APPAC
ACTUALISATIONS ET PERSPECTIVES EN PATHOLOGIE CARDIOVASCULAIRE
15e édition

5-6 ET 7 JUIN 2013
BIARRITZ

Progrès et nouvelles stratégies de prise en charge des troubles du rythme des cardiopathies congénitales de la voie droite

Jean-Benoît Thambo

Pathologies Cardiaques Congénitales du Fœtus de l'Enfant et de l'Adulte
Hôpital Cardiologique du Haut Lévêque,
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LIRYC L'Institut de RYthmologie et modélisation Cardiaque
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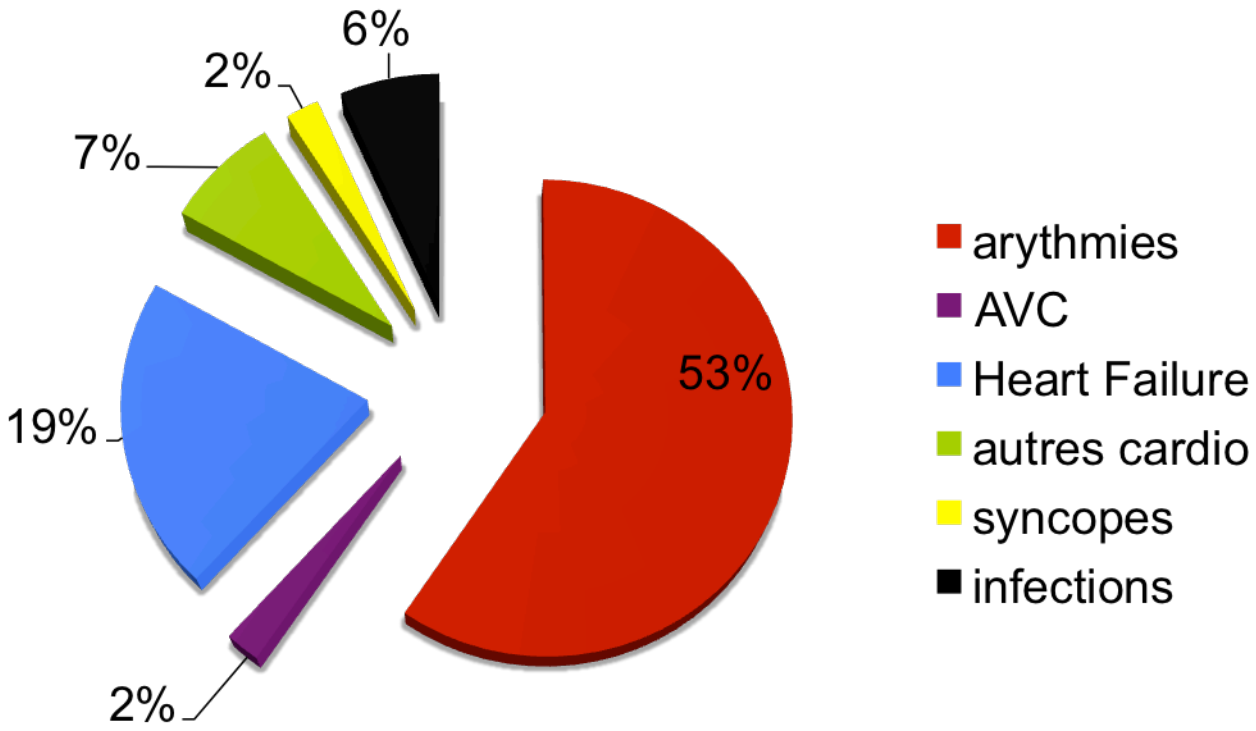
Adultes avec CC : des patients “survivants” mais pas “guéris à vie”

- **De multiples situations à risque élevé**
  - Défaillance cardiaque
  - Arythmie
  - Mort subite
  - Intervention chirurgicale
  - Endocardite infectieuse
  - HTAP
  - Syndrome d’Eisenmenger (shunt droite-gauche)

- **Des situations de la vie courante à considérer**
  - Sport
  - Grossesse
  - Vie professionnelle, Assurances

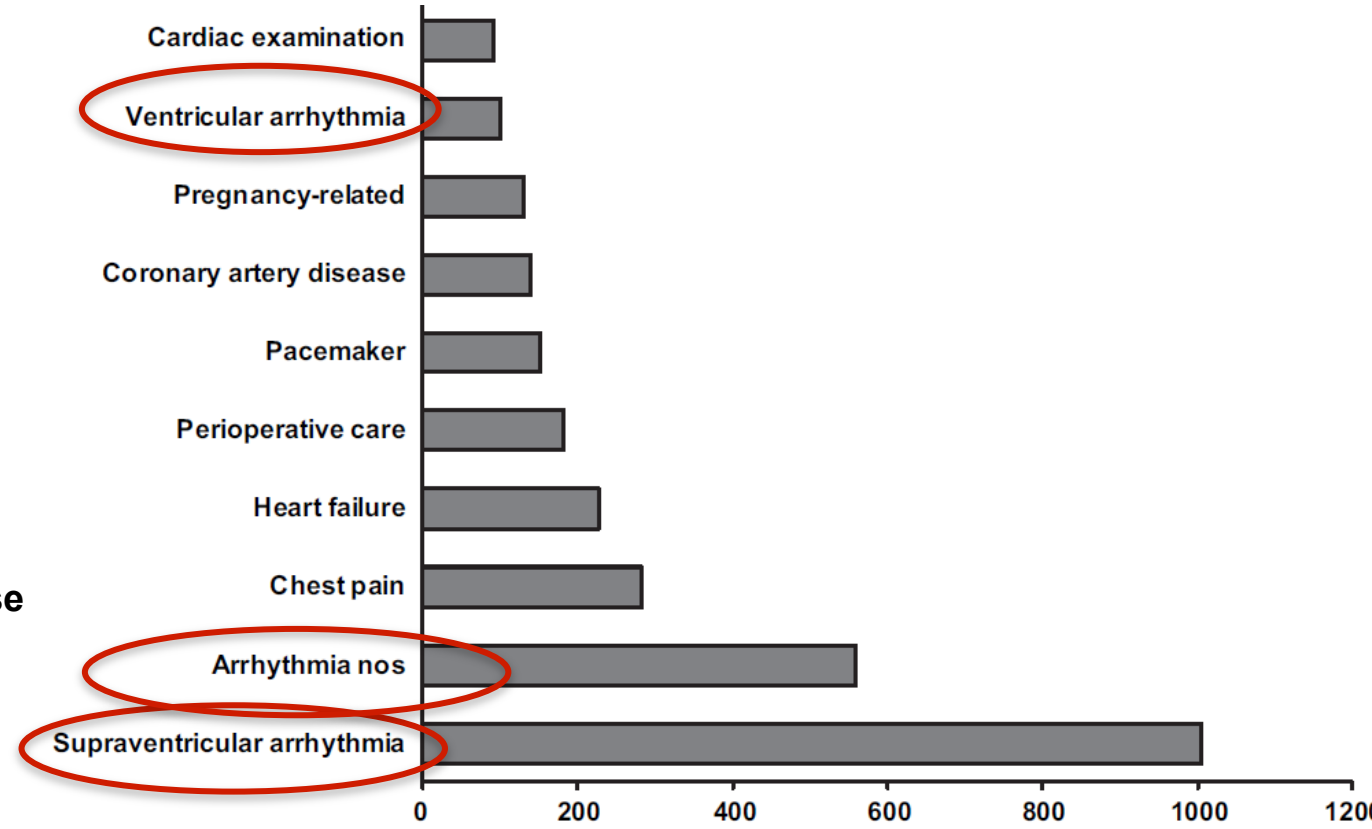
[11]Baumgartner H et al. *Eur Heart J 2010; 31 (23):2915-57*

Motifs d’hospitalisations



Adultes avec CC : plus souvent hospitalisés pour une cause cardiovasculaire

- Taux d'hospitalisation 2 à 3 fois plus élevé que dans la population générale
- Dans 61% des cas : cause cardiovasculaire, en particulier l'arythmie

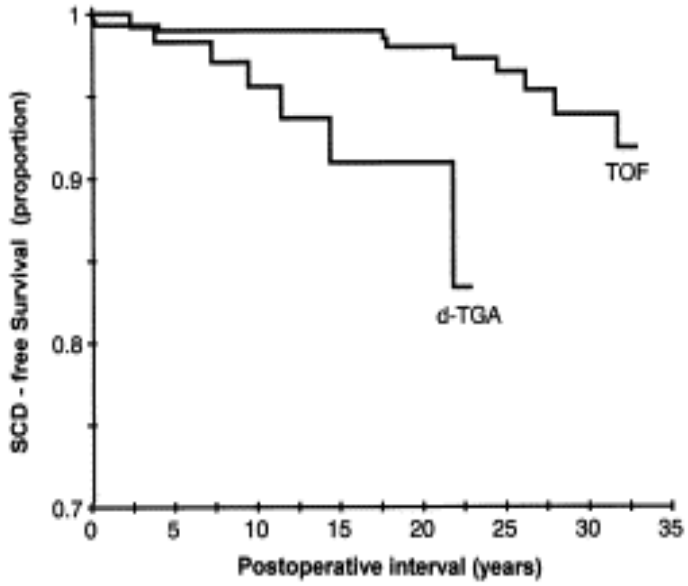


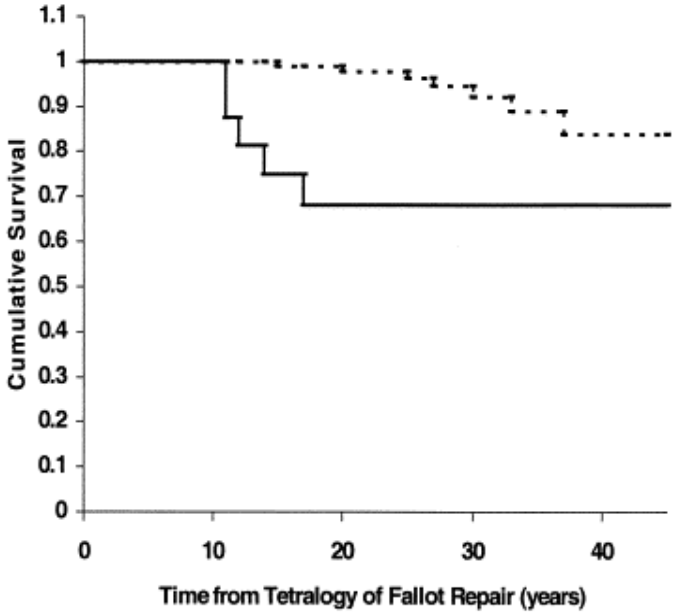
Hospitalisations pour cause cardiovasculaire

