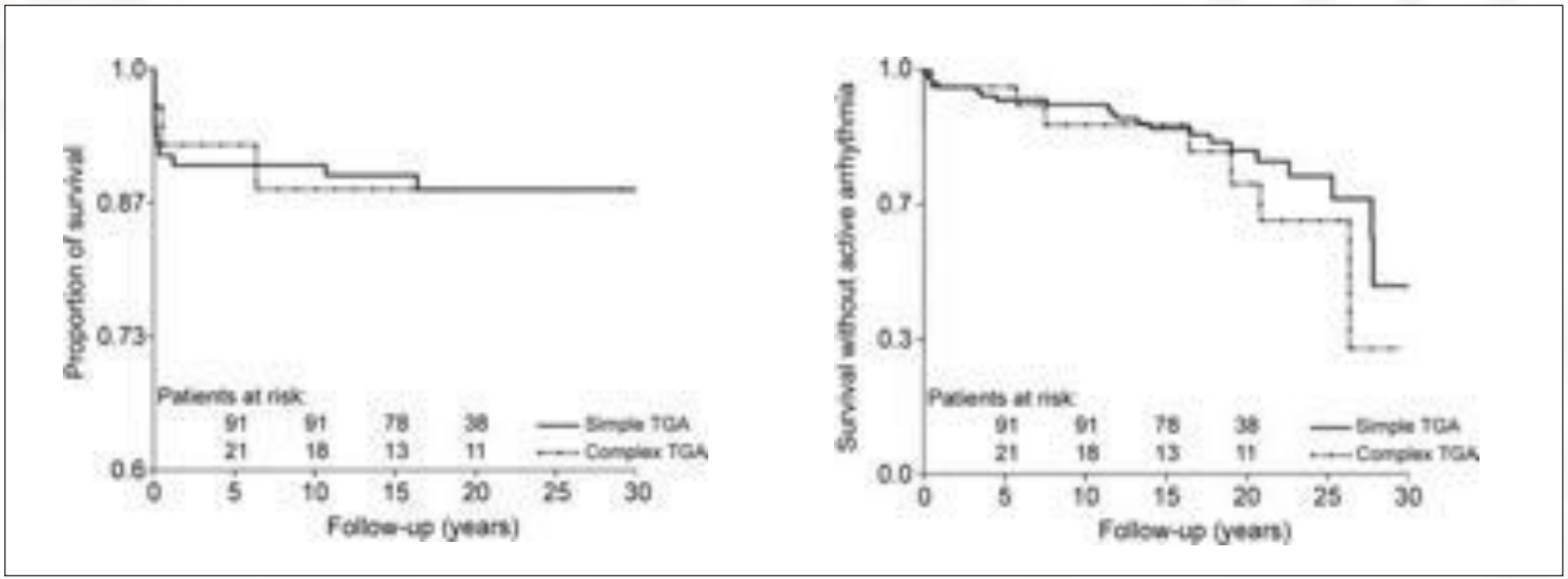
1. Prevention du risque de mort subite
   - **Guidelines !**
   - **Pas d'indication des anti-arrhythmiques**

2. Traitement des arythmies ventriculaires
   - Efficacité marginale des antiarrythmiques
   - Ablation de TV:
     - TV symptomatiques récidivantes (30% de chocs appropriés dans les 3;5ans post DAI)
     - Alternative au DAI: cas **TRES** sélectionnés !
     - Avant un geste de revalvulation pulmonaire

- Discuter avec les chirurgiens pour limiter au maximum les incisions ventriculaires

ARYTHMIES SUPRA-VENTRICULAIRES

- 132 patients
- Chirurgie de Senning entre 1977 et 2004
- Âge moyen de chirurgie 11,6+/-0,5 mois
- 12 patients indication de PM



Roubertie et al. Annals of thoracic surgery 2011

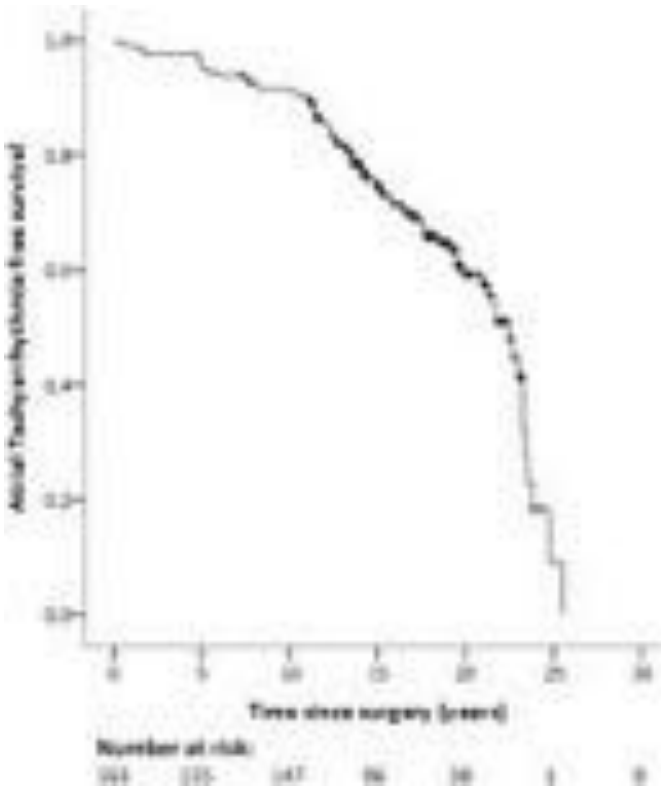
Prevalence of atrial tachyarrhythmia in adults after Fontan operation

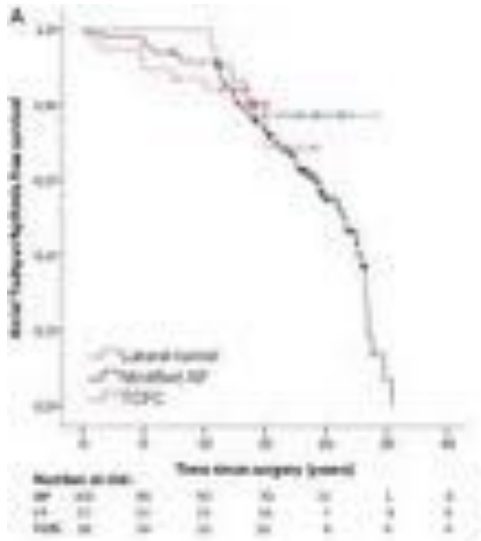
Emily Quinton,[1] Peter Nightingale,[2] Lucy Hudsmith,[3] Sara Thorne,[3] Howard Marshall,[1] Paul Clift,[3] Joseph de Bono[1]

- **166** pts, 29.1 years old
- 63% AP Fontan
- 13% LT Fontan
- 24% TCPC

- 18.6 years mean f/u

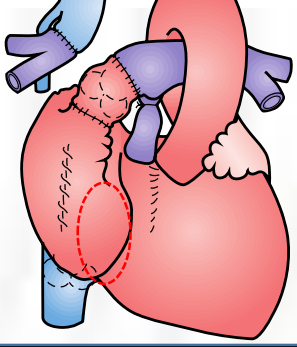
- 42% arrhythmia
- 100% arrhythmias in AP Fontan 26 years post op



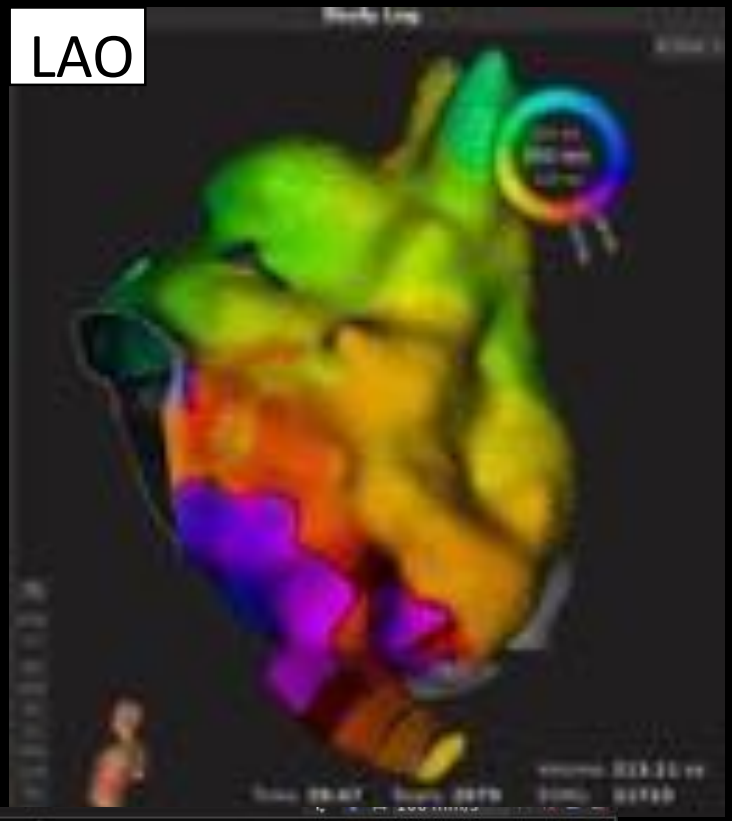


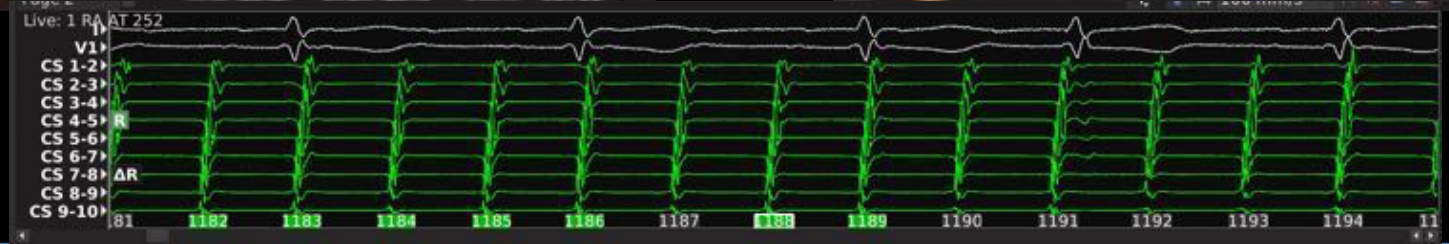
	Total (n=70)	Modified AP (n=56)	Lateral tunnel (n=5)	TCPC (n=9)
Arrhythmia				
IART	46 (66%)	39 (70%)	2 (40%)	5 (56%)
Atrial fibrillation (AF)	8 (11%)	6 (11%)	–	2 (22%)
IART+AF	12 (17%)	9 (16%)	2 (40%)	1 (11%)
SVT	4 (6%)	2 (4%)	1 (20%)	1 (11%)
Mean age at arrhythmia onset (years)	26.7 (±9.3)	27.4 (±9.1)	22.9 (±4.7)	24.1 (±11.7)
Mean time since Fontan to arrhythmia onset (years)	14.2 (±6.4)	15.3 (±6.2)	12.3 (±1.6)	7.3 (±5.3)

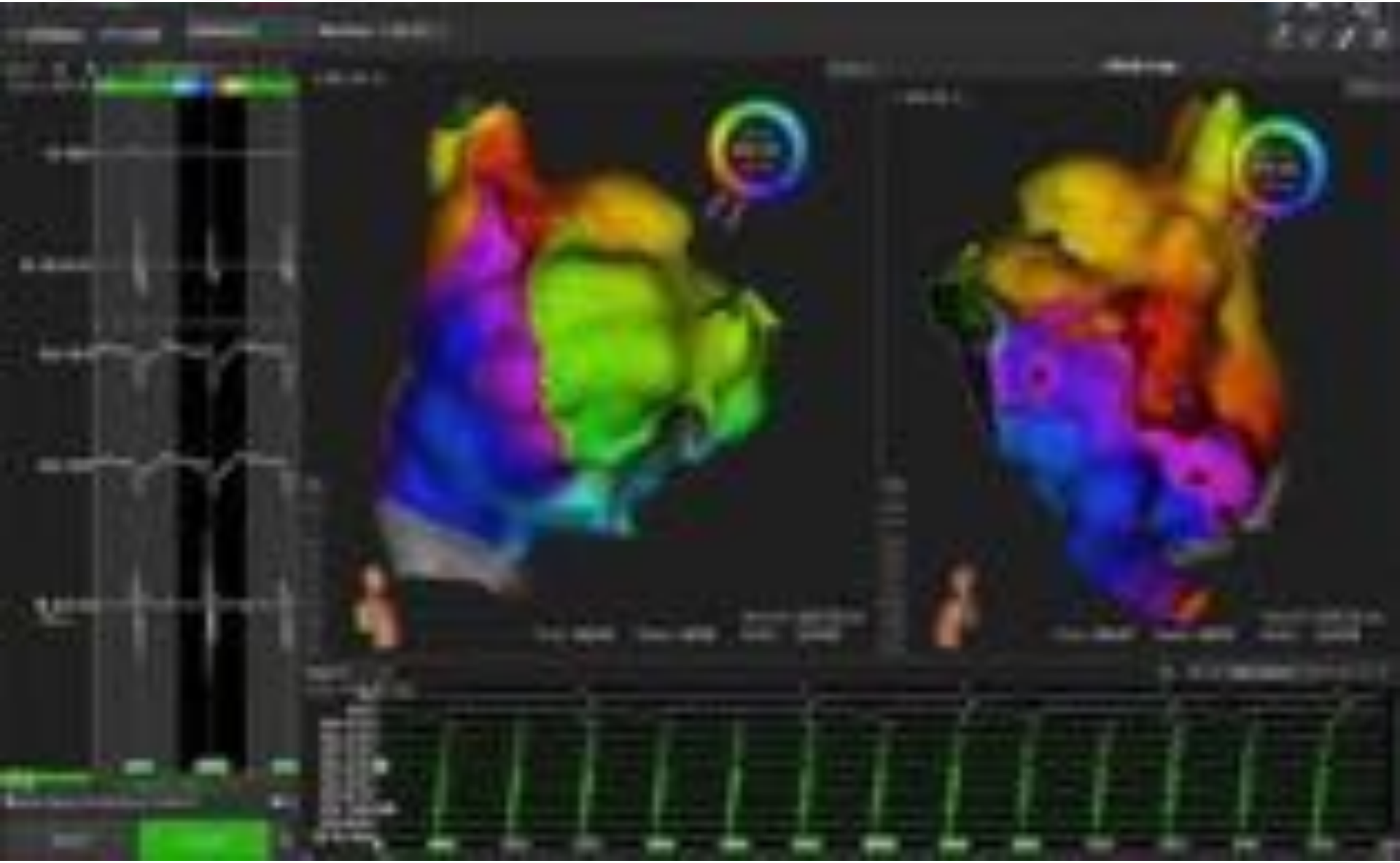
Quinton et al. Heart 2015



Incisional flutter: post-atriotomy

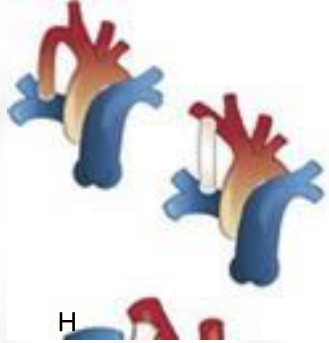






Mechanism and Ablation of Arrhythmia Following Total Cavopulmonary Connection

Rafael Correa, MD; Elizabeth D. Sherwin, MD*; Joshua Kovach, MD*; Douglas Y. Mah, MD; Mark E. Alexander, MD; Frank Cecchin, MD; Edward P. Walsh, MD; John K. Triedman, MD; Dominic J. Abrams, MD, MRCP



57 procedures (52pts)

Access to PVA needed in 33 procedures

- Through fenestration (16)
  - +RetroAo (2)
- Trans baffle puncture (17)

Correa et al. CircEP. 2015

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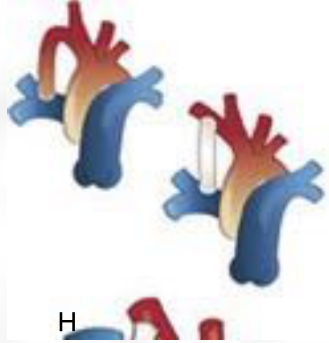

57 procedures (52pts)

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80 arrhythmias among 47 cases

- 25 macroreentrant
- 8 focal AT
- 13 AVNRT
- 4 AVRT through AP
- 4 AVRT through twin AVN
- 5 VT
- 21 unknown

56% of CTI-dependant flutter !