Registre CONCOR n= 5798 entre 2001 et 2005

[14]Verheugt C et al. *Heart 2010;96(11):872-8*

Une nouvelle population, des problèmes spécifiques…



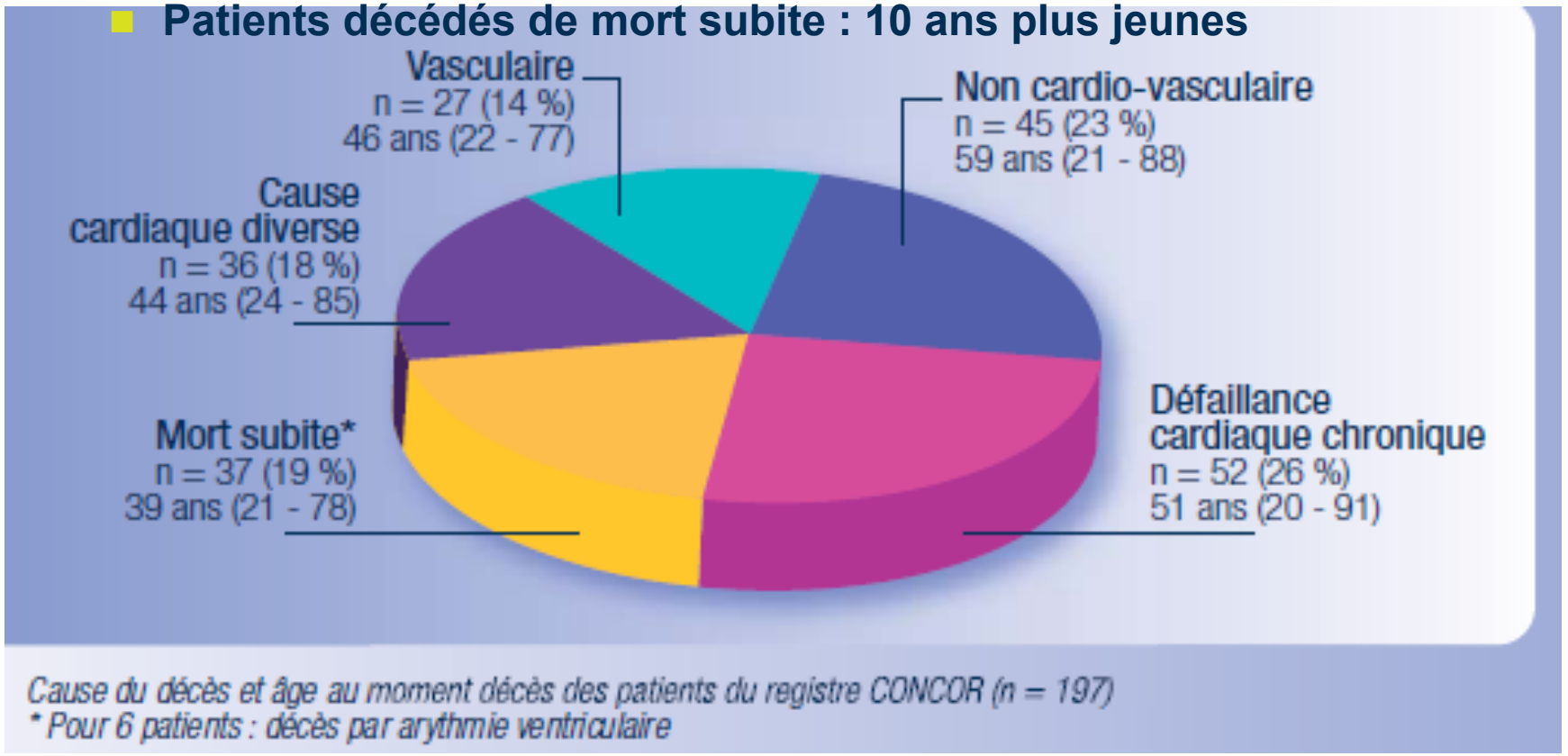


Normal or mild LV systolic dysfunction (n)	121	121	119	116	114
Moderate or severe LV systolic dysfunction (n)	16	16	11	11	11

Ghai, A. JACC 2002

Age et causes des décès (registre CONCOR)

- **Age médian de survenue des décès : 48,8 ans [13]**
- **77% des décès : origine cardiologique**
- **Défaillance cardiaque chronique et mort subite représentent 45% des décès**
- **Patients décédés de mort subite : 10 ans plus jeunes**

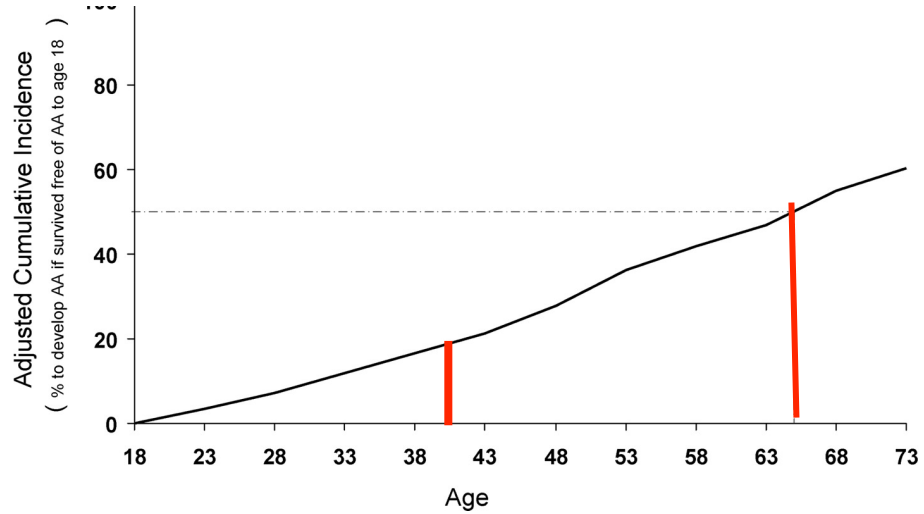


Cause du décès et âge au moment décès des patients du registre CONCOR (n = 197)
** Pour 6 patients : décès par arythmie ventriculaire*

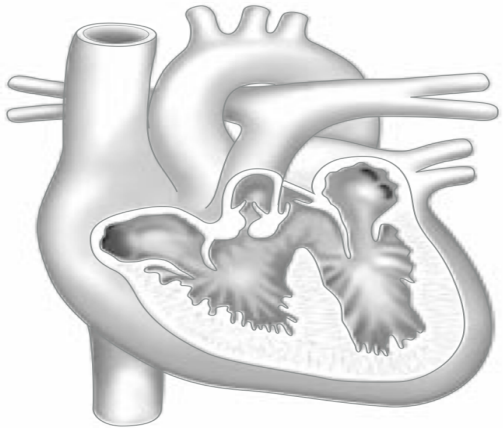
[13]Verheught CL et al. *Eur Heart J 2010 May;31(10):1220-9*

Atrial arrhythmias in ACHD

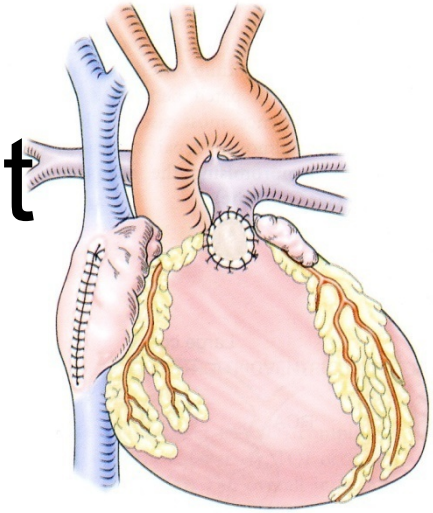
Prévalance of AA = 15,1% in GUCH
3 time higher than in general population

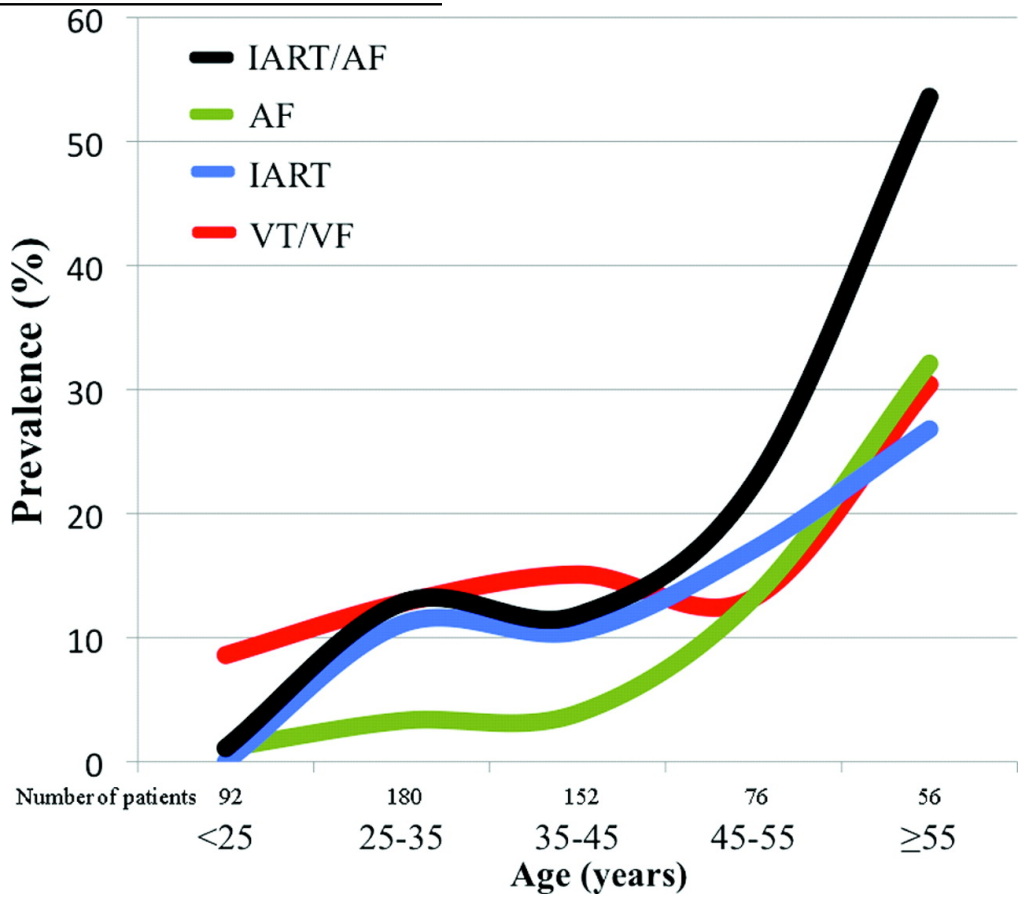


Bouchardy, J. et al. Circulation 2009;120:1679-1686



Tetralogy of Fallot (TOF)





- 556 ToF
- ventricular arrhythmia: 14.6%

Khairy, P, Circulation, 2010

Facteurs favorisant

Late Sudden Death After Repair of Tetralogy of Fallot: A Clinicopathologic Study

JOHN E. DEANFIELD, M.R.C.P., SIEW-YEN HO, M.PHIL., ROBERT H. ANDERSON, M.D., WILLIAM J. MCKENNA, M.D., SALLY P. ALLWORK, PH.D., AND KATHARINE A. HALLIDIE-SMITH, M.R.C.P.

SUMMARY **Retrospective analysis was performed to determine the likely cause of death in six patients who died suddenly 1–9 years after repair of tetralogy of Fallot. The integrity of the atrioventricular conduction system and myocardium was examined in three hearts at necropsy. Two of three patients who complained of palpitation or syncope had frequent premature ventricular complexes on routine ECGs. All the patients had complete right bundle branch block and one had left-axis deviation after repair. Postoperative cardiac catheterization (four patients) showed no residual ventricular septal defects, but right ventricular pressure was elevated in all.**

At necropsy, the atrioventricular conduction tissue was related to the margin of perimembranous ventricular septal defect in two patients, but was well posterior in one patient with an infundibular muscular defect. Histologic examination showed that in all cases the atrioventricular node, atrioventricular bundle and left bundle branch were undamaged. There was, however, extensive fibrosis of the right ventricular myocardium in the ventriculotomy site (three patients), septum (one patient) and outflow tract (one patient).

These clinical and necropsy findings suggest that ventricular arrhythmia rather than atrioventricular block was responsible for sudden death in these patients after repair of tetralogy of Fallot.

Address for correspondence: John E. Deanfield, M.R.C.P., Division of Cardiology, Royal Postgraduate Medical School, Hammersmith Hospital, Du Cane Road, London W12 OHN, England.

Received July 14, 1982; revision accepted October 21, 1982.
Circulation 67, No. 3, 1983.

TABLE 1. *Clinical and Electrocardiographic Findings*

Pt	Age at repair (years)	Age at death (years)	Postoperative ECG	Arrhythmia	Symptoms
1*	11	13	RBBB	0	0
2*	8	17	RBBB	VPCs	Palpitation, syncope
3*	16	25	RBBB	0	0
4	11	12	RBBB	0	0
5	13	20	RBBB	0	Palpitation
6	14	19	RBBB + LAD	VPCs	Syncope

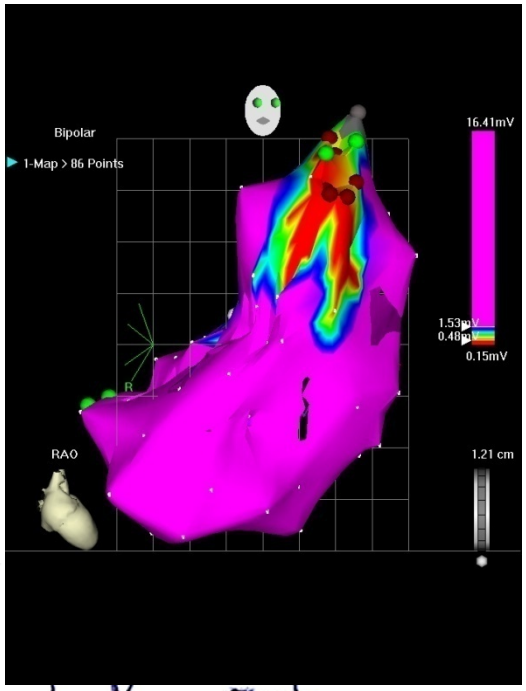
*Hearts studied at necropsy.

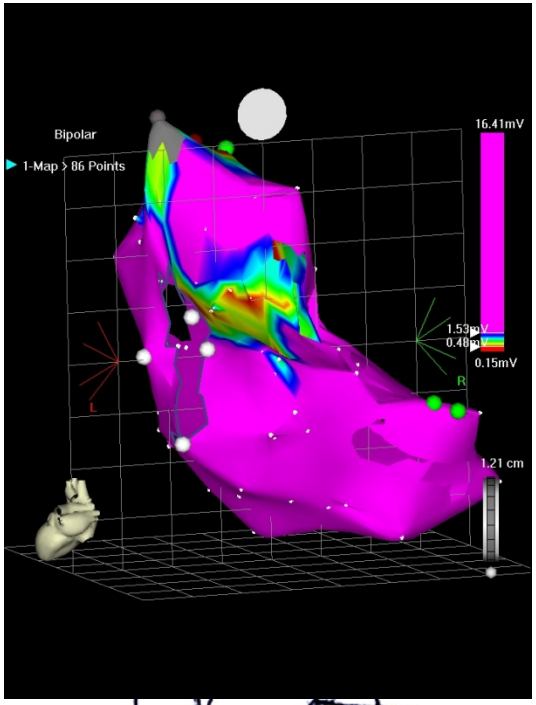
Abbreviations: RBBB = right bundle branch block; LAD = left-axis deviation; VPC = ventricular premature complex.

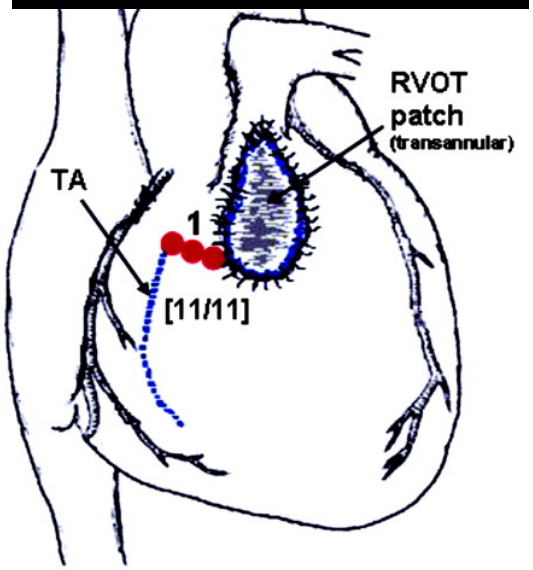
TABLE 3. *Distribution of Myocardial Fibrosis*

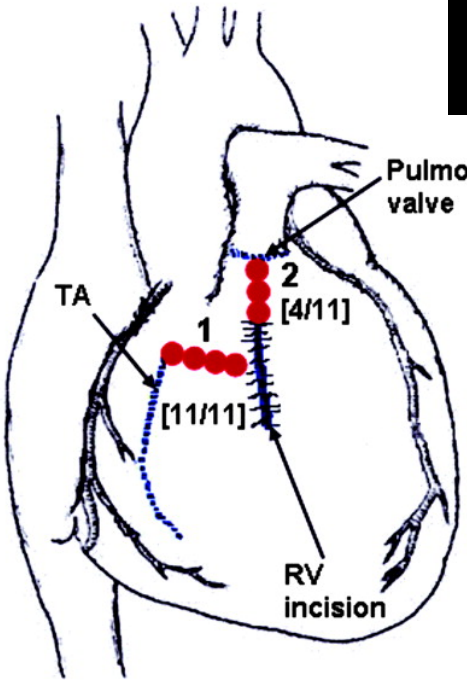
	Right ventricle				Left ventricle
Pt	Ventriculotomy site	Septum	Outflow	Free wall	Free wall
1	+ + +	+ + +	+	+ +	0
2	+ + +	+	+ + +	+	0
3	+ + +	+	+	+ +	0

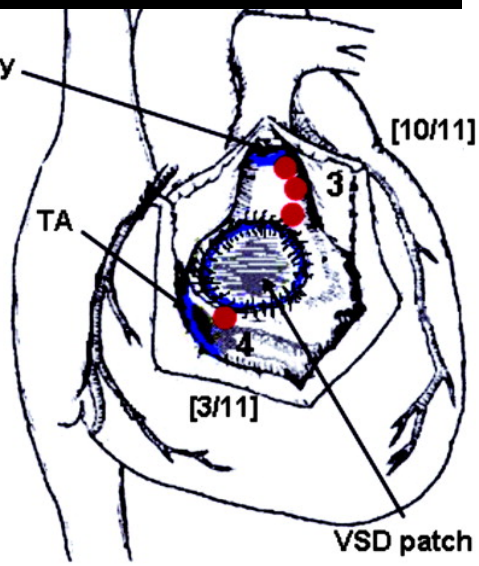
Abbreviations: + = mild fibrosis; + + = moderate fibrosis; + + + = severe fibrosis; 0 = normal.