Correa et al. CircEP. 2015

Mechanism and Ablation of Arrhythmia Following Total Cavopulmonary Connection

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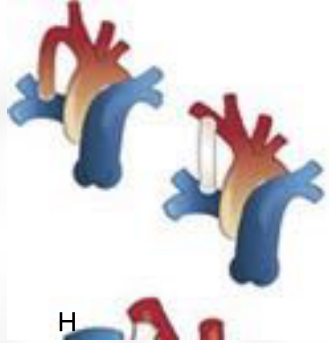

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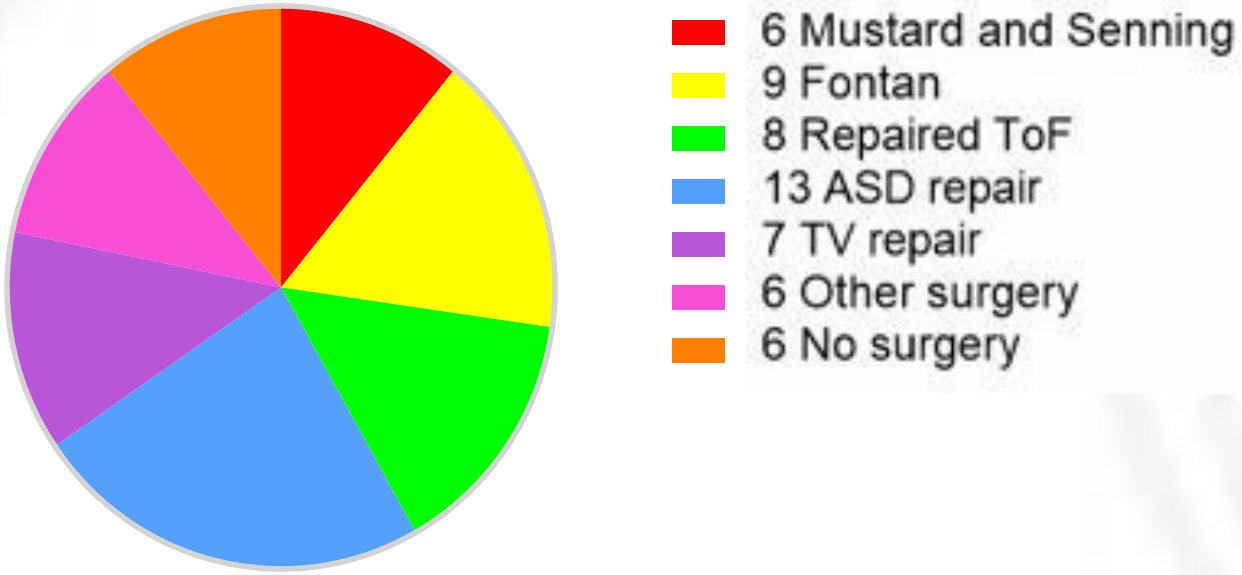
- 4 AVRT through twin AVN
- 5 VT
- 21 unknown

32 pts with f/u

- 25 success
- 3 partial success
- 3 failures

Correa et al. CircEP. 2015

METHODS



- 55 CHD patients from 7 tertiary centres were referred for recurrent, haemodynamically significant atrial arrhythmias.

	Parameter	Mustard and Senning	Fontan	Repaired ToF	ASD repair	TV repair	Other surgery	No surgery	TOTAL
Patient characteristics	No. patients	6	9	8	13	7	6	6	**55**
	Age (years)	34 ± 7	32 ± 6	47 ± 12	50 ± 14	45 ± 16	46 ± 11	53 ± 8	**44 ± 13**
	Male sex	5 (83%)	5 (56%)	6 (75%)	6 (46%)	5 (71%)	6 (100%)	1 (17%)	**34 (62%)**
	Time since 1st operation (years)	35 ± 6	27 ± 4	42 ± 8	35 ± 13	4 ± 3	25 ± 5	0 ± 0	**30 ± 12**
	Previous EP procedure	2 (33%)	3 (33%)	2 (25%)	8 (62%)	2 (29%)	3 (50%)	2 (33%)	**22 (40%)**
Tachycardia characteristics	Total no. arrhythmias	8	18	10	17	7	9	8	**77**
	No. arrhythmias per patient	1.3 ± 0.5	2.0 ± 0.9	1.3 ± 0.4	1.3 ± 0.7	1.0 ± 0.0	1.5 ± 0.5	1.3 ± 0.5	**1.3 ± 0.7**
	Right atrium/ left atrium	8 (100%) /0 (0%)	18 (100%) /0 (0%)	10 (100%) /0 (0%)	15 (88%) /3 (18%)	5 (71%) /2 (29%)	6 (67%) /3 (33%)	6 (75%) /2 (25%)	**68 (88%) /10 (13%)**
	Tachycardia cycle length (ms)	292 ± 58	412 ± 140	331 ± 81	280 ± 53	314 ± 70	352 ± 29	228 ± 45	**311 ± 93**

>50% of CTI-dependant flutter

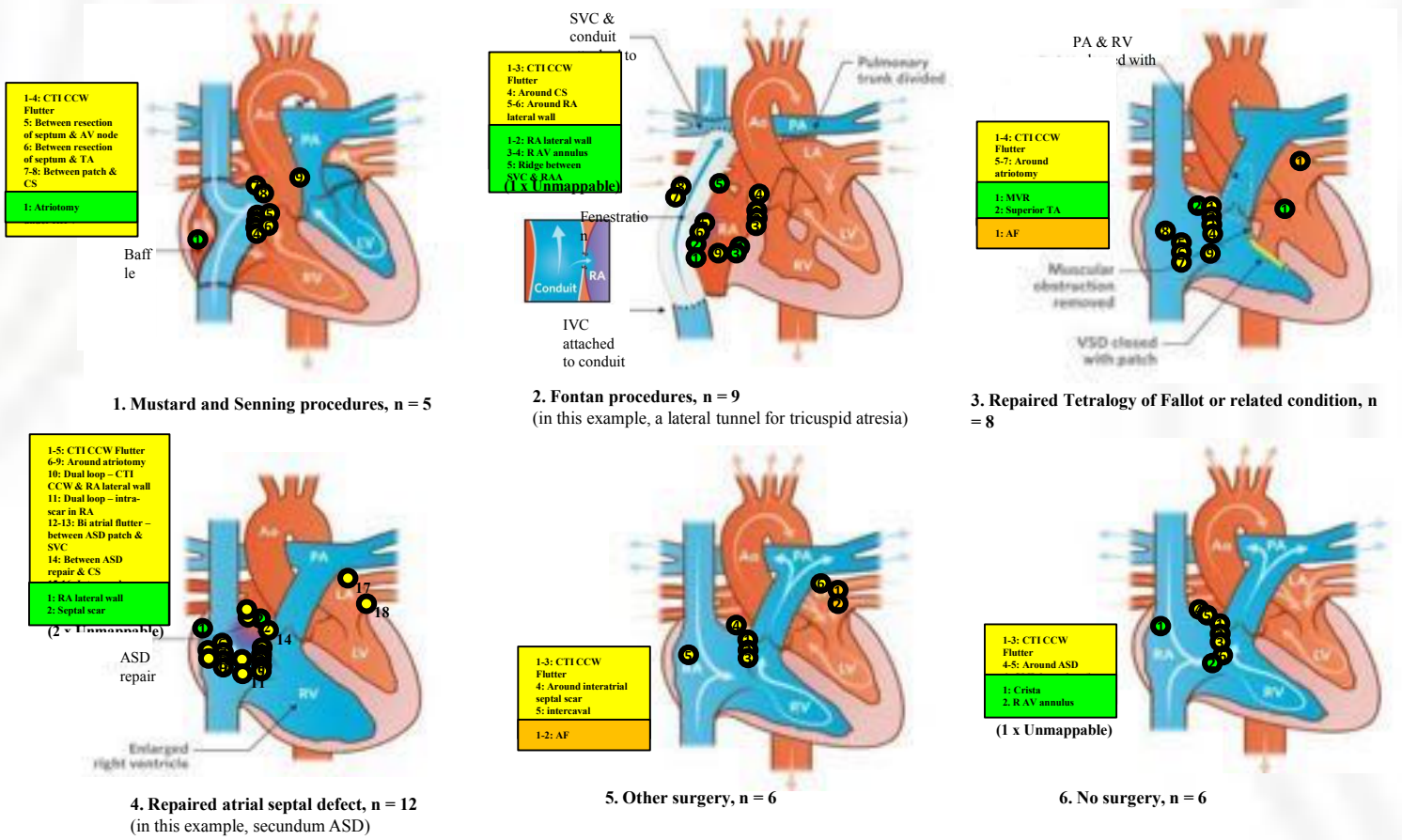
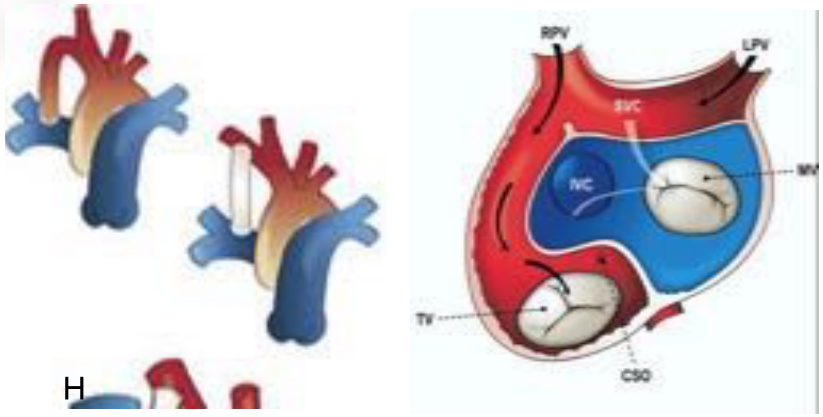


Fig 2:
Diagrams showing the types of congenital heart disease in the study population. Each circle represents a tachycardia. Yellow circles indicate locations of the critical isthmuses of macro-reentrant tachycardias; green circles indicate sites of focal or micro-reentrant tachycardias; orange circles indicate AF (location for AF not precise).

ARRHYTHMIAS IN GUCH

- **2 Problems for the Electrophysiologist**
  - Access to the heart cavities



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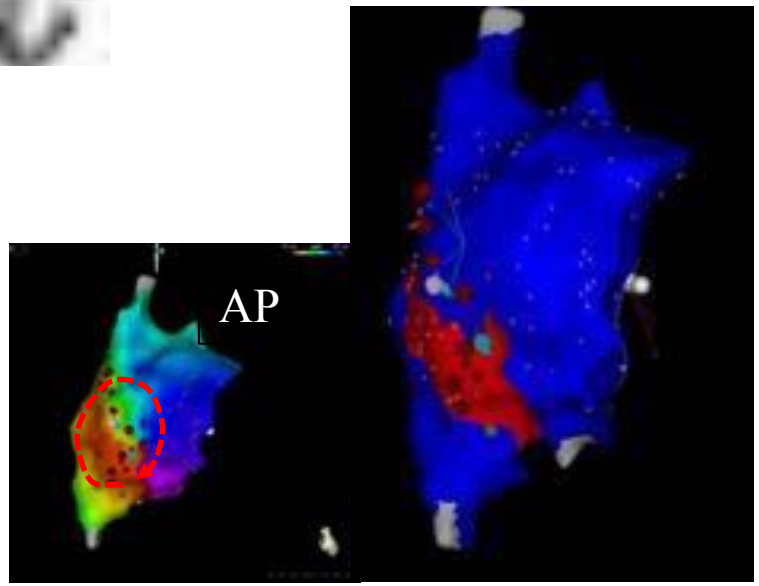
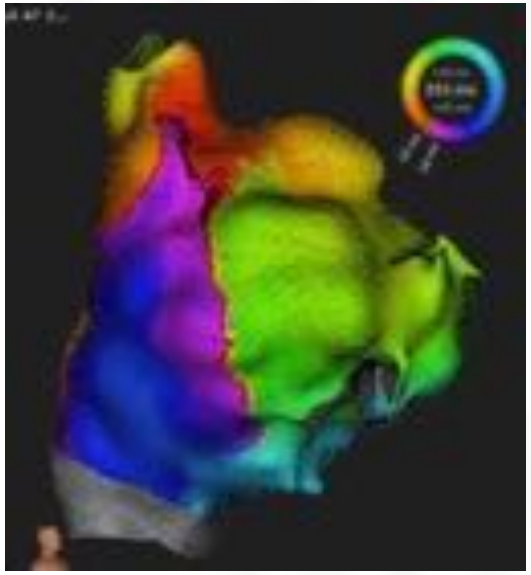
  - Diagnosis of the Tachycardia(s)

EVOLUTION OF MAPPING CAPABILITIES

- Mapping





2000 – 50pts

2010 – 217pts

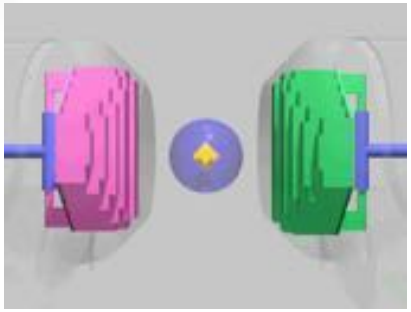
2017 – 11730pts

ACCESS OF THE HEART CAVITIES

Remote-Controlled Magnetic Navigation and Ablation With 3D Image Integration as an Alternative Approach in Patients With Intra-Atrial Baffle Anatomy

Sabine Ernst, MD, PhD, FESC; Sonya V. Babu-Narayan, MB, BS, BSc, MRCP, PhD; Jennifer Keegan, PhD; Irina Horduna, MD; Jonathan Lyne, MB, BChir, BSc, MRCP; Janice Till, MD; Philip J. Kilner, MD, PhD; Dudley Pennell, MD, FRCP, FACC, FESC; Michael L. Rigby, MD, FRCP; Michael A. Gatzoulis, MD, PhD

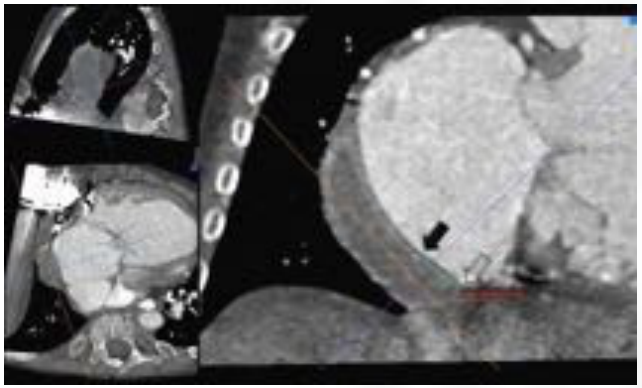
Ernst et al. circEP 2011

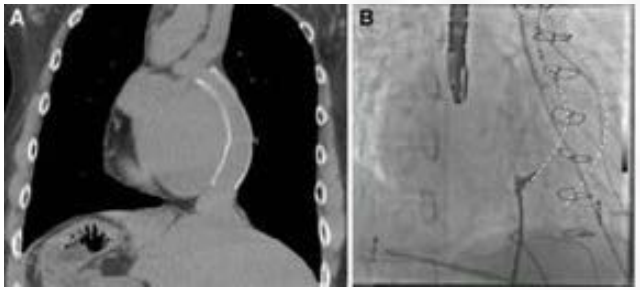


Transcaval Puncture for Access to the Pulmonary Venous Atrium After the Extracardiac Total Cavopulmonary Connection Operation

Jeremy P. Moore, MD, MS; Benjamin Hendrickson, MD; Daniel Z. Brunengraber, MD; Kevin M. Shannon, MD

Mooreet al. circEP 2015





ACCESS OF THE HEART CAVITIES

"contortionist" approach

Pro:
- no puncture
- Safety

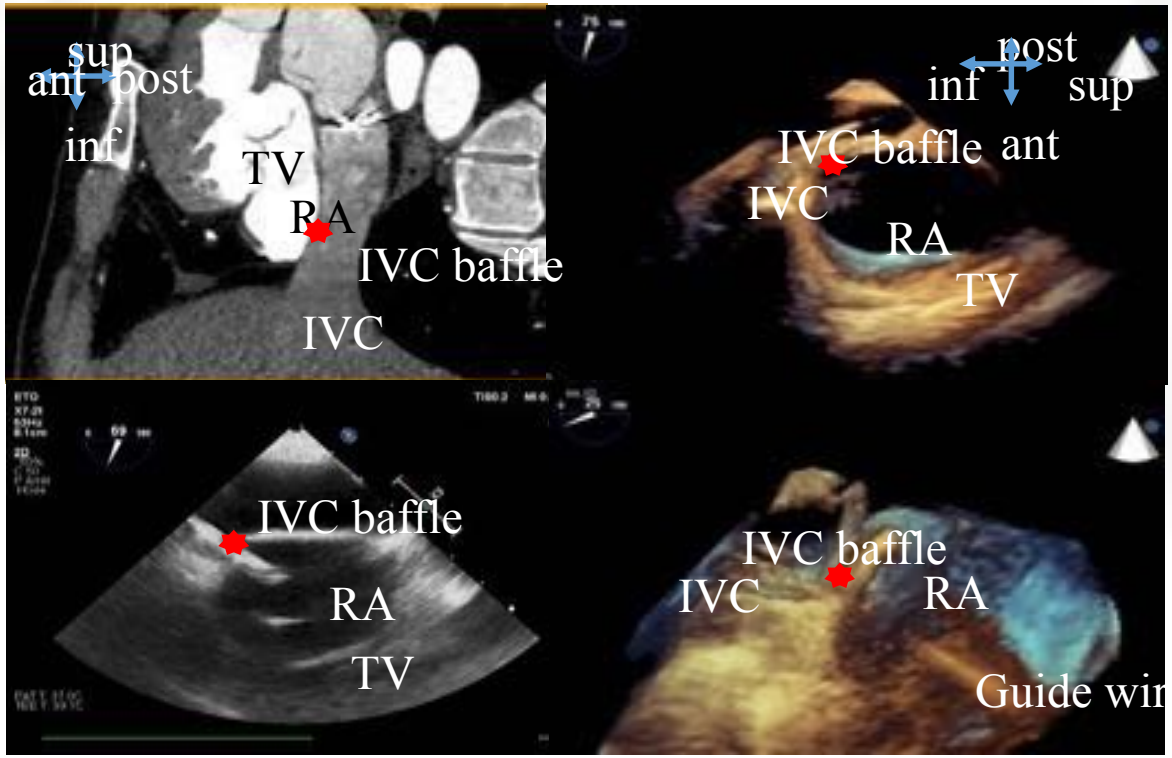
Cons:
- Mapping catheter=ablation catheter
- New mapping tech No
- Poor control of ablation cath.