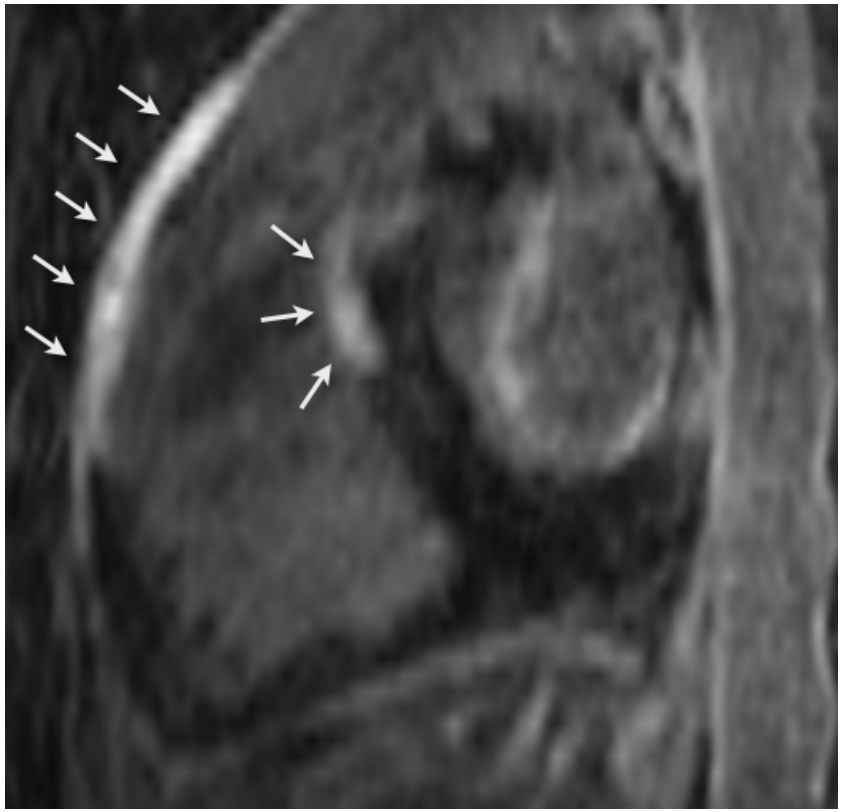


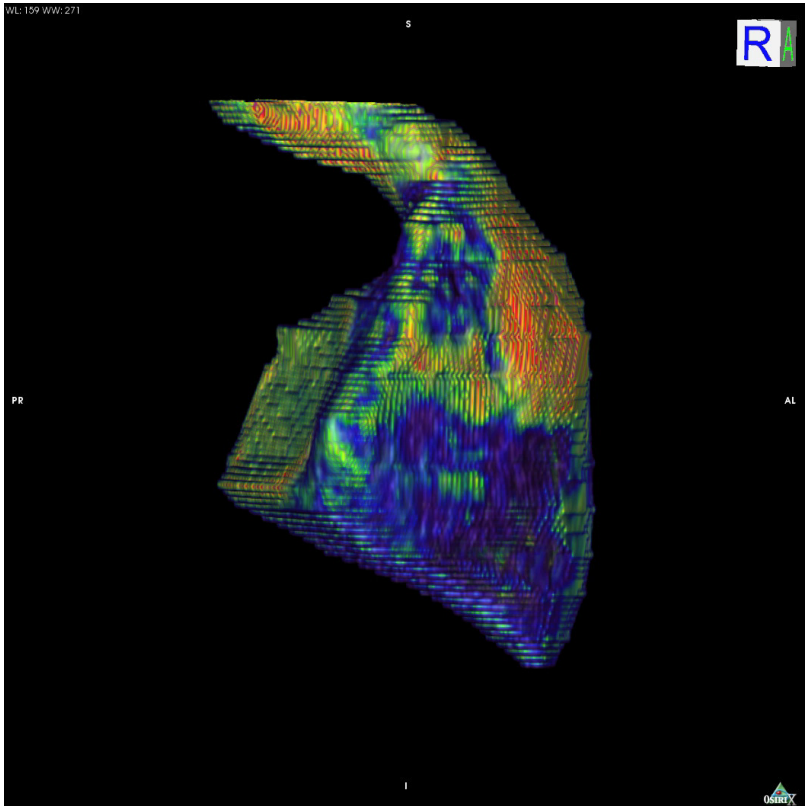




Zeppenfeld, K. et al. Circulation 2007;116:2241-2252

Tétralogie de Fallot: réparation chirurgicale

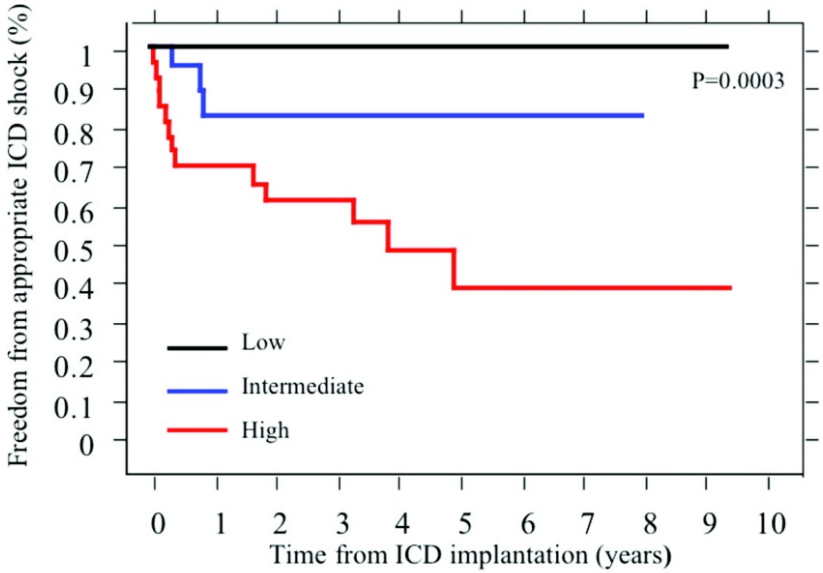




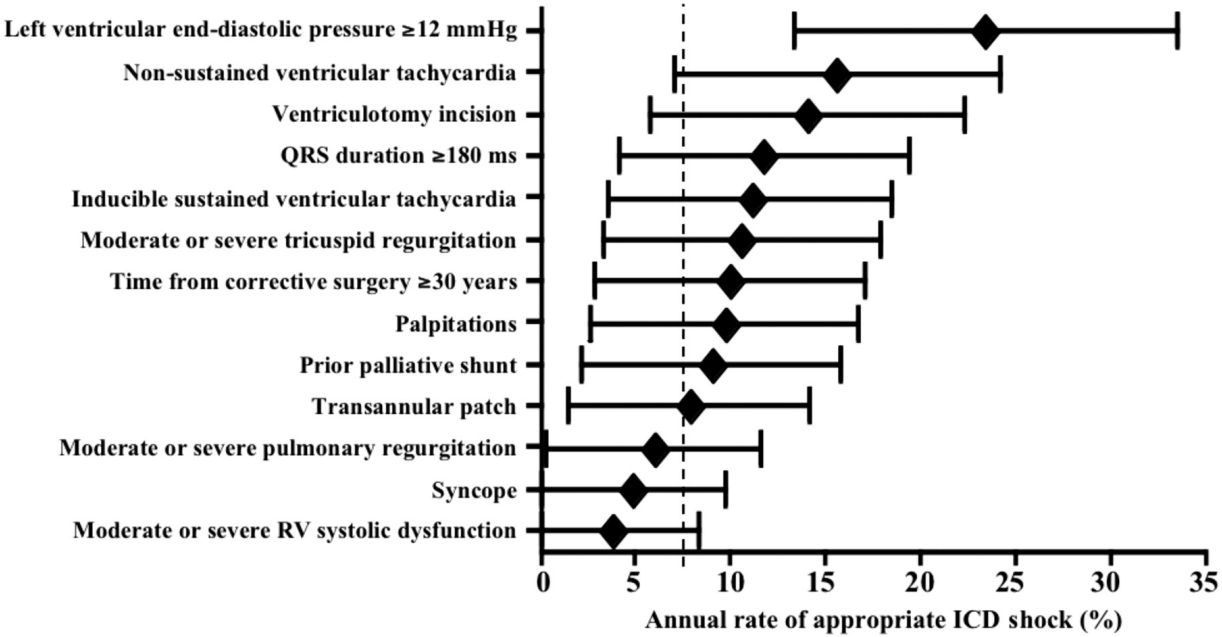
Risk Score for Appropriate ICD Shocks in Primary Prevention

Prior palliative shunt	2
Inducible sustained ventricular tachycardia	2
QRS duration ≥ 180 ms	1
Ventriculotomy incision	2
Nonsustained ventricular tachycardia	2
LVEDP ≥ 12 mm Hg	3
Total points	0–12

Freedom from appropriate ICD shocks in primary prevention according to risk category



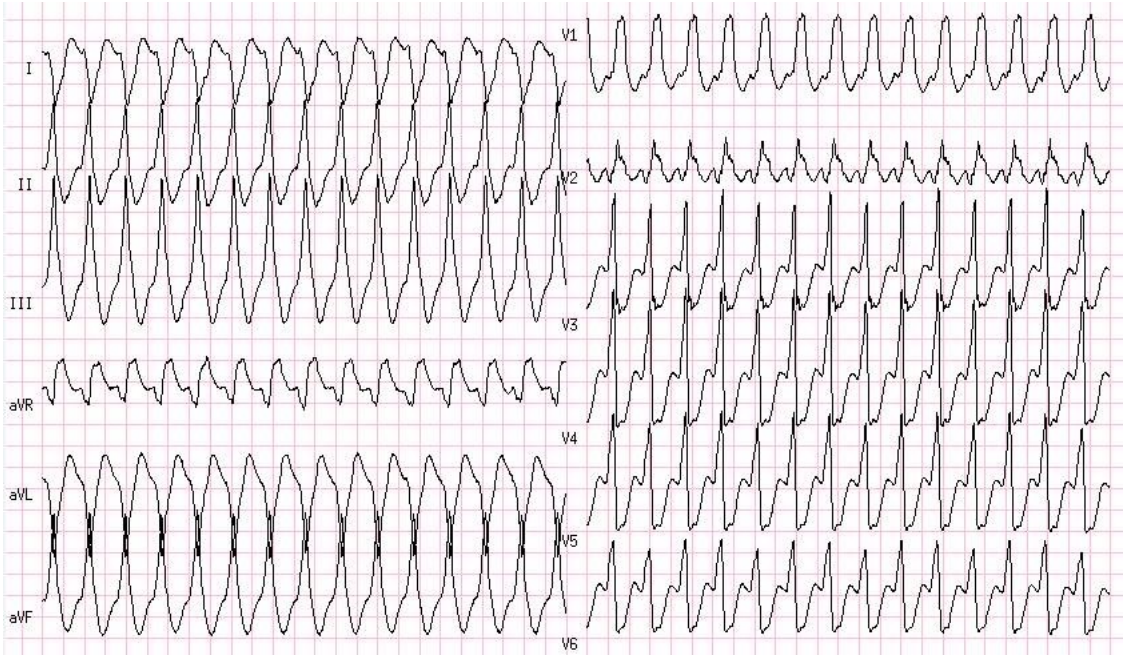
Risk score	Risk category	N	Annualized rate of appropriate shocks
0-2	Low	18	0%
3-5	Intermediate	24	3.8%
6-12	High	26	17.5%

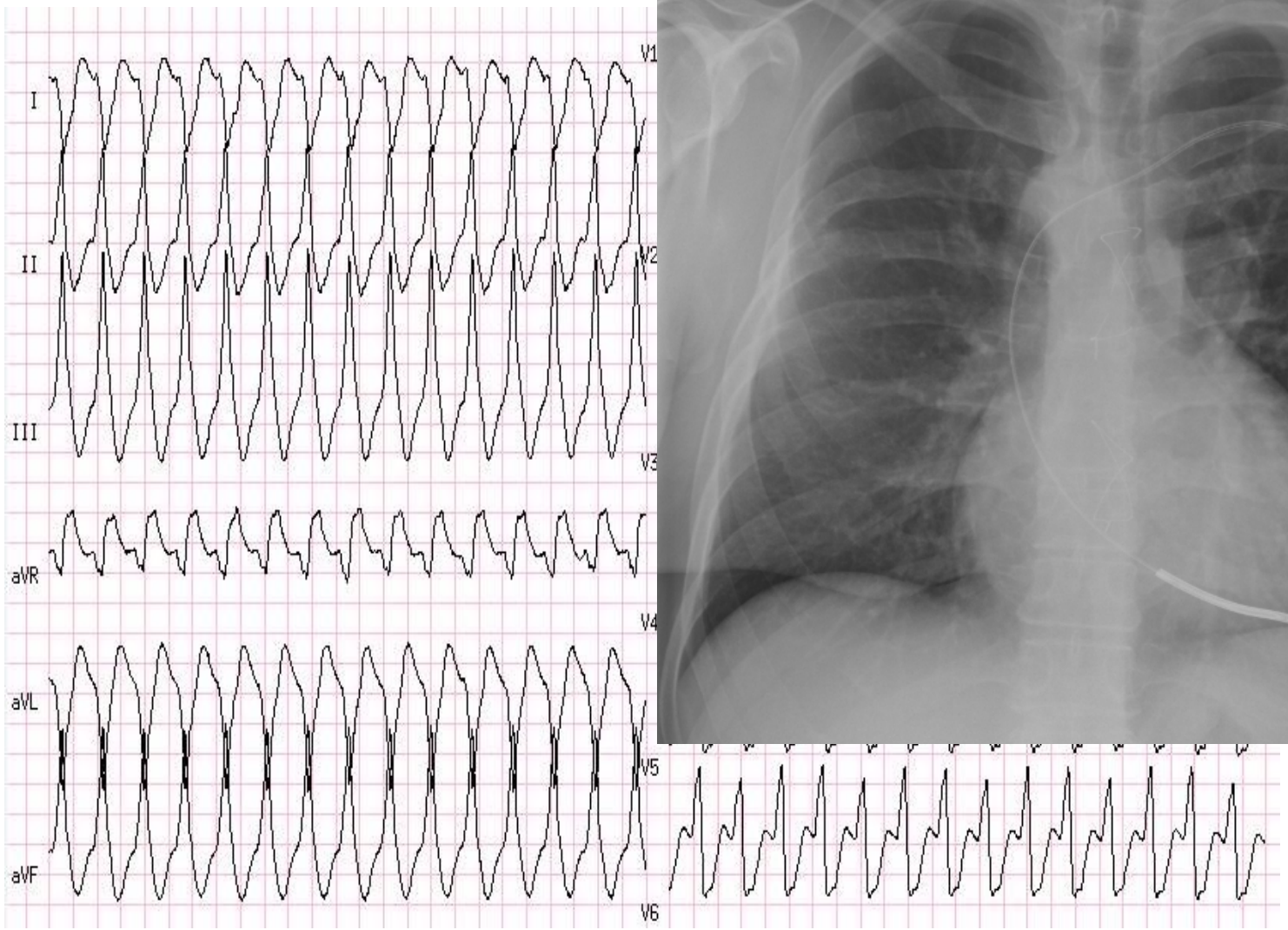


Khairy P.Circulation 2008

Actualité dans la Tétralogie de Fallot
Prise en charge

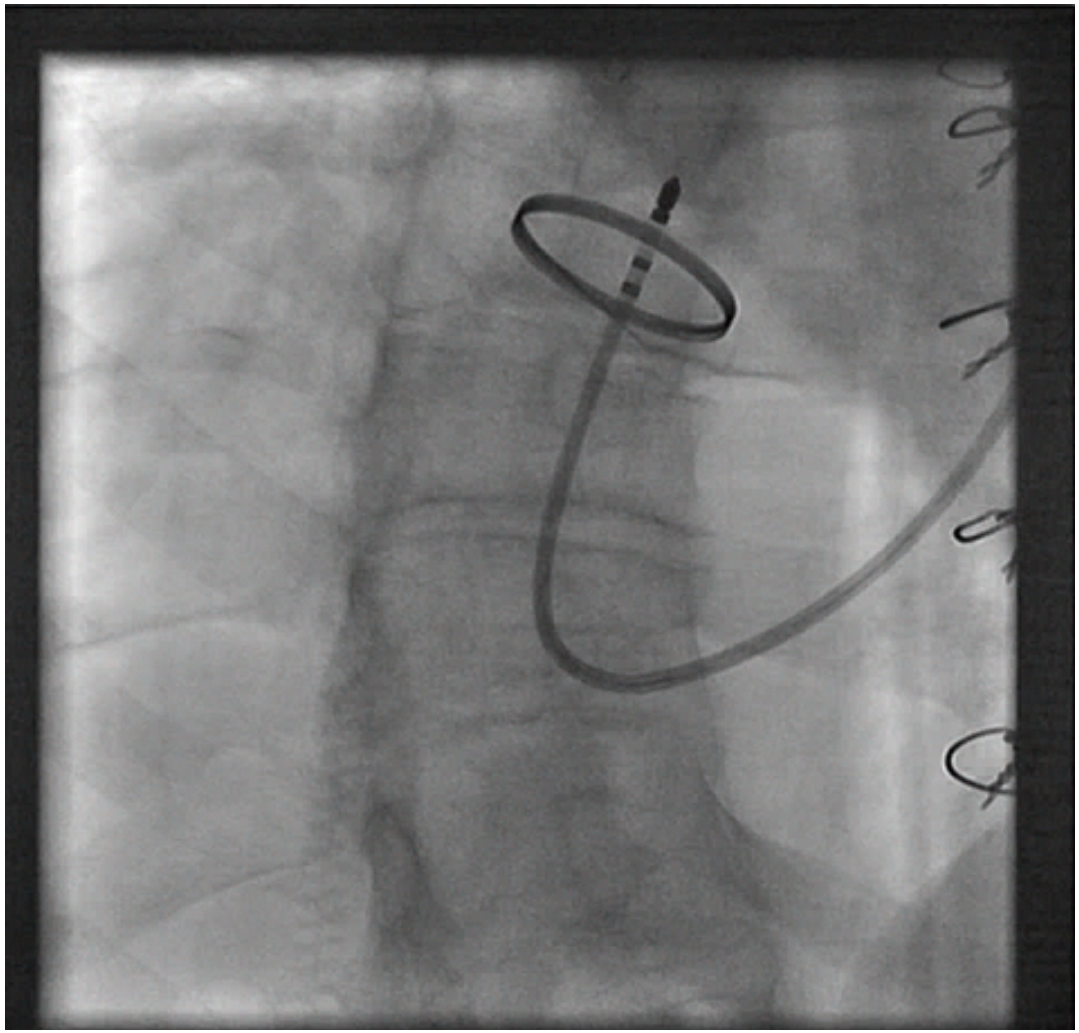
Patient de 20 ans, Fallot opéré puis RVAo
ATCD de malaises sans PCI
Nombreuses ESV au Holter

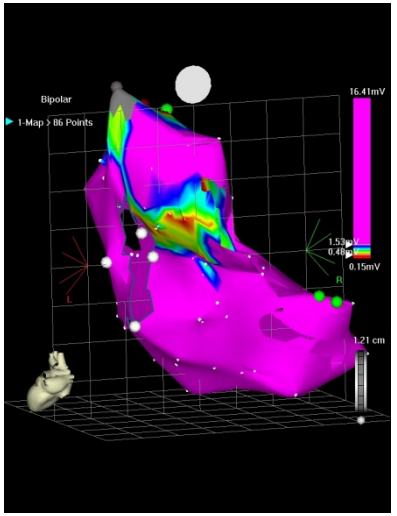


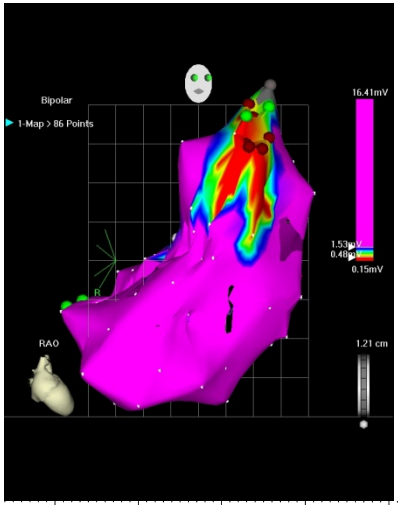

I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6

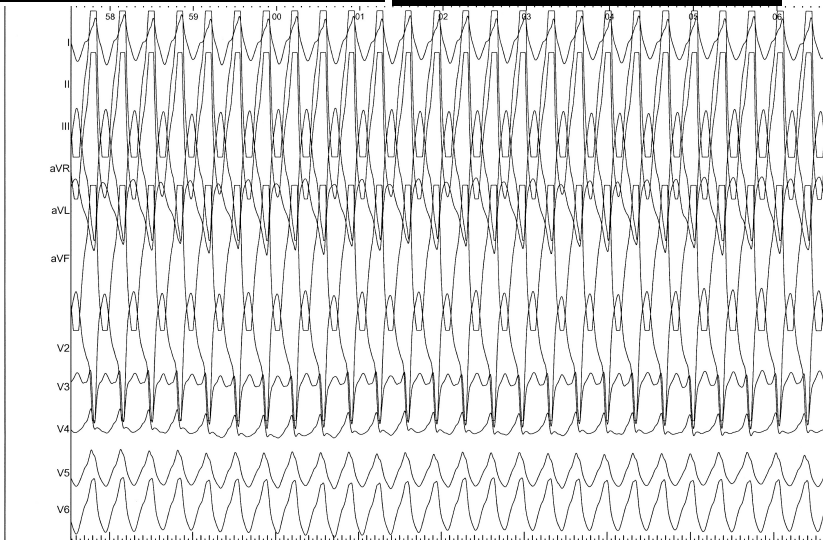
1) L’ablation par RF pour

Traiter les troubles du rythme ventriculaires







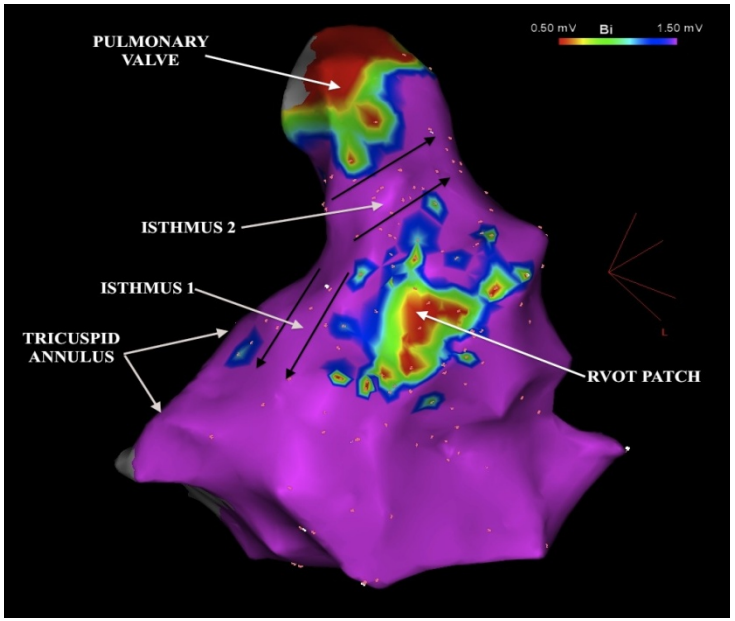


2) L’ablation par RF pour

Traiter les zones à risques avant survenue évènements rythmiques

Patients opérés d’une TF possèdent tous un substrat arythmogéne

- Le temps et l’altération des conditions hémodynamiques induisent une fibrose ralentissant la conduction dans les isthmes anatomiques, favorisant les TV
- Vitesse de conduction < 0,4 m/s au sein d’un isthme prédictive de TV inductible