"Direct" approach

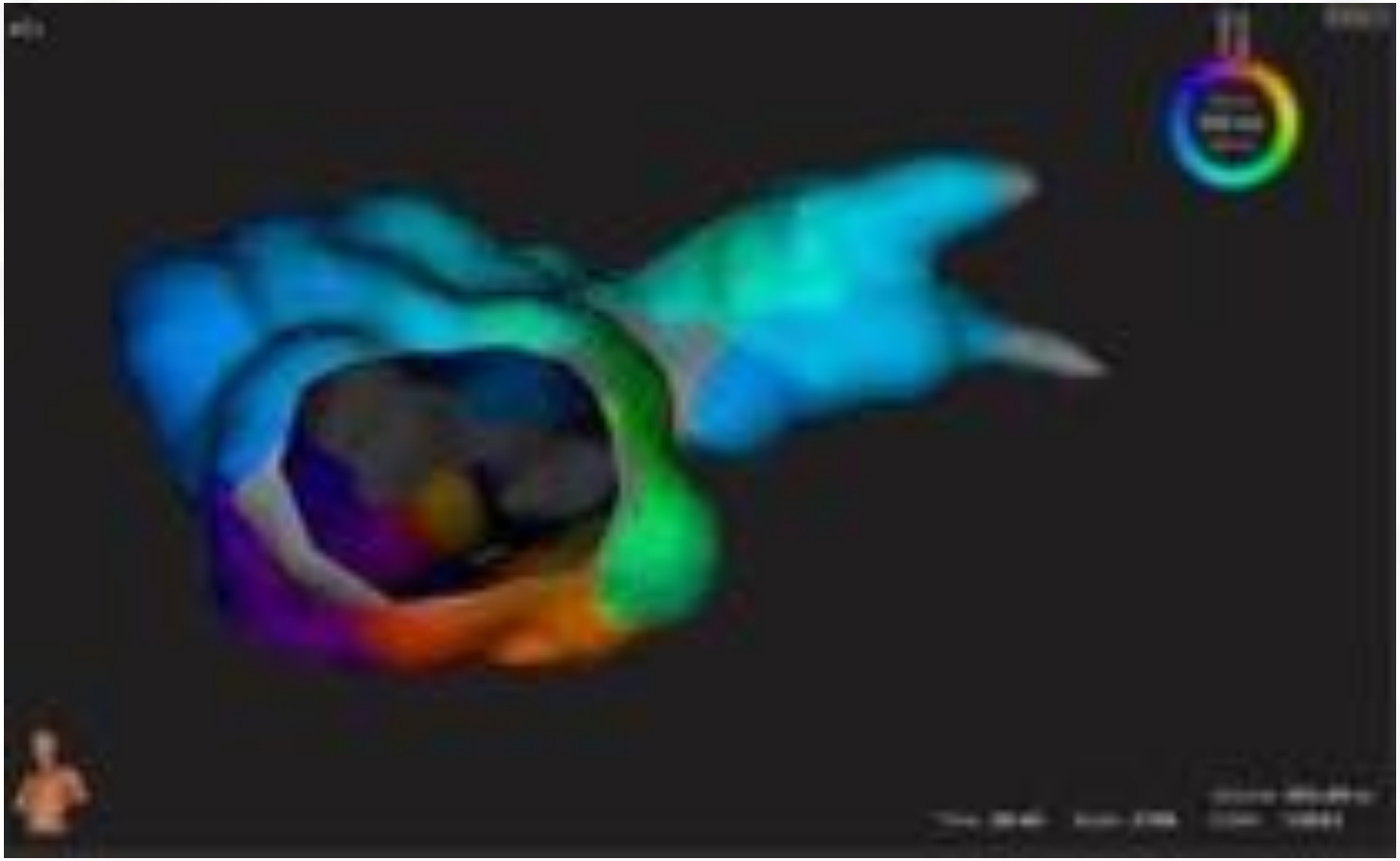
Pro:
- Any catheter including multielectrode
- New mapping tech OK
- Better control of abl