Z Jalal HRS 2012

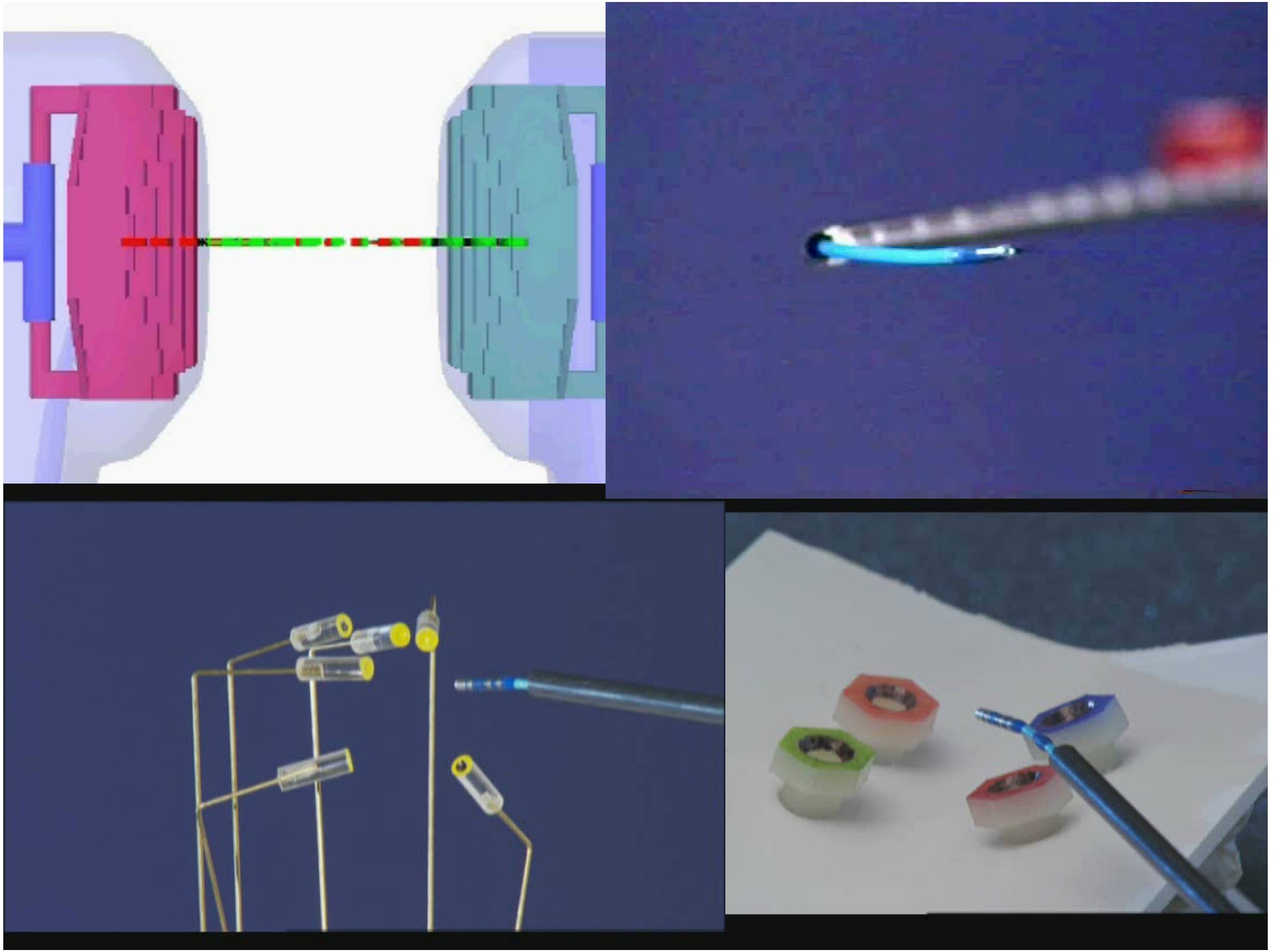
RF + cardiopathies congénitales = Difficultés

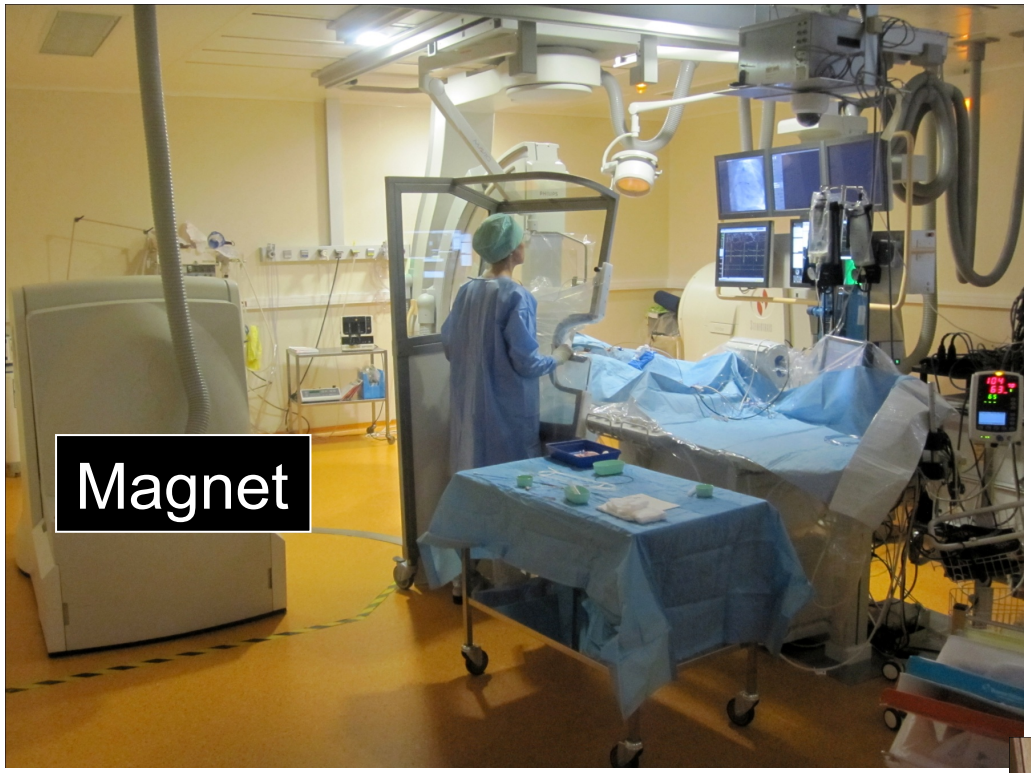
- **Ablation acute success rate is 77-78 % in CHD vs 95 %**

Chetaille, heart rhythm 2004

- **Ablation is challenging**
  - **Issues,**
  - **heart anatomy,**
  - **av node and hiss location ?**

Système Stereotaxis




Magnet

Bien stratifier le risque = Mieux comprendre

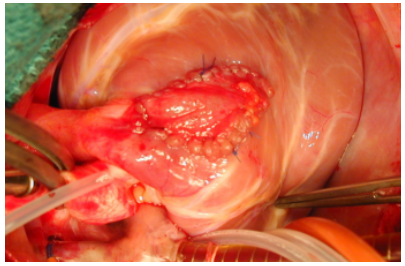
Fallot = Fuite pulmonaire = Mort subite

BBD ?

Interaction VG VD ?

Relation entre TV isthmes et mort subite ?

Fuite pulmonaire



IP

Sténose pulmonaire résiduelle

Surcharge volumique VD

Dilatation du VD

Élargissement du QRS:
« électromécanique »
Arythmie ventriculaire

Interaction VD-VG
-asynchronisme VD-VG
-modification de la courbe P/V

Dilatation de l'anneau tricuspide

Altération fonction VG

Altération fonction VD

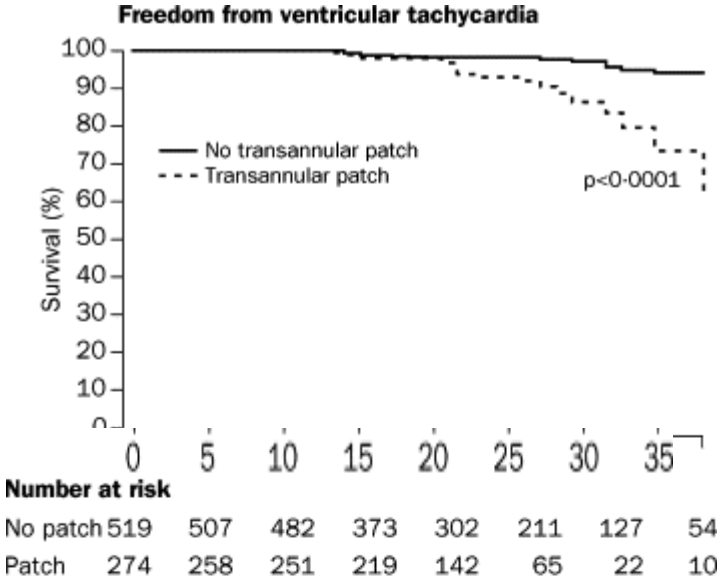
IT

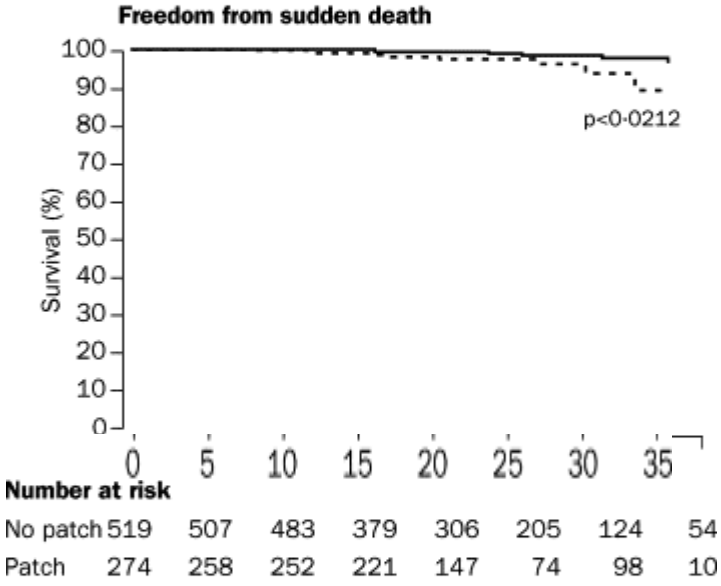
Dilatation de l'OD

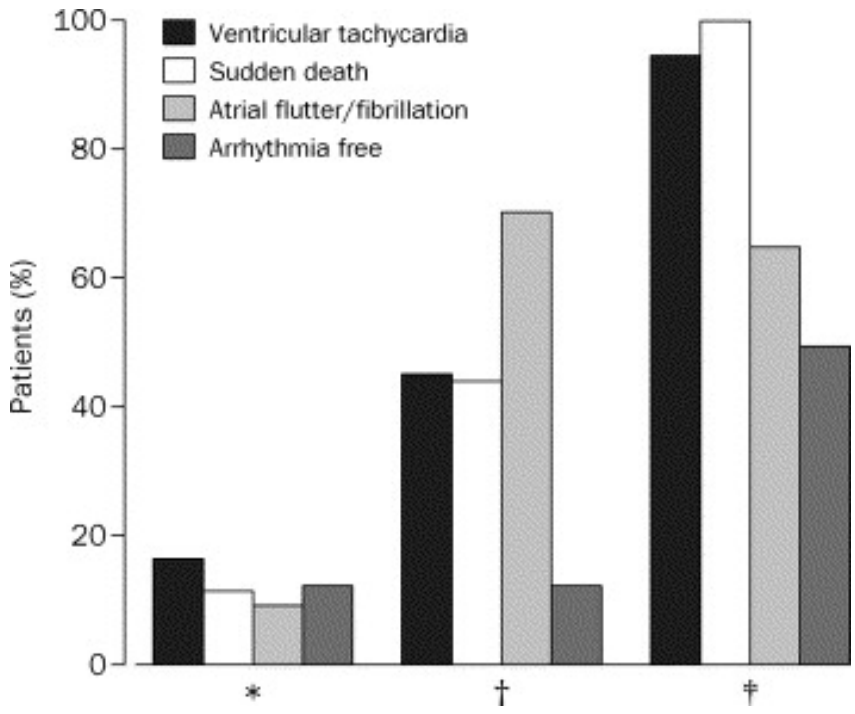
Arythmie auriculaire

Lésion chirugicale (voie trans-atriale)

Fallot/PR/VT - SD







PS
> 60 mmHg

TR
> 2/4

PR
> 2/4

Gatzoulis Lancet 2000

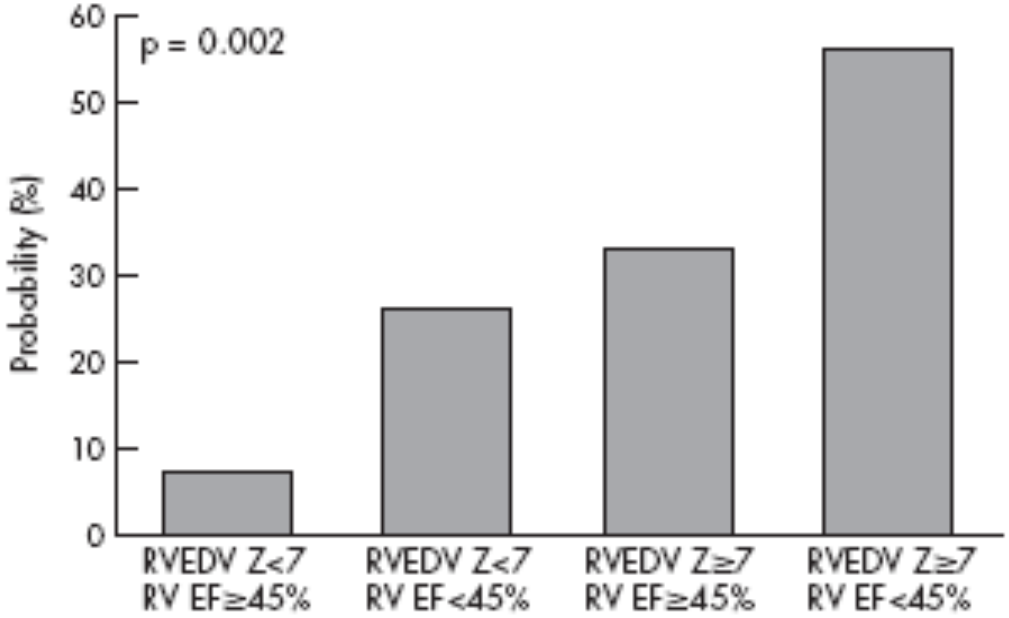


Figure 1 Probability of major adverse clinical outcomes based on multivariate logistic regression model containing right ventricular end-diastolic volume (RVEDV) Z-score and right ventricular ejection fraction (RV EF).

Knauth AL et al *Heart* 2008;94:211-216

Quand remplacer la valve pulmonaire

Optimal Timing for Pulmonary Valve Replacement in Adults After Tetralogy of Fallot Repair

Judith Therrien, MD, Yves Provost, MD, Naeem Merchant, MD, William Williams, MD, Jack Colman, MD, and Gary Webb, MD

Indication opératoire:
-VTD>150ml/m²
-Anévrysme infundibulaire>40mm
-Altération de la fonction VD

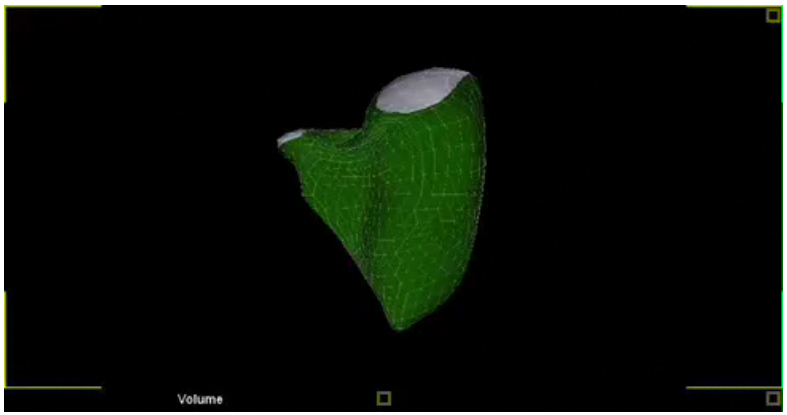
Therrien J. Am J Cardiol 2005

IRM

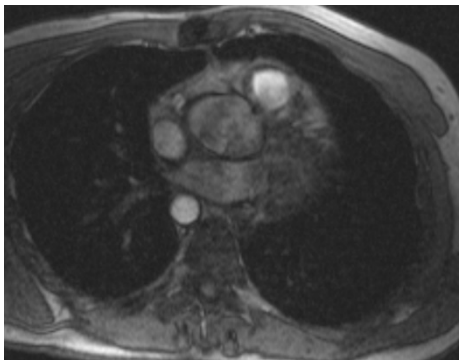
Examen de référence

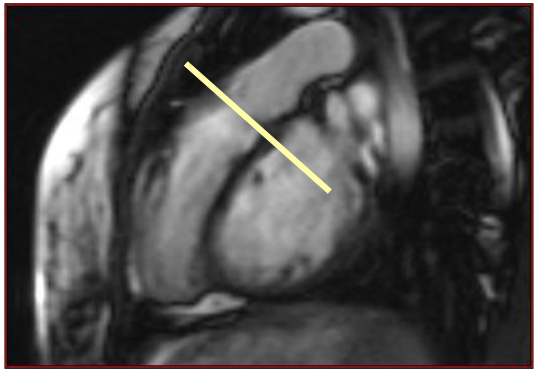
ETT

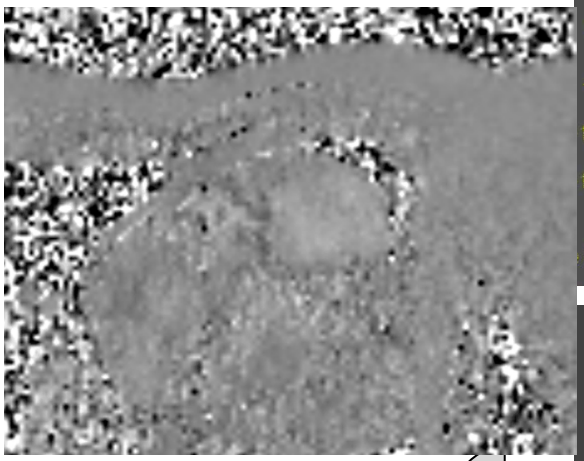
Position rétrosternale
Patients multiopérés
Analyse volumique et fonctionnelle complexe

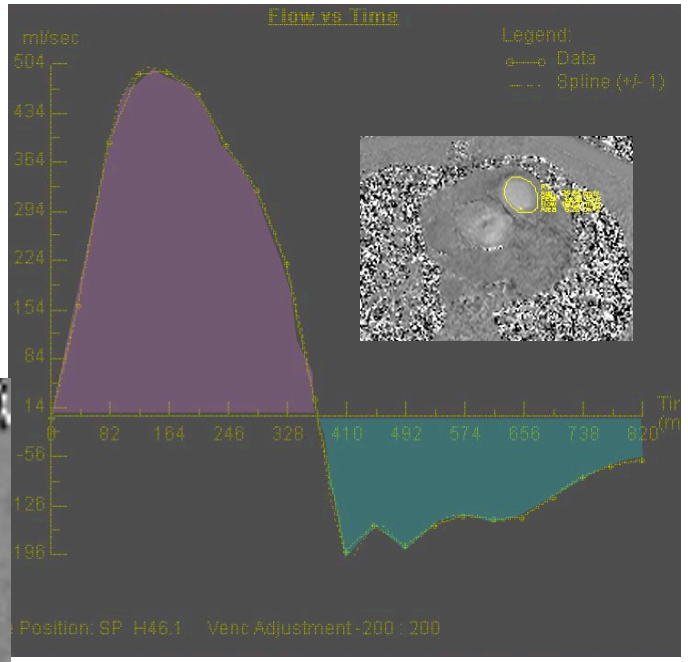


Quantifier l'Insuffisance pulmonaire









Flow		
Average Flow Over Range:	77.15	ml/sec
Average Flow Per Minute:	3.69	l/min
Forward Volume:	120.45	ml
Reverse Volume:	57.38	ml
Net Forward Volume:	63.07	ml
Net Forward Volume / BSA:	---	ml/m^2