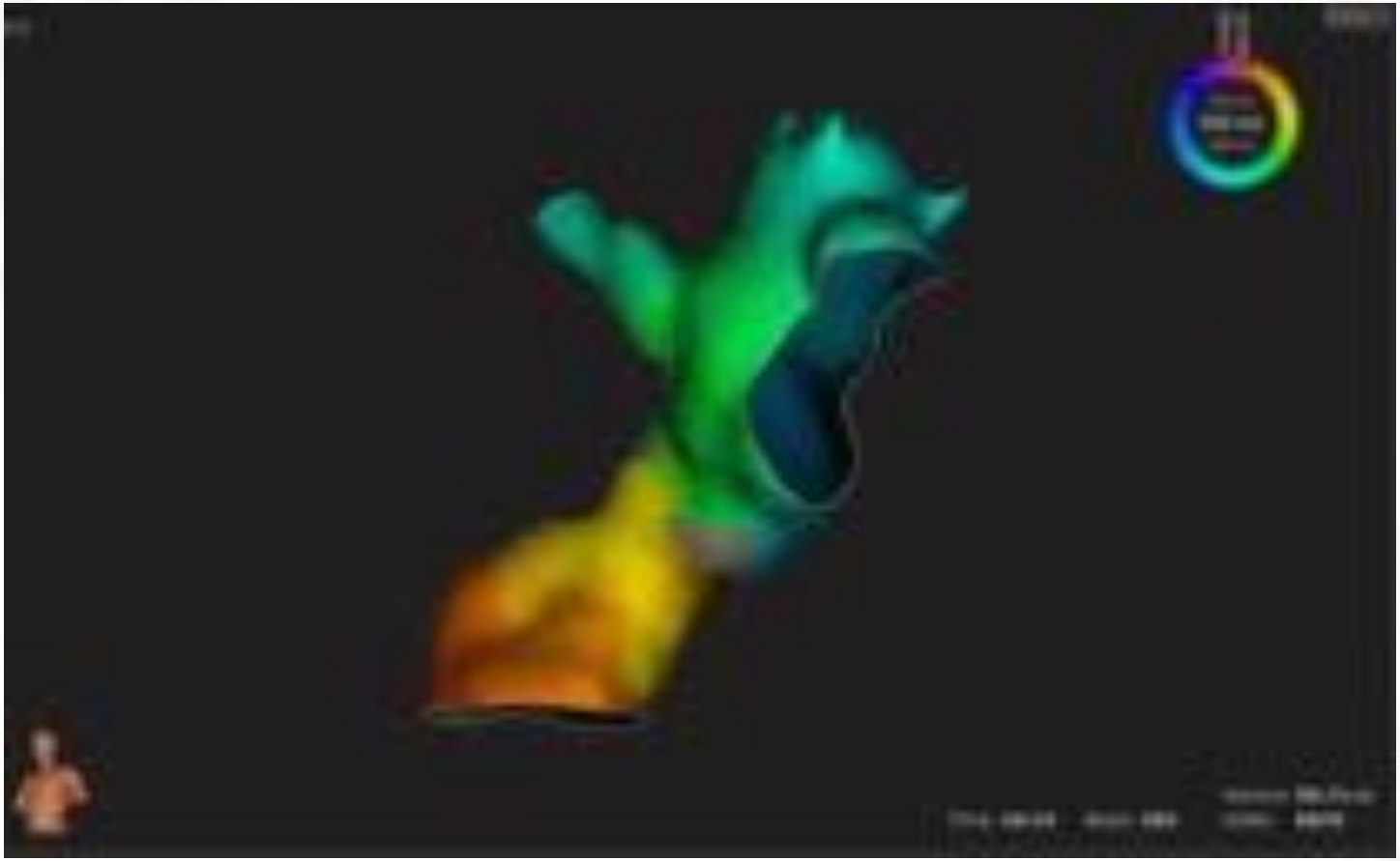
Cons:
- puncture
- Safety

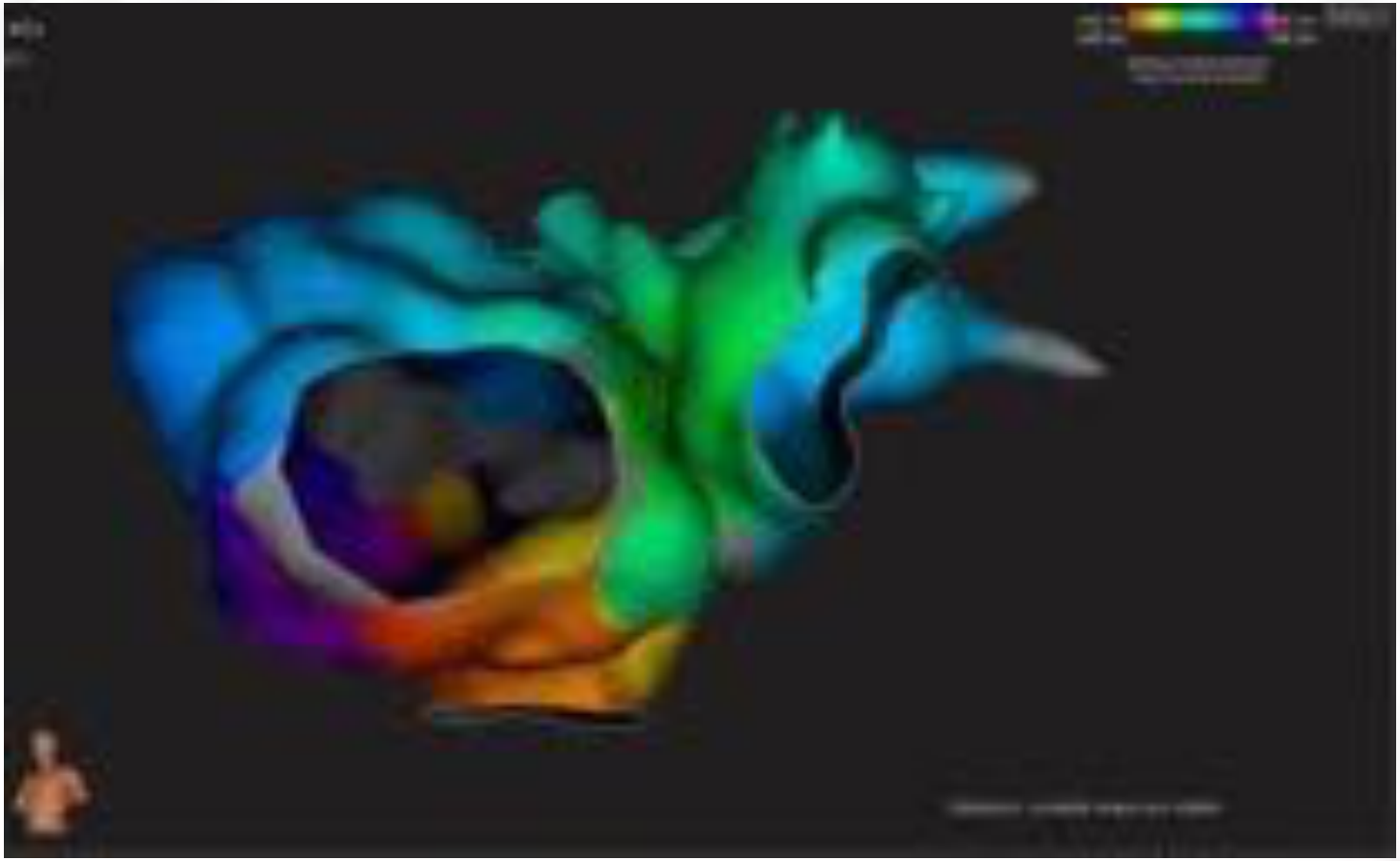
Procedure: access

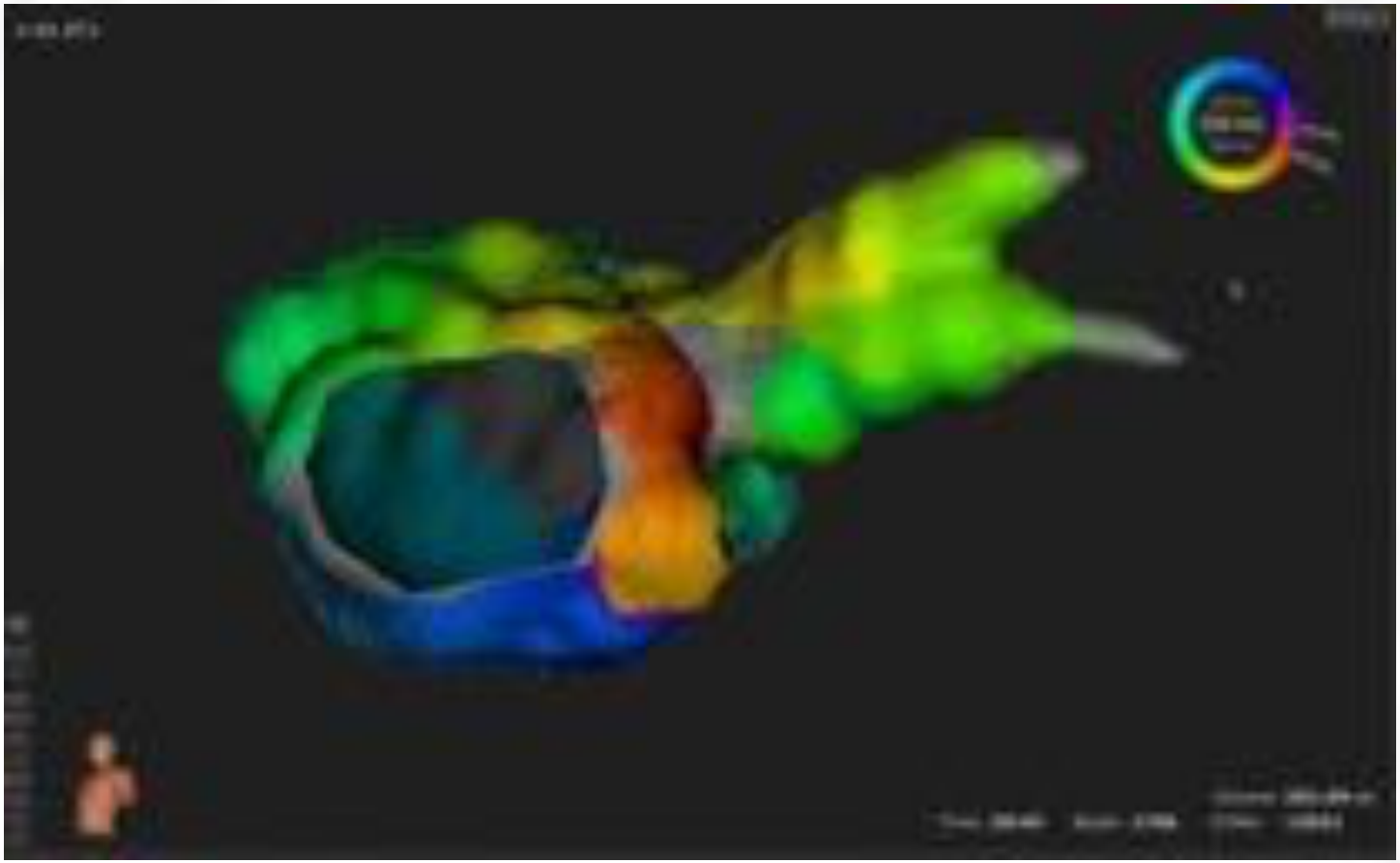


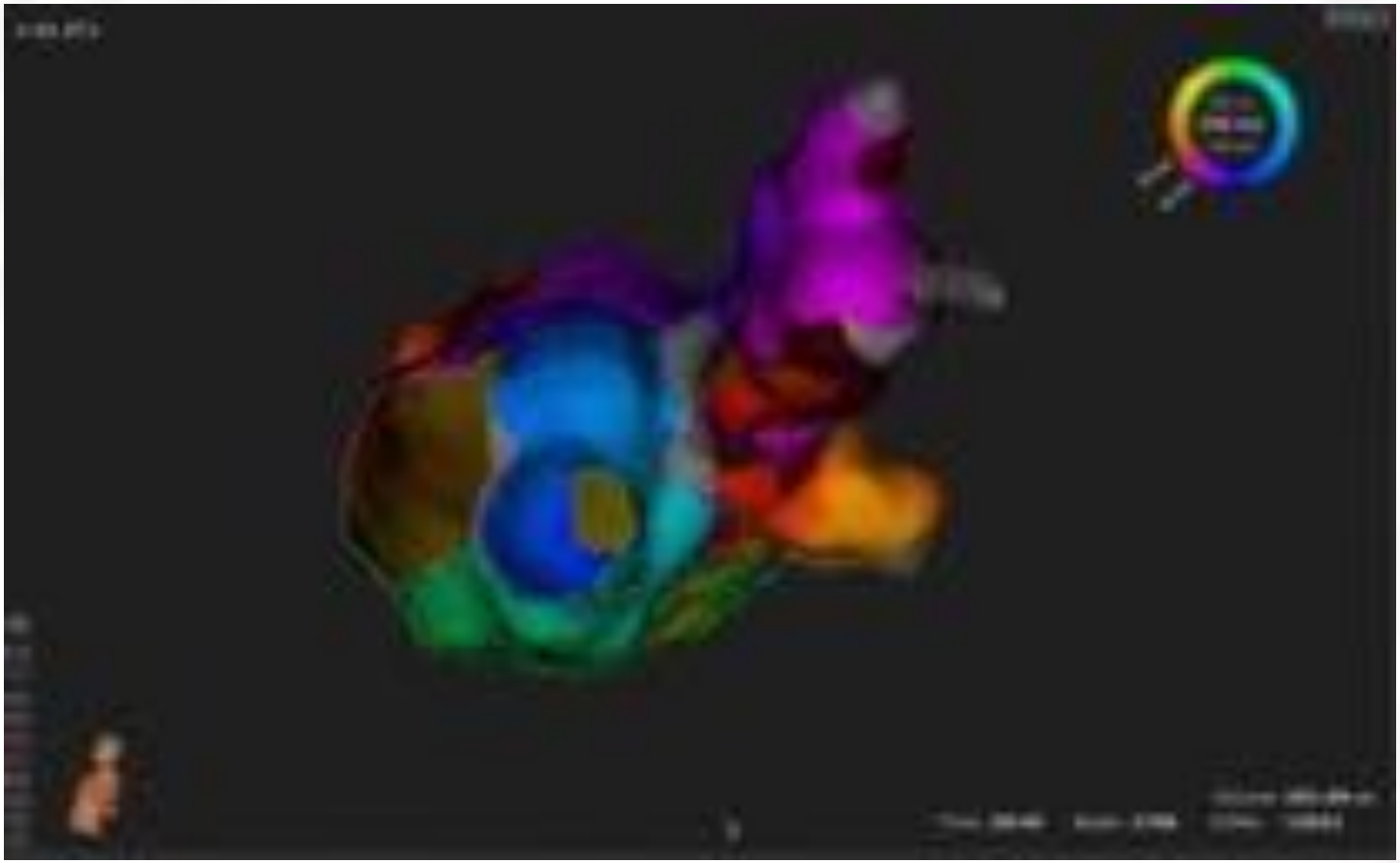
- Anterior puncture is advocated to get direct access to the RA

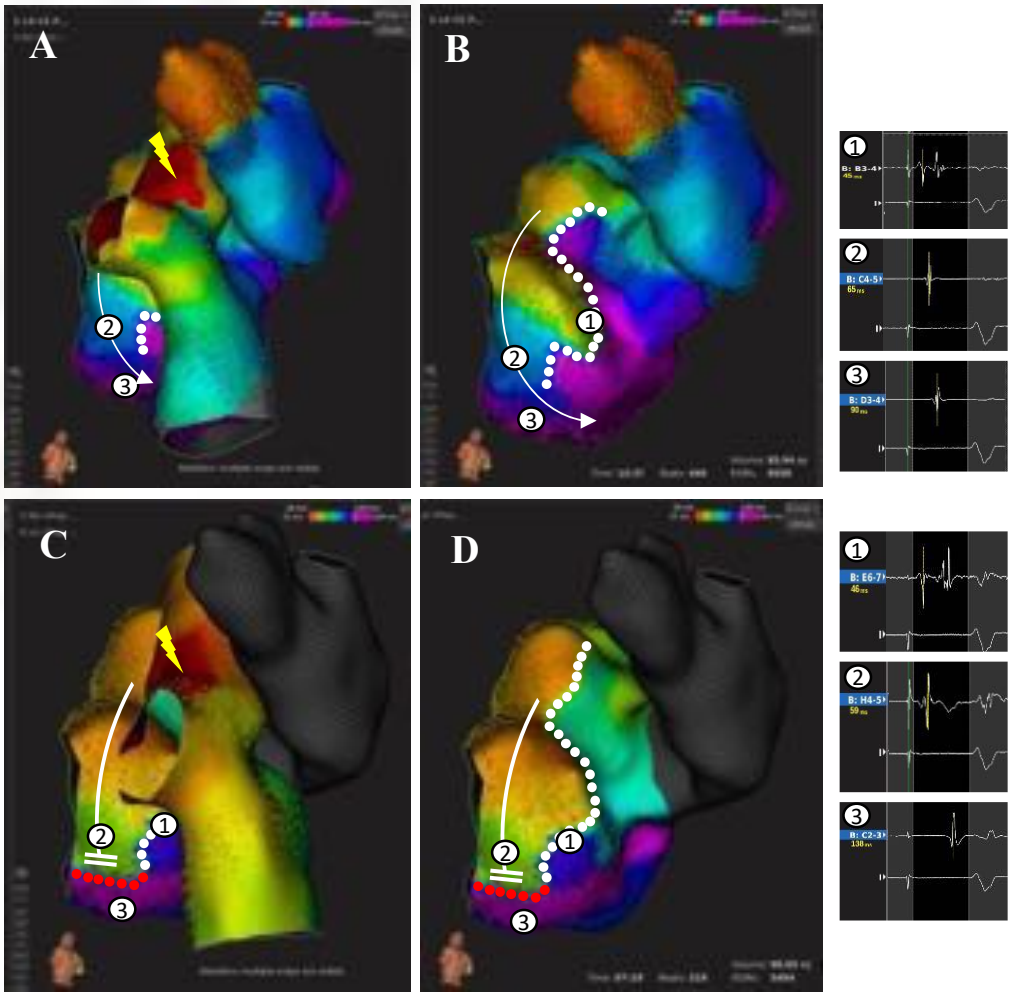




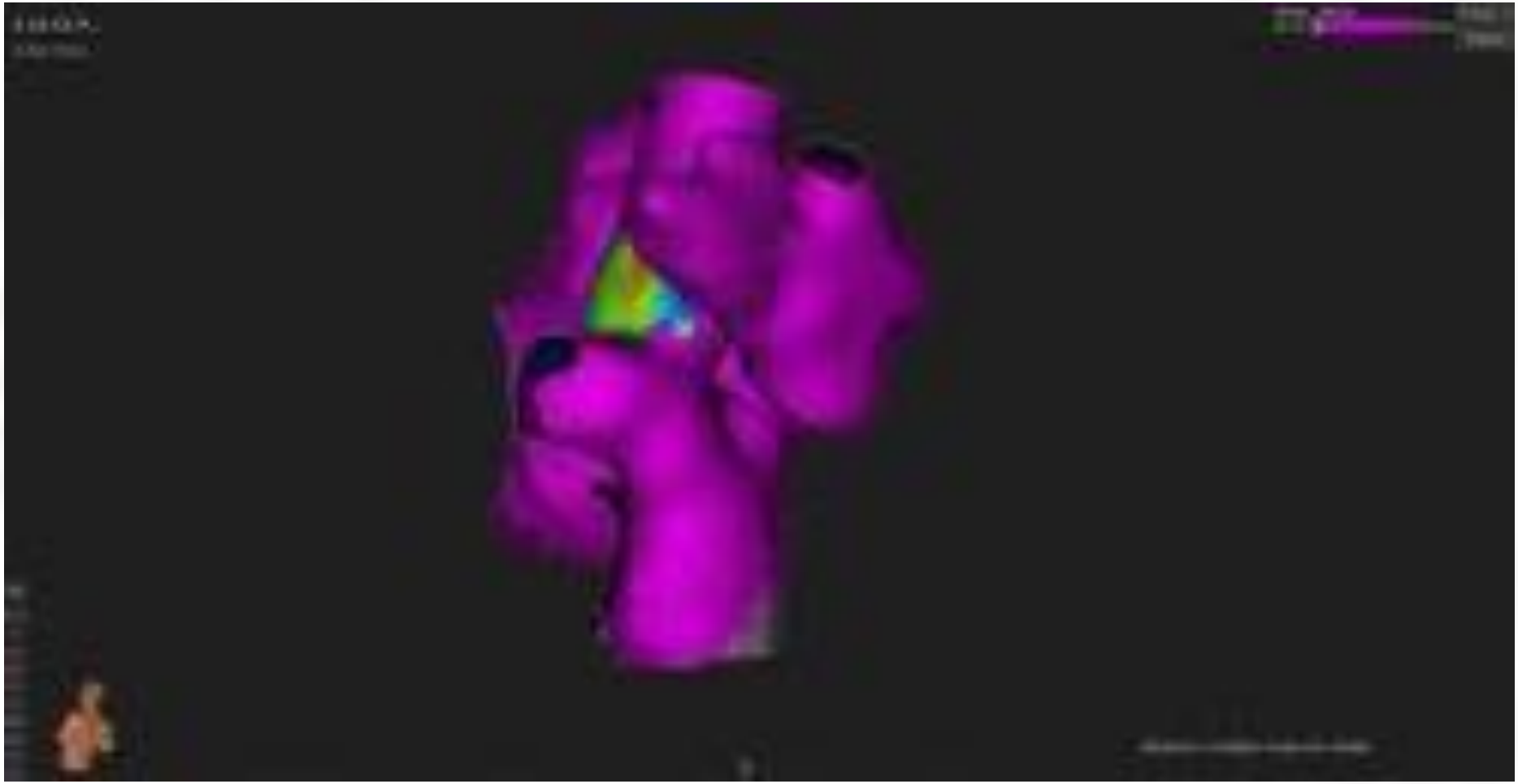


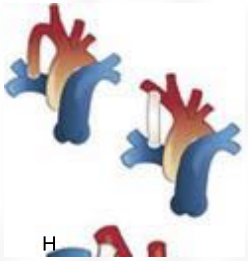






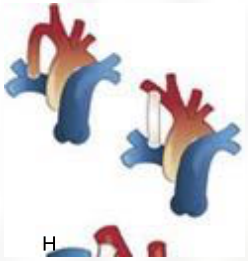
- Patient with TGA with Senning atrial switch.
- AT non sustained, tachy activation map not possible
- Pacing from baffle demonstrated line of block on septal aspect
- After ablation across the remaining short gap, pacing from baffle demonstrated CTI block



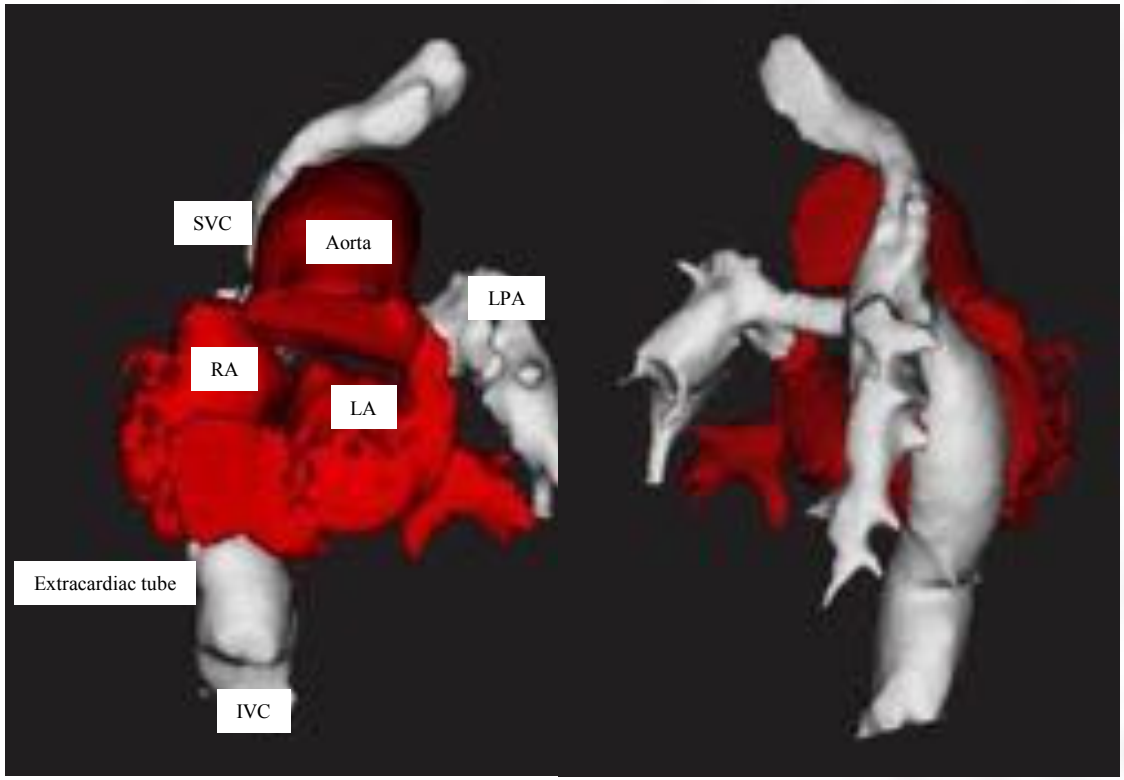


Extracardiac Fontan

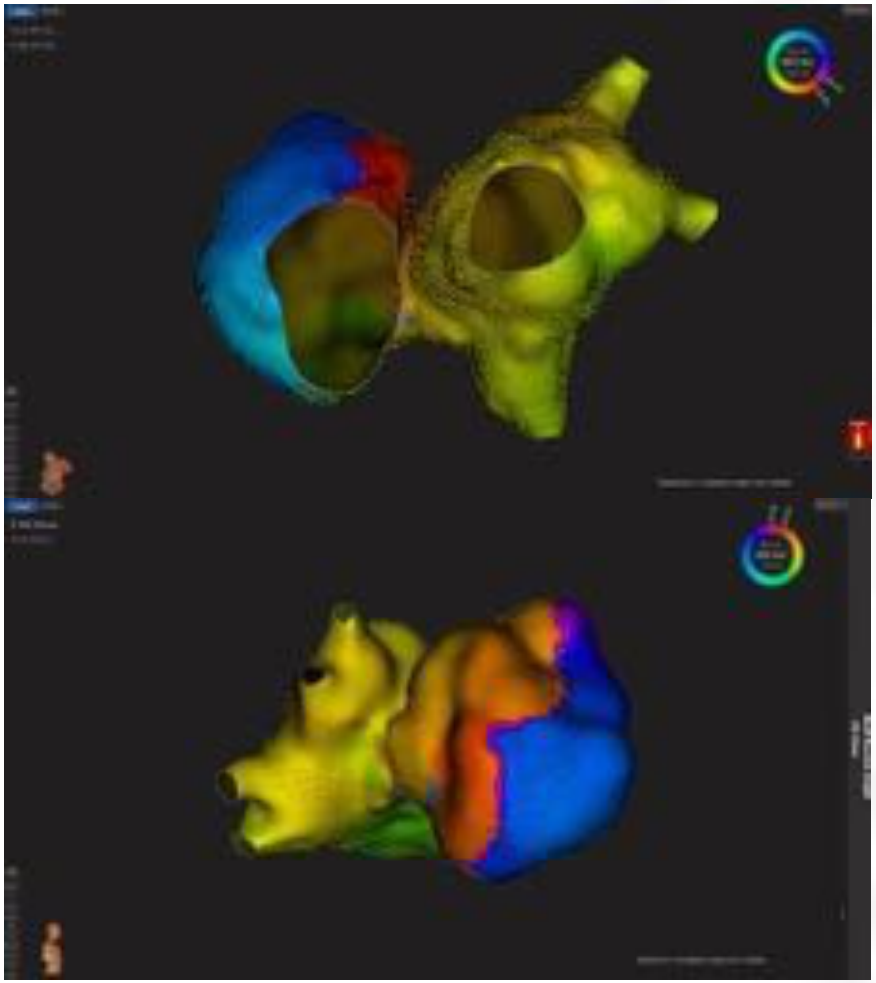
- 32 y.o
- Complex congenital heart disease: double outlet right ventricle + tricuspid atresia +ASD + transposition of the great vessels
- "Classic" Fontan surgery in 1992
- 2010: CTI ablation for a common flutter: bidirectional block hardly obtained
- 2011: total cavopulmonary connection via an extracardiac tube + right atrial resection + tricuspid annulus closure with a patch
- 2017: multiple symptomatic AT recurrences



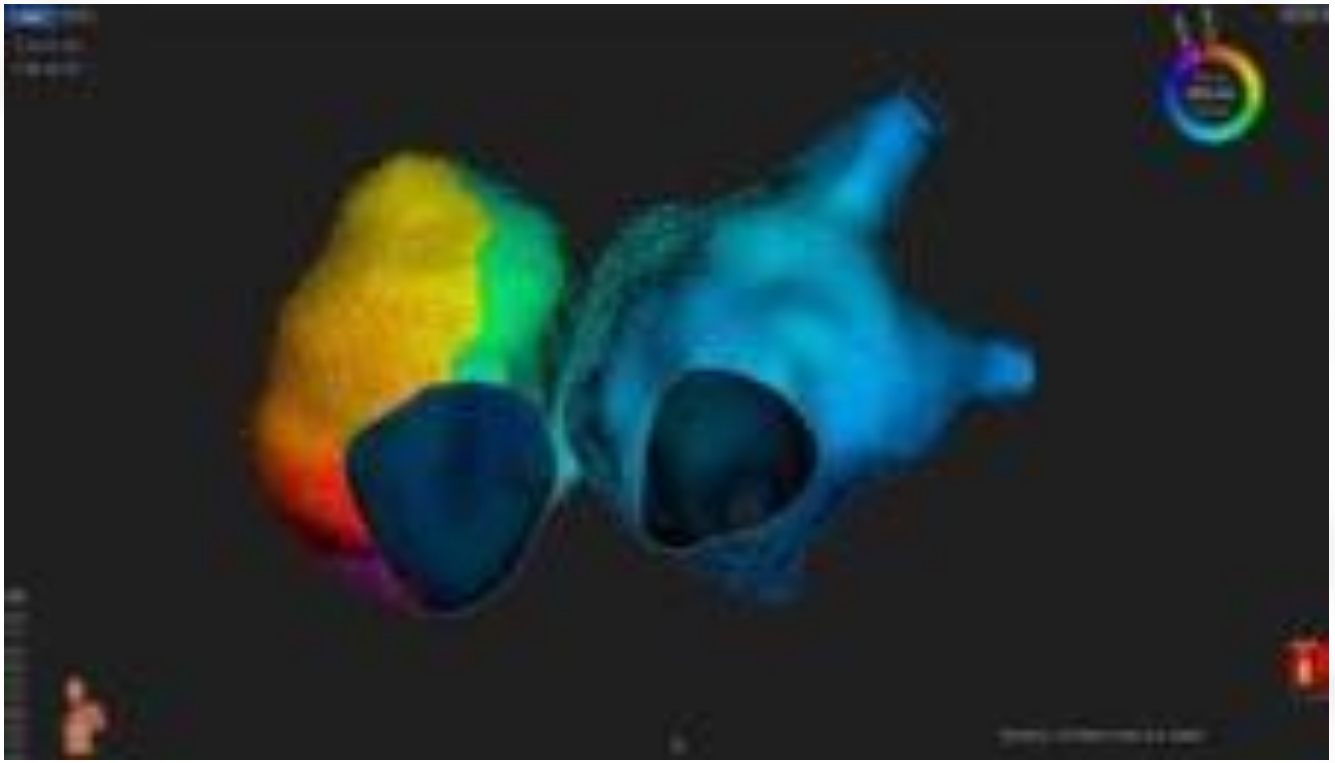
Extracardiac Fontan



TEE guided transcaval puncture



Clockwise common flutter: gap on the antero-septal right atrial gap



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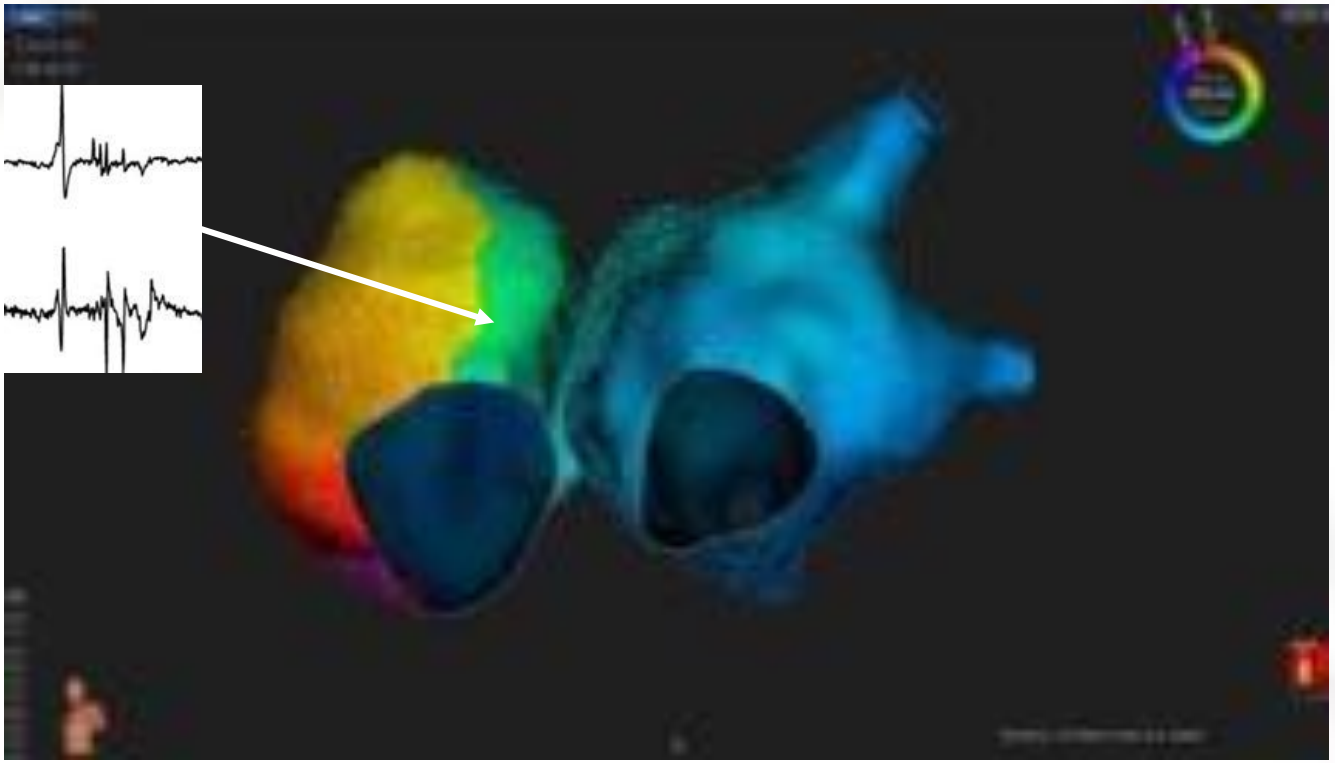
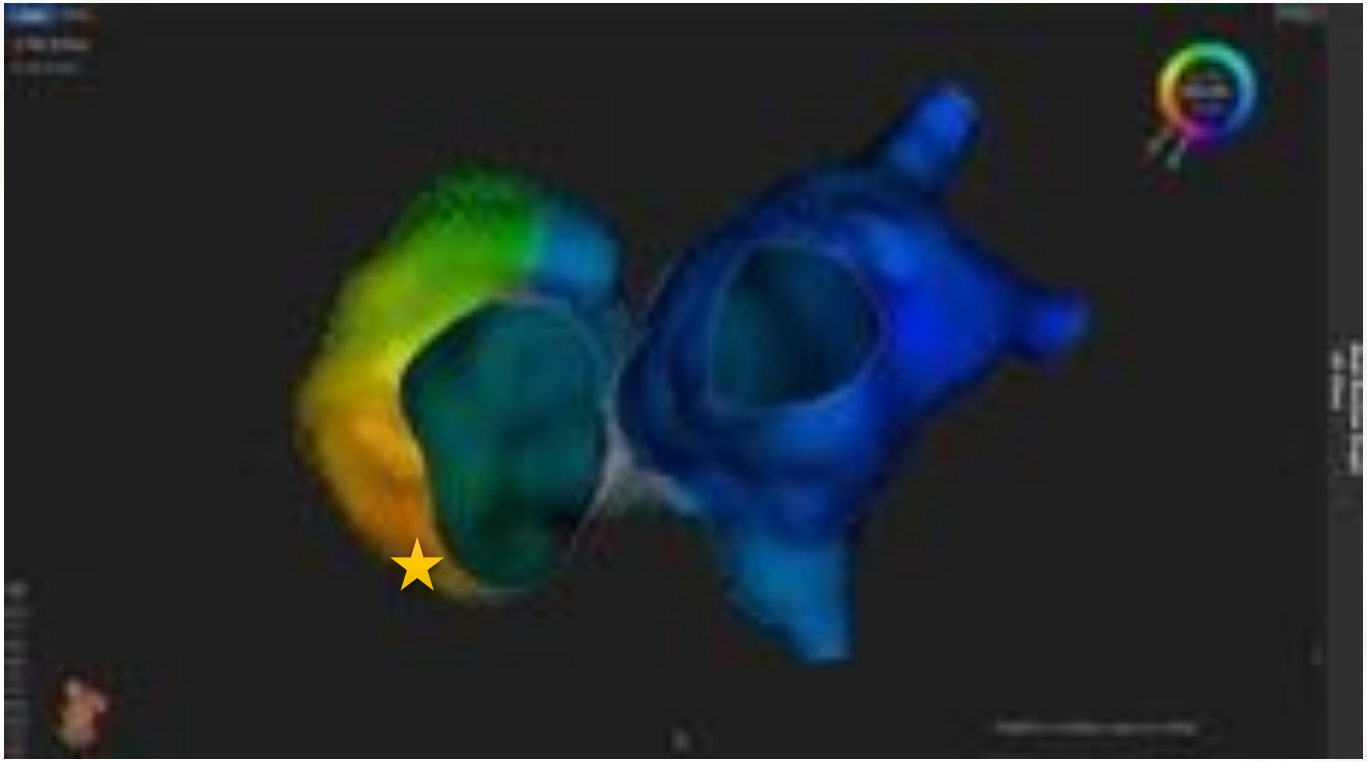


Clockwise common flutter: post – ablation mapping

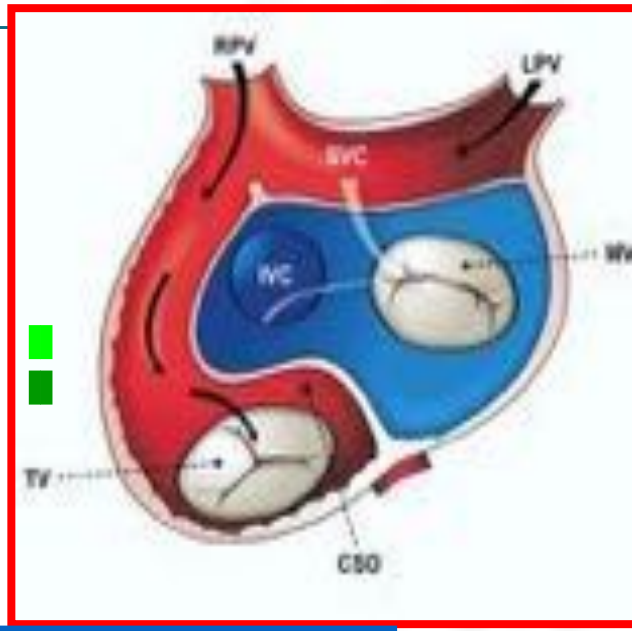


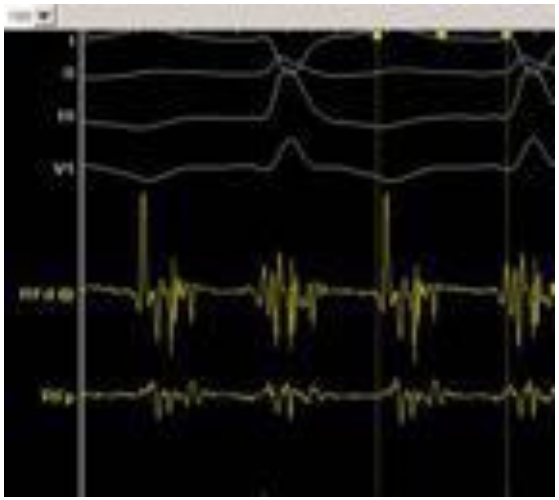
CONCLUSIONS

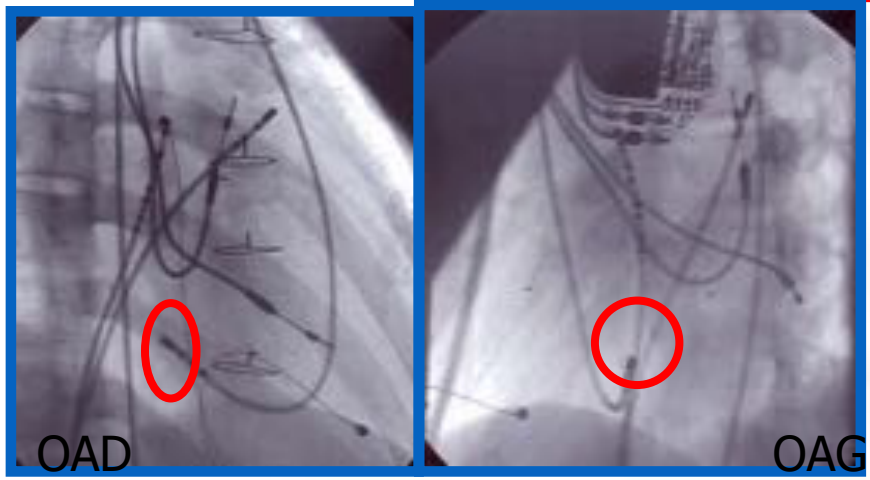
- Ne pas oublier les principes généraux de prise en charge:
  - Traitement anticoagulant !!
  - Traitement antiarrhythmique
- Amélioration importante des systèmes de cartographie
  - Acquisition: multielectrodes, electrodes de petites tailles (printed++)
  - Data management
    - Haute densité
    - Algorithme d'annotation
    - Algorithme d'interpolation
- Très en faveur d'une approche permettant leur utilisation
- Attention:
  - Ne pas attendre du système de cartographie de donner toujours la bonne réponse.
  - Ne pas oublier les principes de base (entrainement etc…)!!

FLUTTER ATRIAL ET TGA

- Isthme Cavo-Tricuspide est séparé par le “baffle”
- Localisation du sinus coronaire depend de la position du baffle







Our experience of substrate mapping in ToF

- Population

- Patients with an indication of EPS
- Patients scheduled for ablation (Atrial arrhythmias, PVC, VT….)
- Before redo cardiac surgery (PVR++)

- Which exams?

- High resolution cardiac MRI
- RV substrate mapping to identify potential isthmuses
- Ventricular stimulation at baseline and with isoproterenol

PROTOCOL FOR PRE-OPERATIVE EP STUDY

- Before redo surgery for PVR
  - Identification of potential isthmuses (hr MRI, EPS)
  - If VT inducible and/or slow conduction in isthmuses →Isthmuses ablation

- During Surgery
  - Cryo-ablation of isthmuses if VT was still inducible at the end of the catheter ablation
  - Pulmonary valvulation

- New EPS 1 to 3 months post surgery
  - If inducible → ICD

Protocol with Paul Khairy, Montreal, Canada

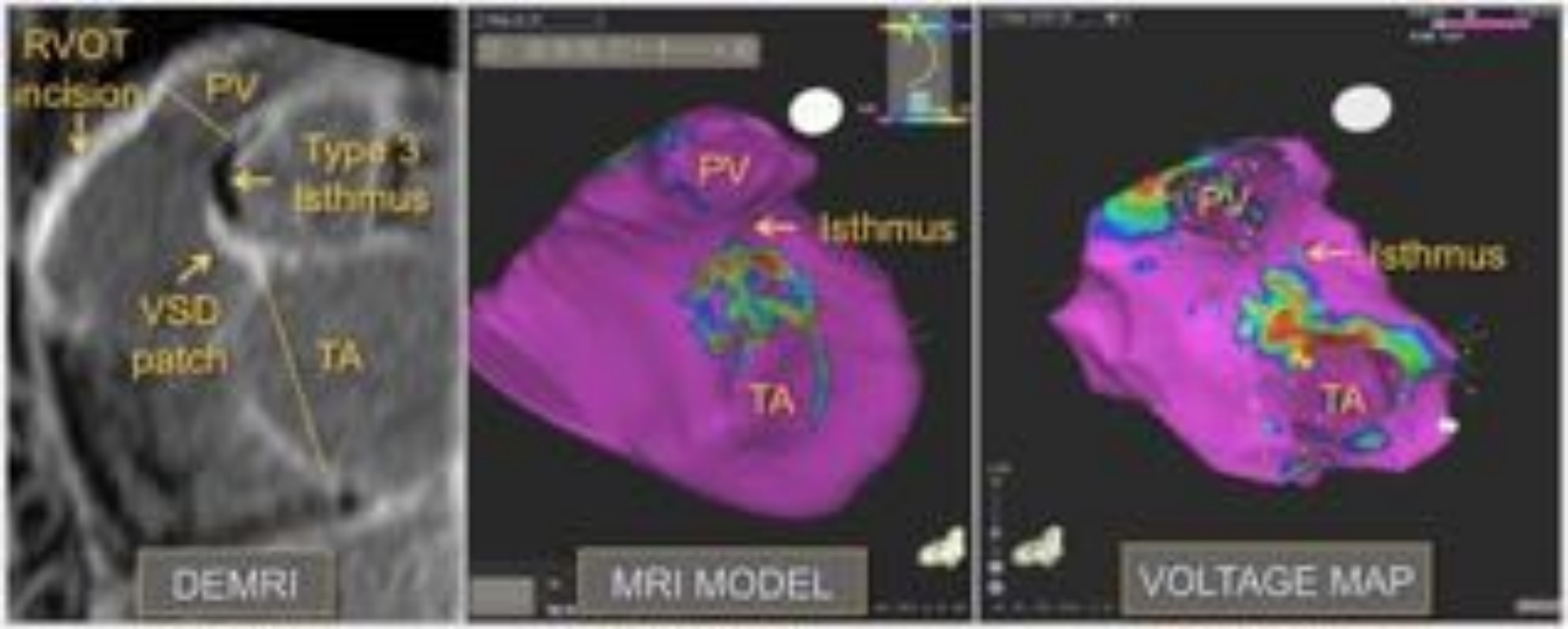
CONCLUSION

- **ICD** in case of previous cardiac arrest or spontaneous syncopal VT
- Catheter ablation of VT & isthmuses with slow conduction in case of VT ± ICD
- In case of surgery: Surgical cryo-ablation of isthmuses may be interesting ++
- **No indication of** Anti-arrhythmic for SCD prevention
- Absence of ventricular incision during the initial surgery may limit the risk of late ventricular arrhythmias.

PHRC NATIONAL

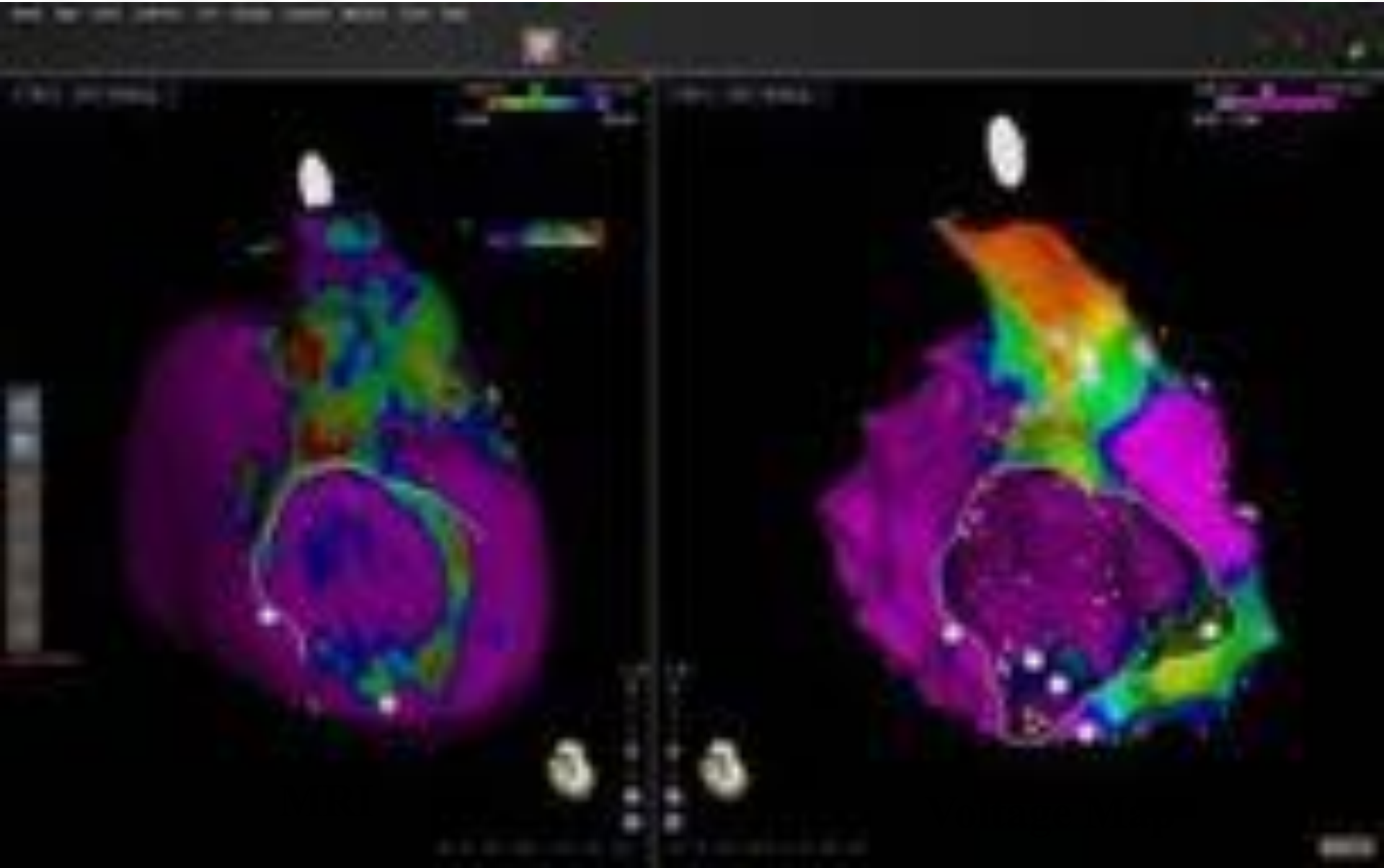
High resolution Cardiac MRI

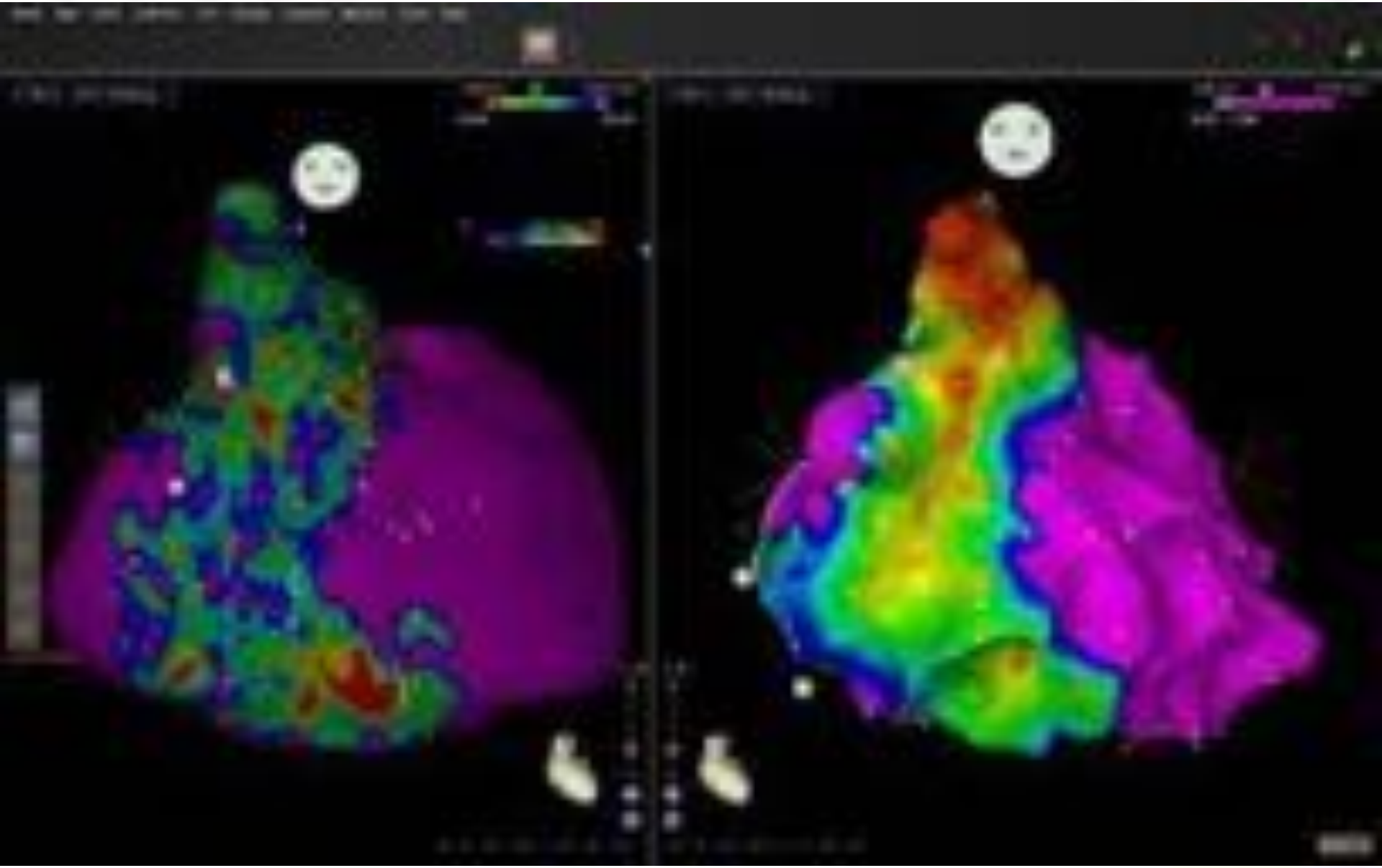
1) Good correlation with isthmuses found on voltage map
2) Good evaluation of isthmuses sizes
3) Anatomically short isthmuses are correlated to slow conduction



Cochet H et al. HRS 2012

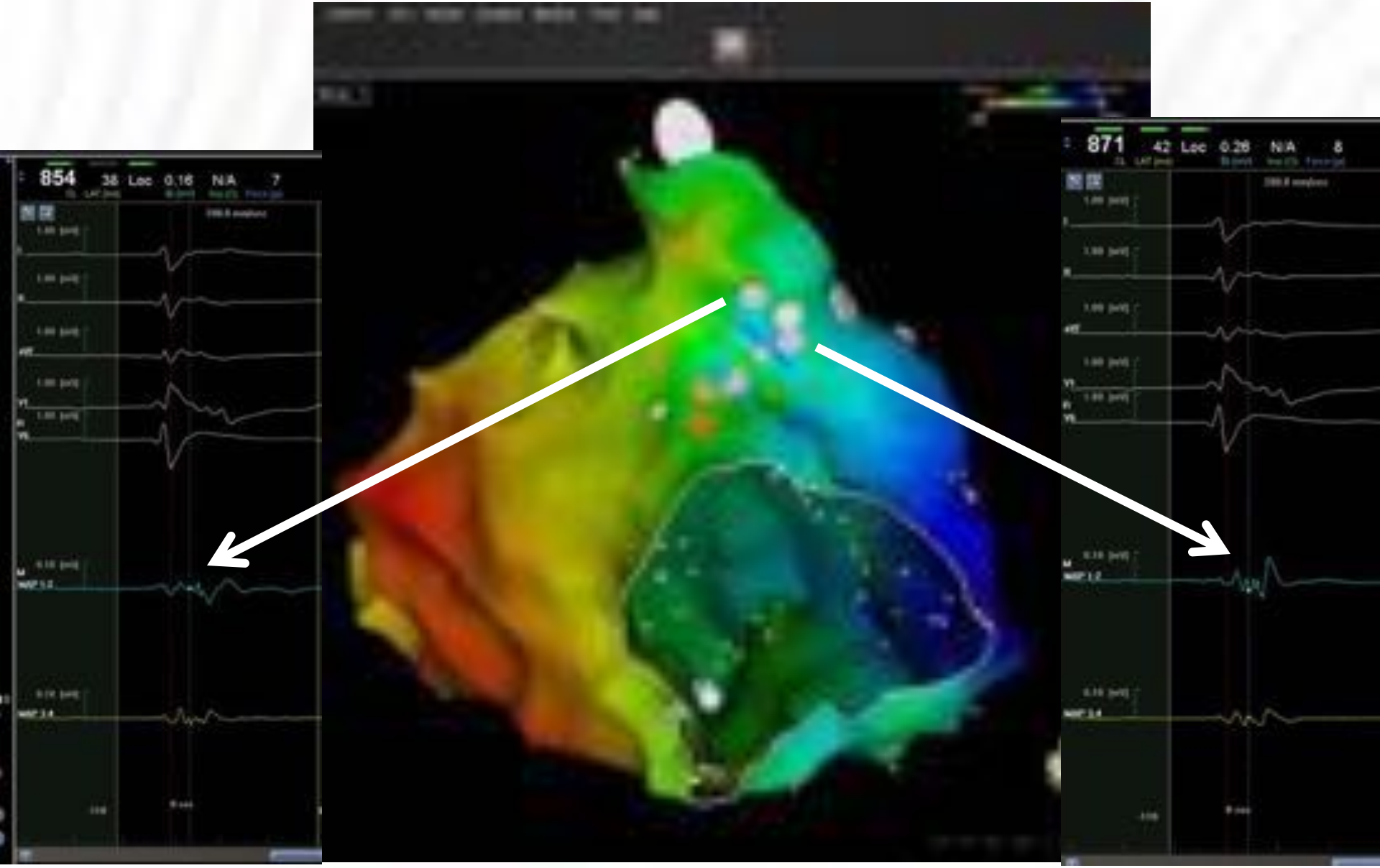
13 yo ToF boy
NSVT on holter and scheduled for surgery





MRI

Voltage Map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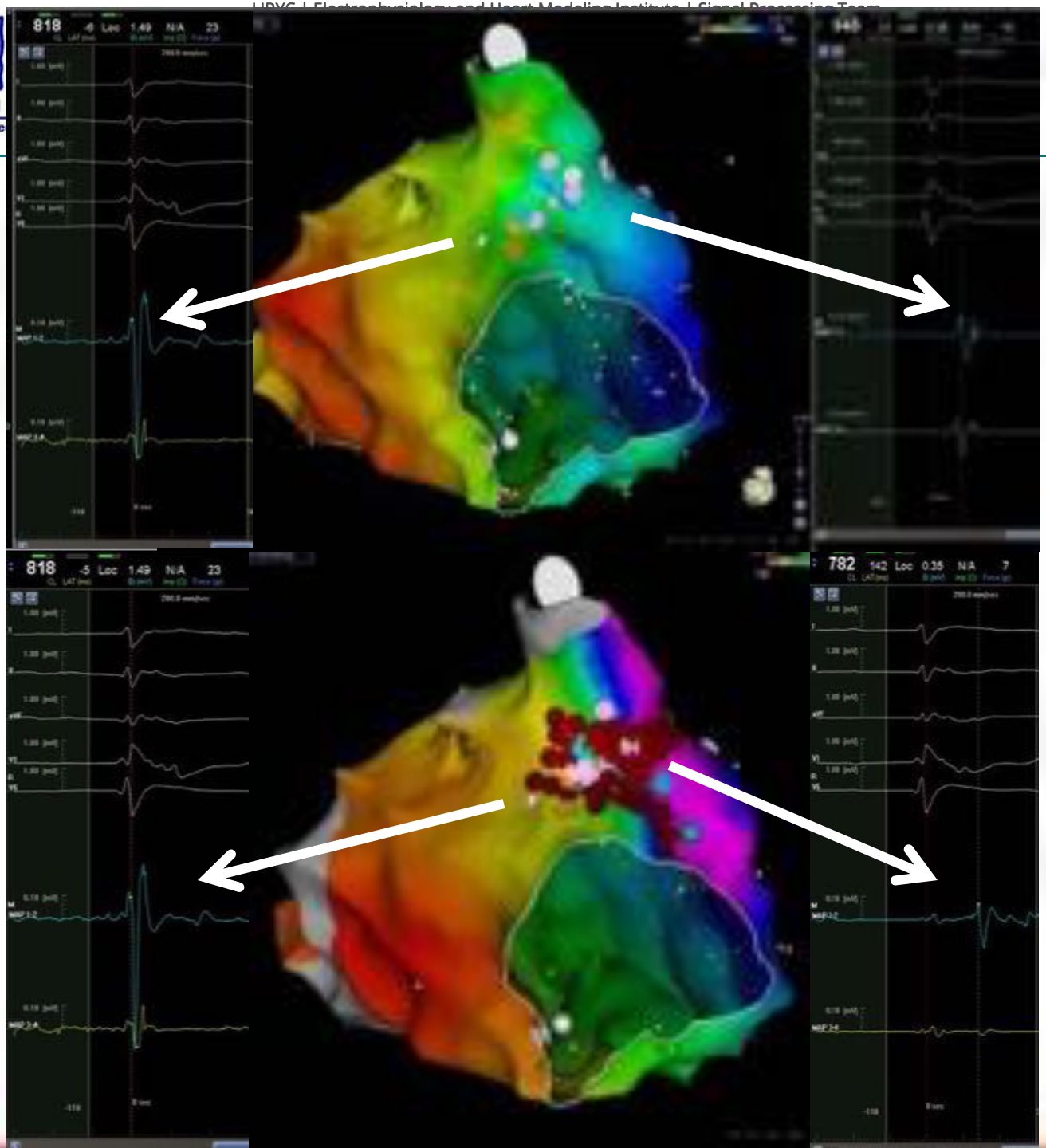
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818 -5 Loc 1.49 N/A 23
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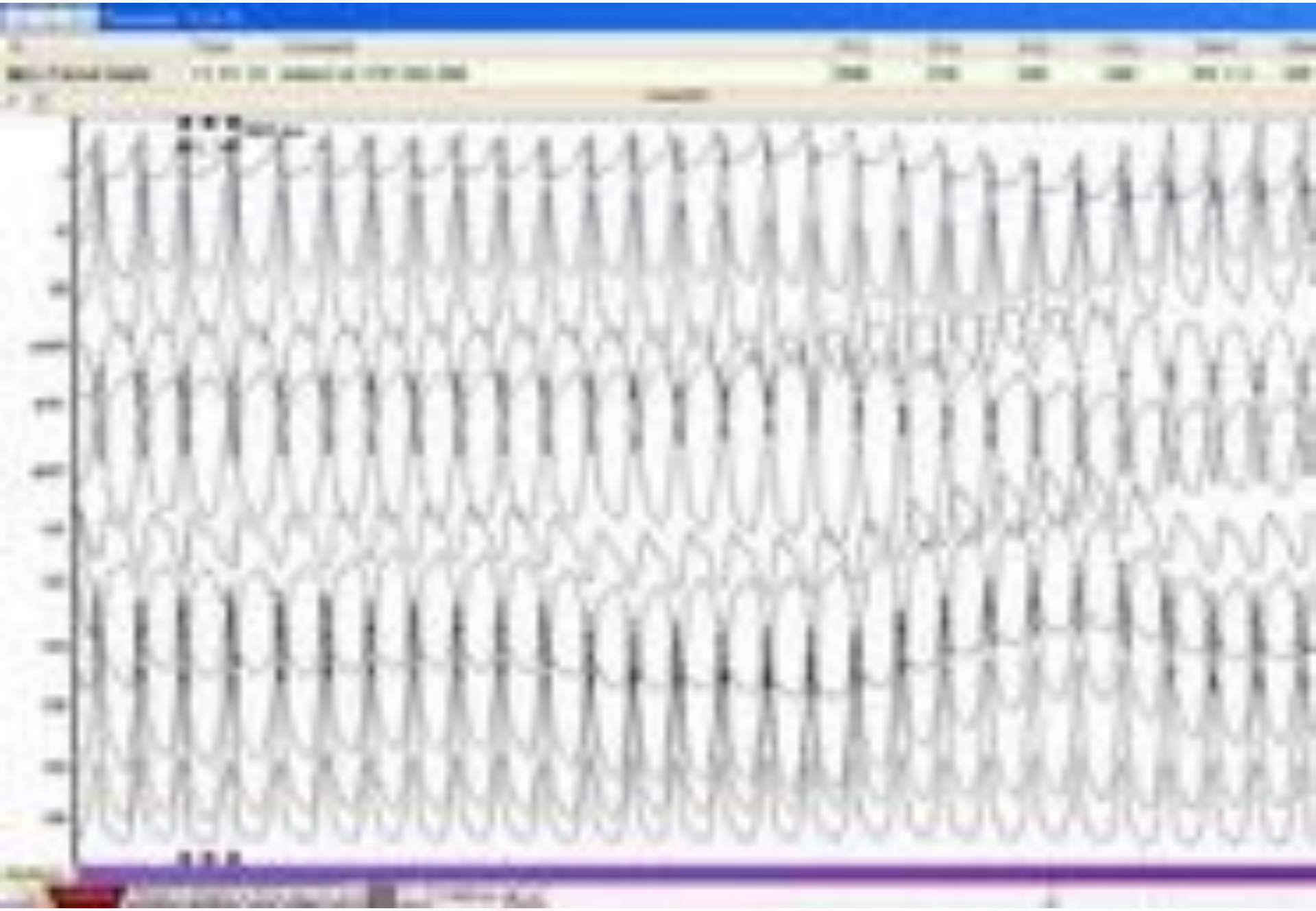

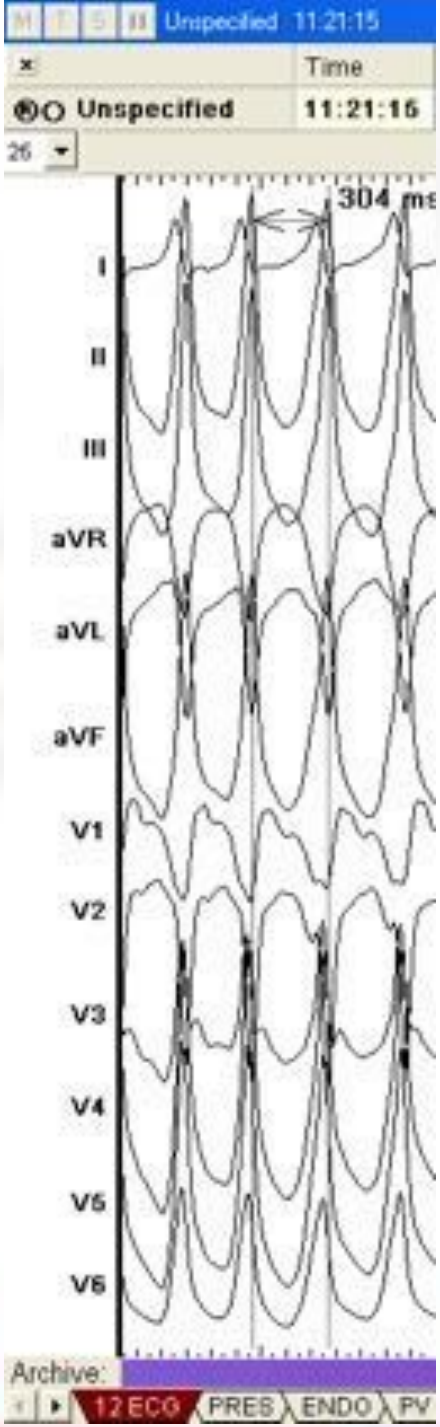
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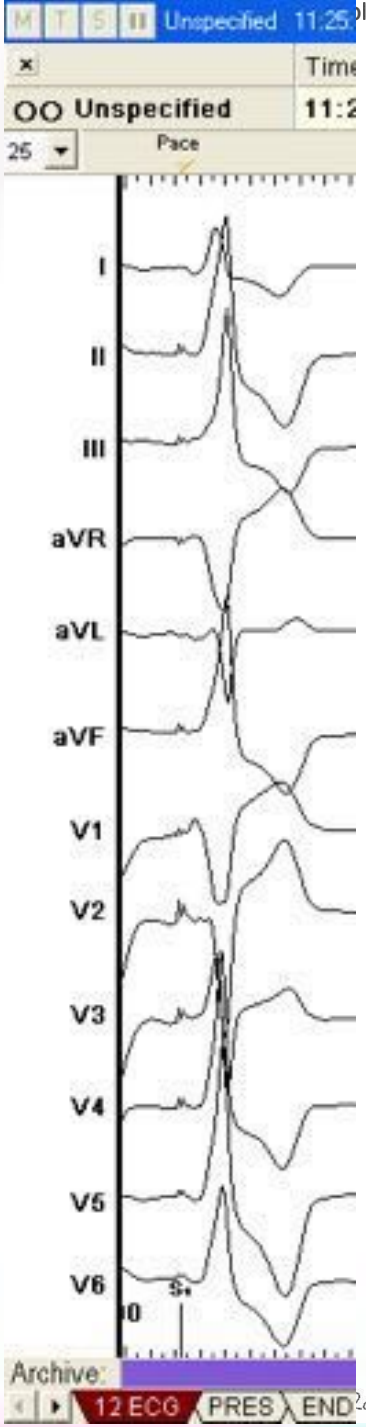
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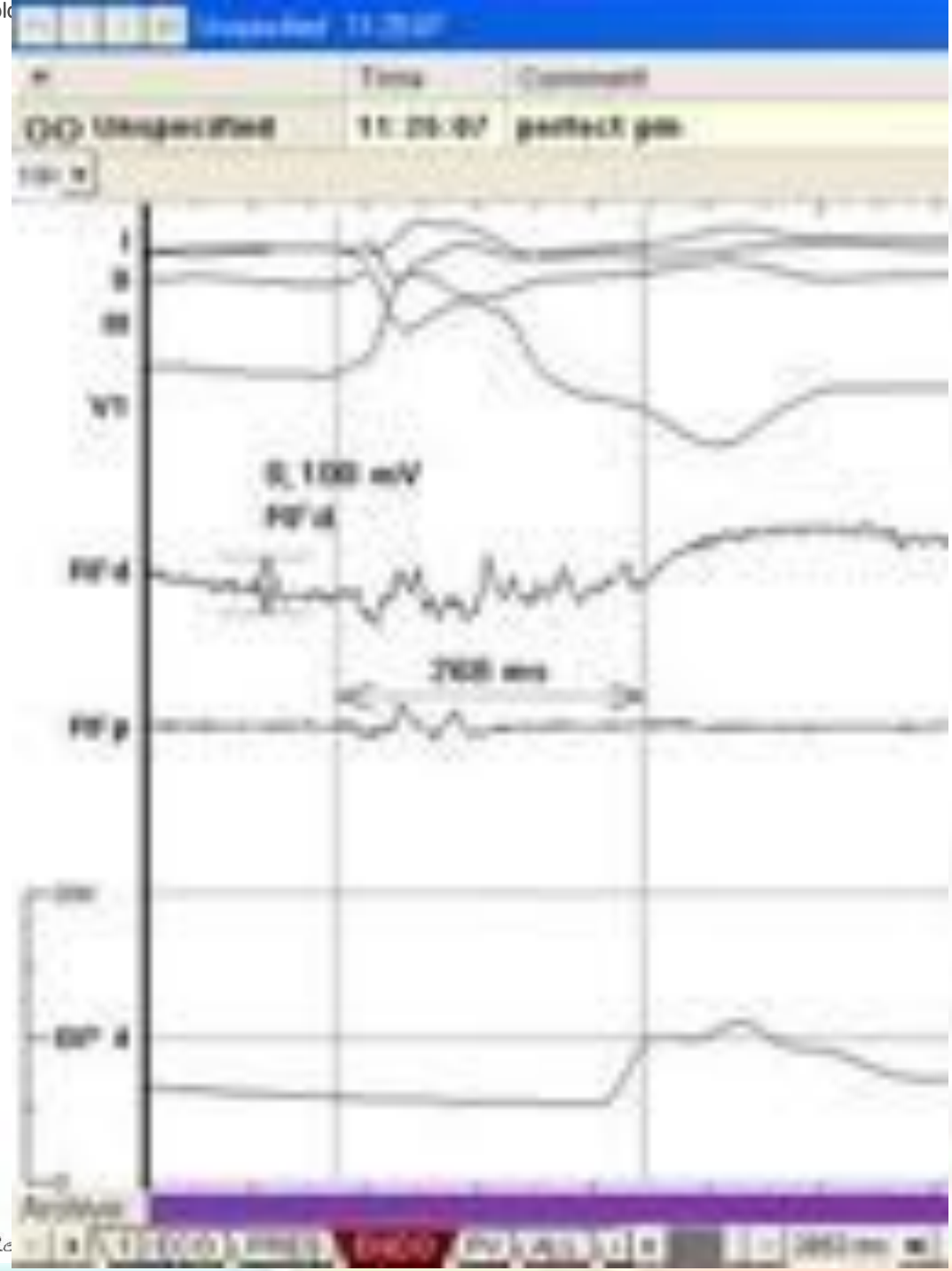
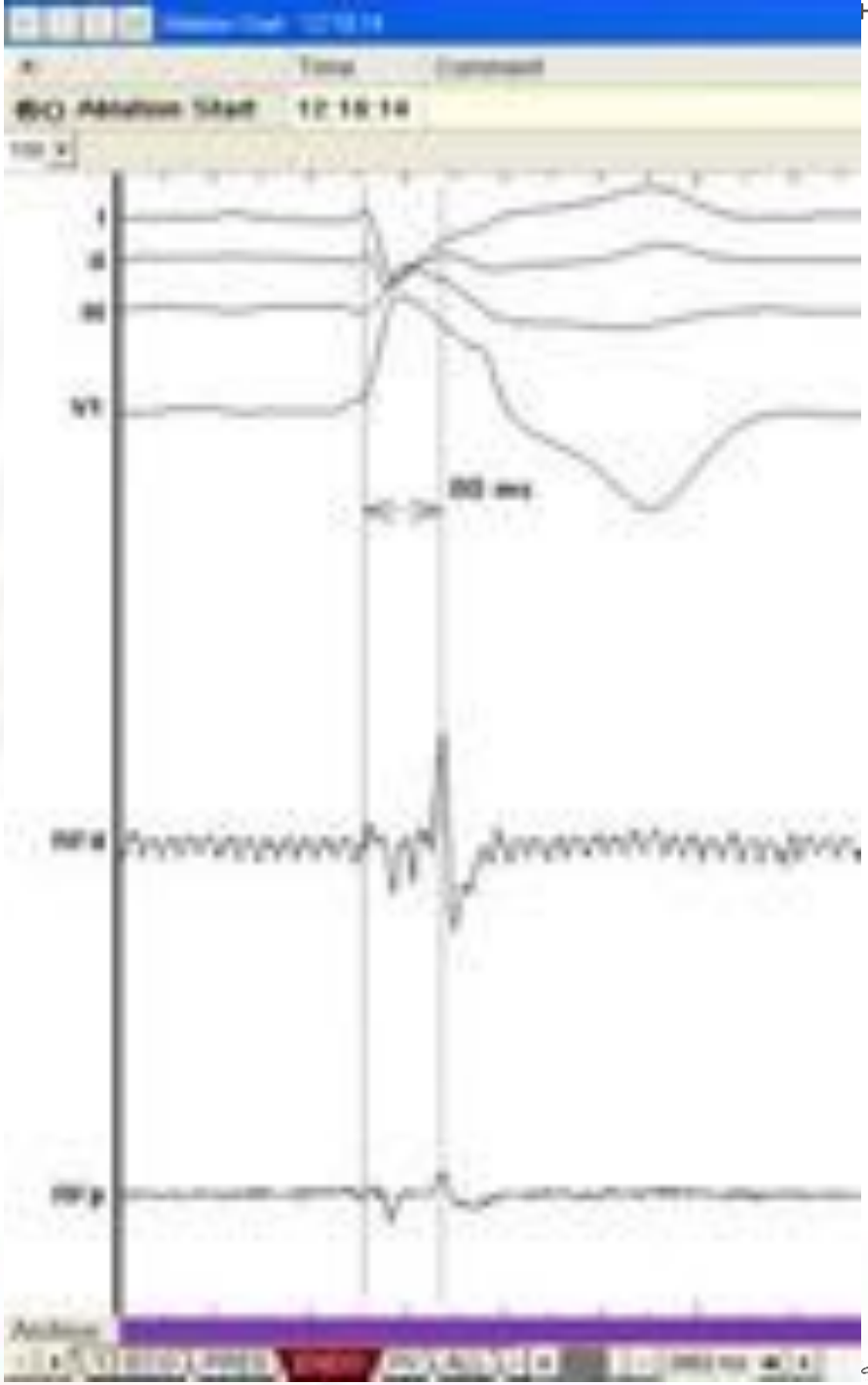
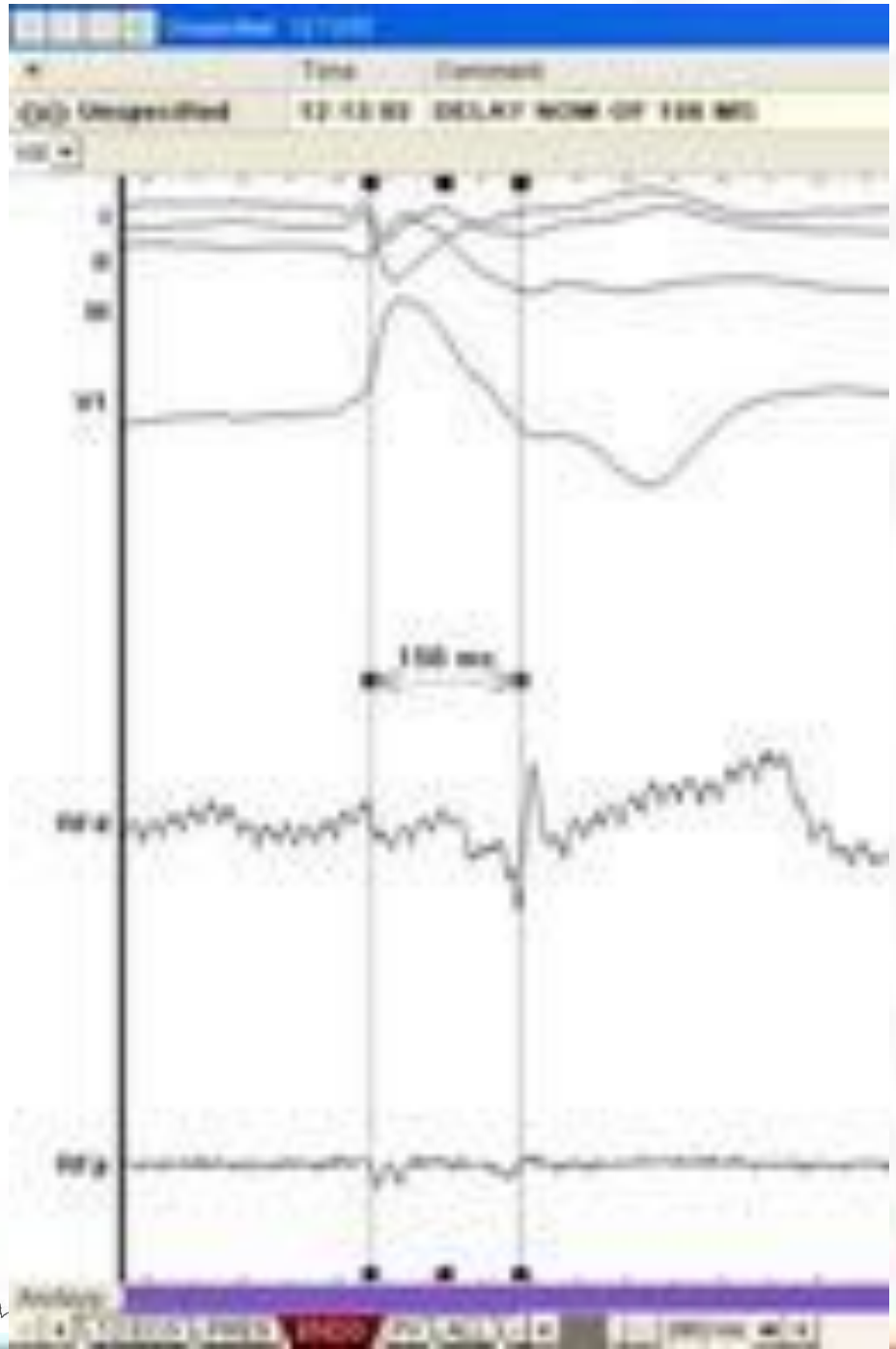
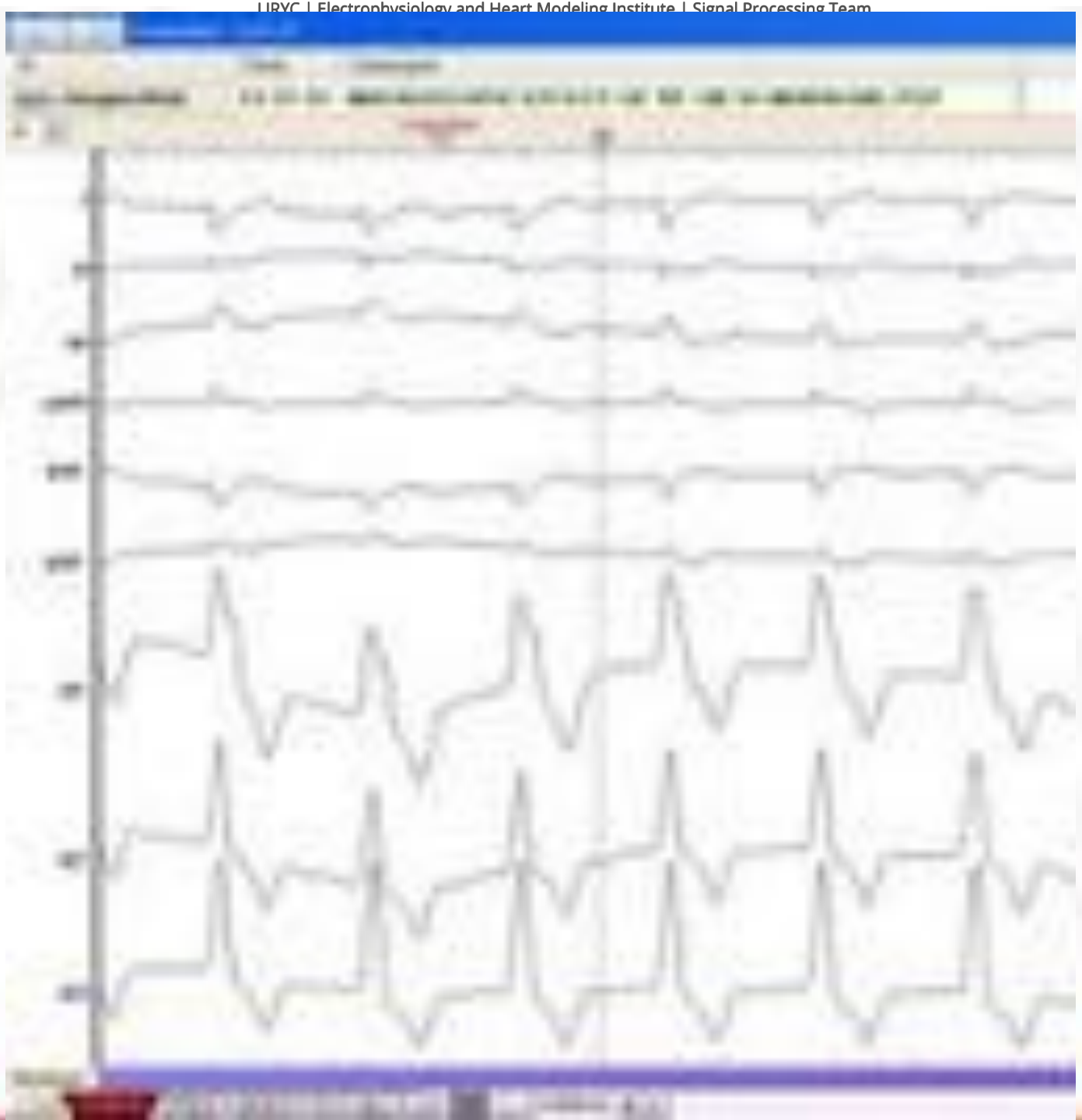
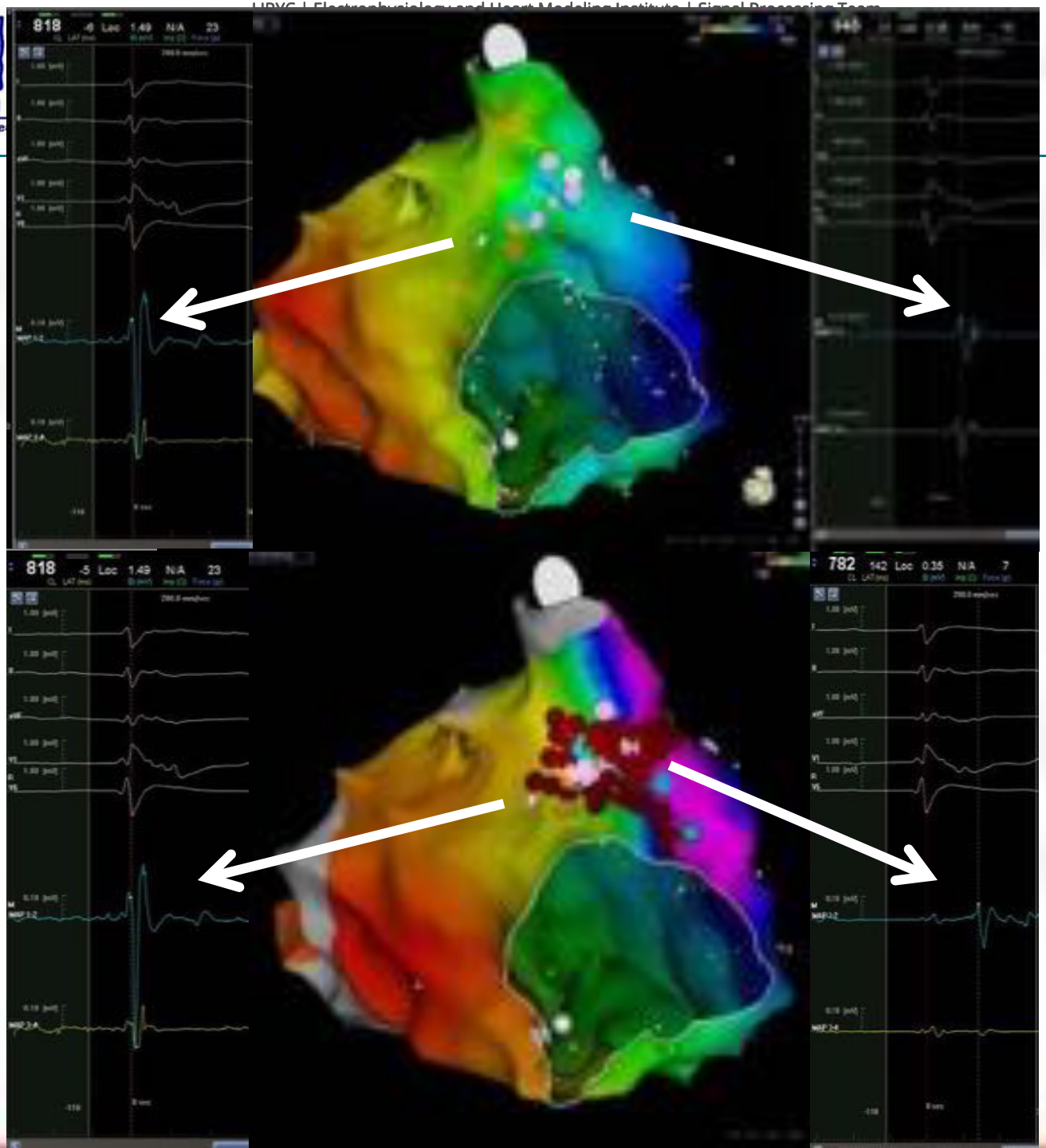
Pace
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
Archive:
12 ECG
PRES
END

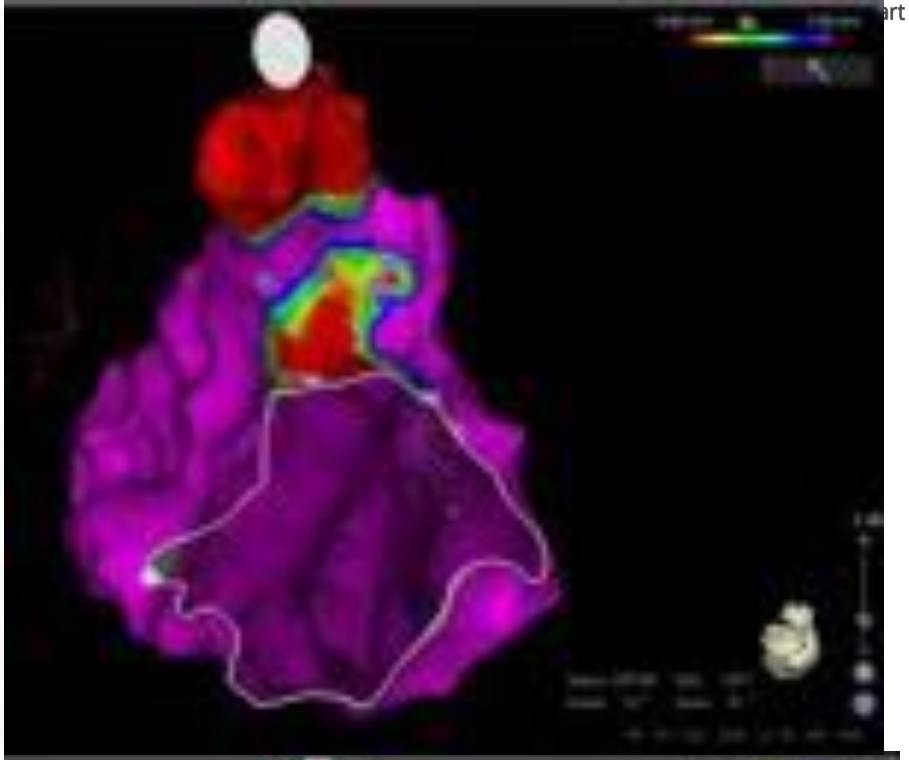

Time
Unspecified 11:25:07
perfect pin
I
II
III
V1
RF d
RF p
V6

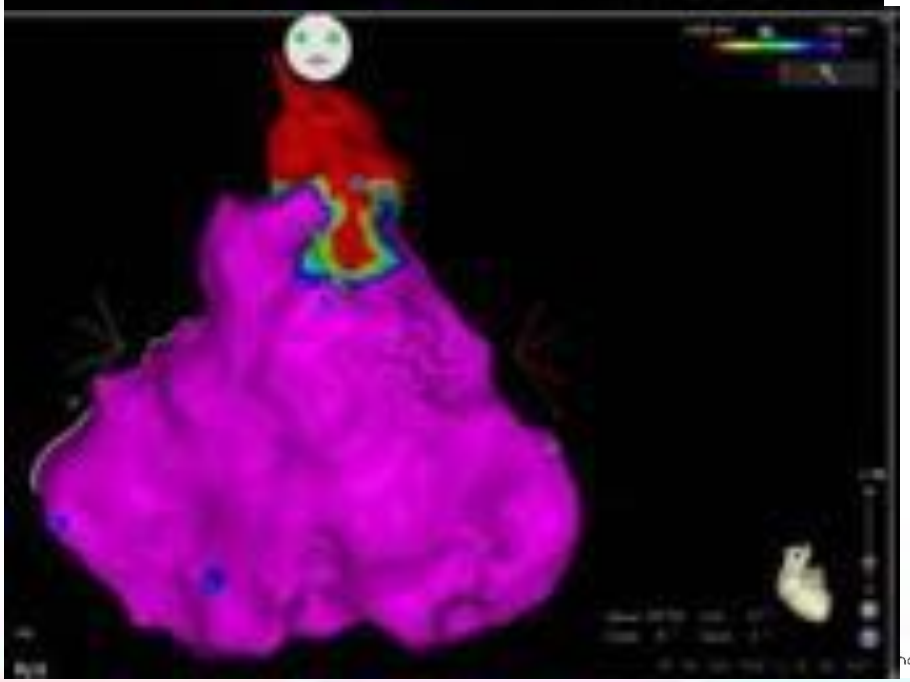

Time
Comment
12 15 14
I
II
III
V1
80 ms
Ref #
Ref p
Archive


Time
Comment
I
II
III
V1
150 ms
Ref #
Ref p
Archive




818 -6 Loc 1.49 N/A 23
818 -5 Loc 1.49 N/A 23
782 142 Loc 0.35 N/A 7





24 yo male with lightheadness

- Pulmonary Regurgitation

-But no indication for surgery