Right Ventricle - Normalized				
Cardiac Function			Normal Range (F) (MRI)	Units
End Diastolic Volume	EDV	134.2	48.00 ... 87.00	ml/m^2
End Systolic Volume	ESV	70.9	11.01 ... 27.60	ml/m^2

$$\text{Fraction de Régurgitation} = \frac{\text{Forward Volume}}{\text{Reverse Volume}}$$

IP sévère (>40%)

Pulmonary Valve Replacement in Tetralogy of Fallot
Impact on Survival and Ventricular Tachycardia

David M. Harrild, MD, PhD; Charles I. Berul, MD; Frank Cecchin, MD; Tal Geva, MD; Kimberlee Gauvreau, ScD; Frank Pigula, MD; Edward P. Walsh, MD

Background—Pulmonary valve replacement (PVR) in repaired tetralogy of Fallot (TOF) reduces pulmonary regurgitation and decreases right ventricular (RV) dilation, but its long-term impact on ventricular tachycardia (VT) and mortality is unknown. This study aimed to determine the incidence of death and VT in TOF after PVR and to test the hypothesis that PVR leads to improvement in these outcomes.

Methods and Results—A total of 98 patients with TOF and late PVR for RV dilation were identified. Matched control subjects were identified for 77 of these patients; control subjects had TOF with RV dilation but no PVR. Matching was done by age (±2 years) and baseline QRS duration (±30 ms). No significant differences were found in age, QRS duration, type or decade of initial repair, age at TOF repair, or presence of pre-PVR VT between the 2 groups; limited echocardiographic and magnetic resonance imaging data showed no difference in left ventricular function but more RV dilation among PVR patients than control subjects. In the PVR group, 13 events occurred over 272 patient-years. No significant change in QRS duration was seen for any group. Overall 5- and 10-year freedom from death, VT, or both was 80% and 41%, respectively. In the matched comparison, no significant differences were seen in VT, death, or combined VT and/or death ($P=0.32$, $P=0.06$ [nearly favoring controls], and $P=0.21$).

Conclusions—This cohort experienced either VT or death every 20 patient-years. In a matched comparison with a similar TOF group, late PVR for symptomatic pulmonary regurgitation/RV dilation did not reduce the incidence of VT or death.
(*Circulation*. 2009;119:445-451.)

Follow-Up After Pulmonary Valve Replacement in Adults With Tetralogy of Fallot

Association Between QRS Duration and Outcome

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Olivier Wijers, MSc,* Cees A. Swenne, PhD,* Ernst E. van der Wall, MD, PhD,*
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Leiden, Amsterdam, and Utrecht, the Netherlands

Objectives The aim of this study was to analyze whether QRS duration, before and after pulmonary valve replacement (PVR), is related to long-term outcome in patients with tetralogy of Fallot (TOF).

Background Key factors that determine outcome after PVR in adult TOF patients are largely unknown. Recognition of such factors assists the identification of patients at increased risk of adverse events.

Methods Adults who previously underwent total correction for TOF ($n = 90$; age 31.4 ± 10.3 years) and required PVR for pulmonary regurgitation were included. The QRS duration was measured pre-operatively and 6 months after PVR. The post-operative changes in QRS duration were calculated. Adverse events (death, re-PVR, ventricular tachycardia, and symptomatic heart failure) were noted during follow-up.

Results During 5.5 ± 3.5 years of follow-up, 13 adverse events occurred. The 5-year event-free survival rate was 76% for patients with a pre-operative QRS duration >180 ms and 90% in patients with a QRS duration ≤180 ms ($p = 0.037$). For patients with a post-operative QRS duration >180 ms, 5-year event-free survival was 71%, whereas it was 91% for patients with a post-operative QRS duration ≤180 ms ($p = 0.004$). After multivariate correction, a post-operative QRS duration >180 ms (hazard ratio: 3.685, 95% confidence interval: 1.104 to 12.304, $p < 0.05$) and the absence of a reduction in QRS duration post-PVR (hazard ratio: 6.767, 95% confidence interval: 1.704 to 26.878, $p < 0.01$), was significantly associated with adverse outcome.

Conclusions Severe QRS prolongation, before or after PVR, and the absence of a reduction in QRS duration after PVR, are major determinants of adverse outcome during long-term follow-up of patients with TOF. (J Am Coll Cardiol 2010;56:1486–92)

Interaction VD/VG

Multicenter Case-Control Study of Ventricular Arrhythmias in Tetralogy of Fallot

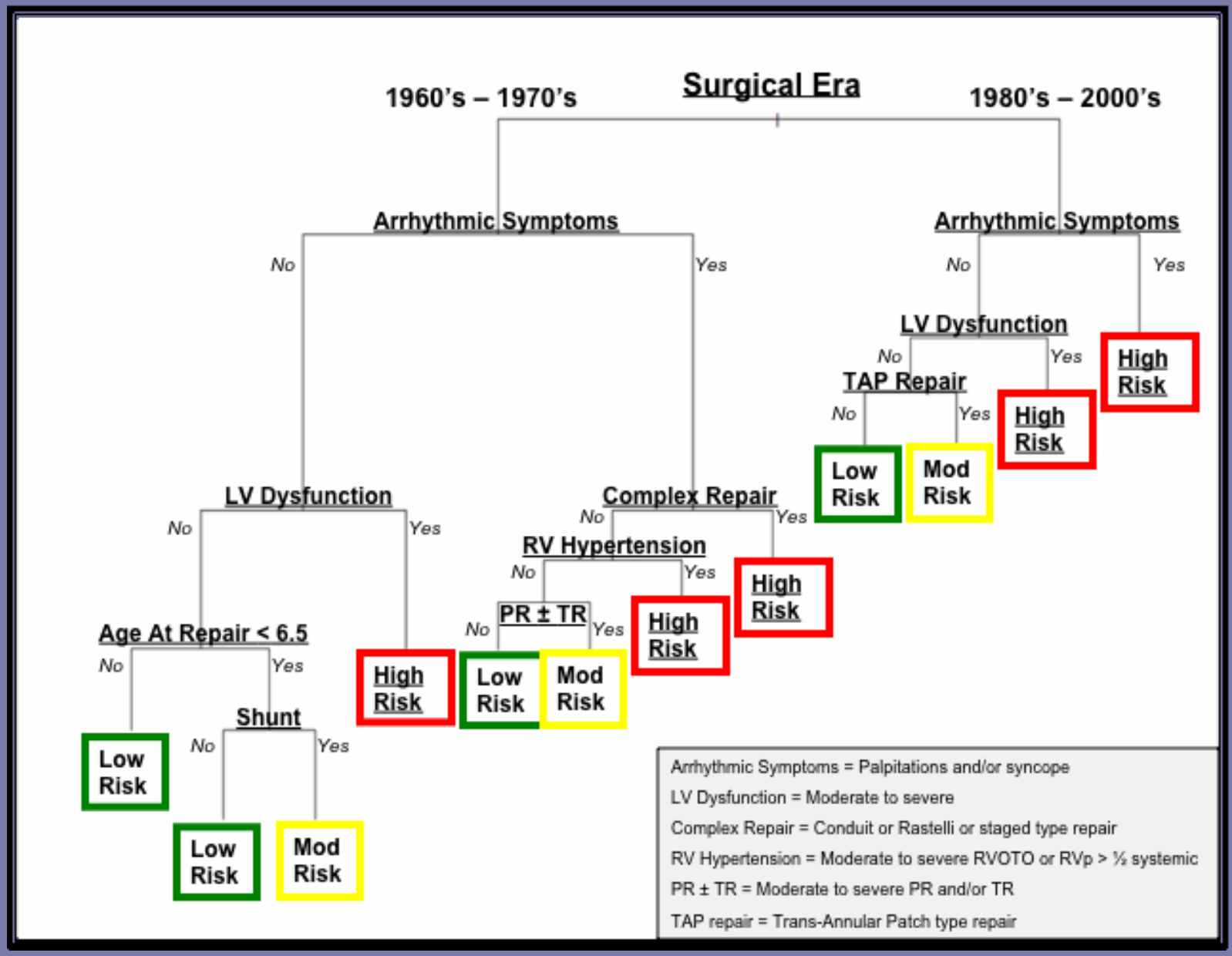
72 Cases + 216 Controls

Mean age at EVENT: 27.1 ± 12.3 years

Event Type	N (%)
Sudden Death	9 (12%)
Resuscitated Cardiac Arrest	15 (21%)
Sustained Ventricular Arrhythmia without arrest	41 (57%)
Appropriate ICD shock	7 (10%)

E Walsh, C Gonzalez, J Atallah,
and Participating Members of PACES

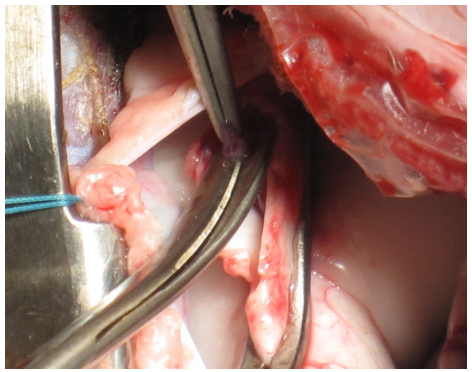
Random Forest Decision Tree

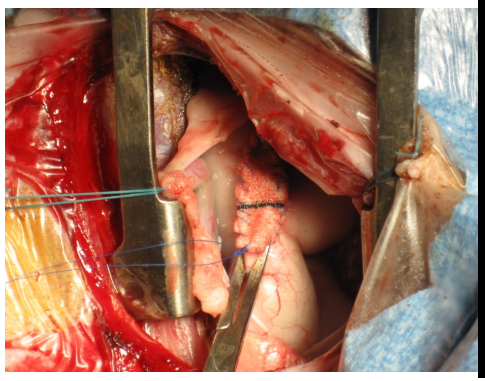


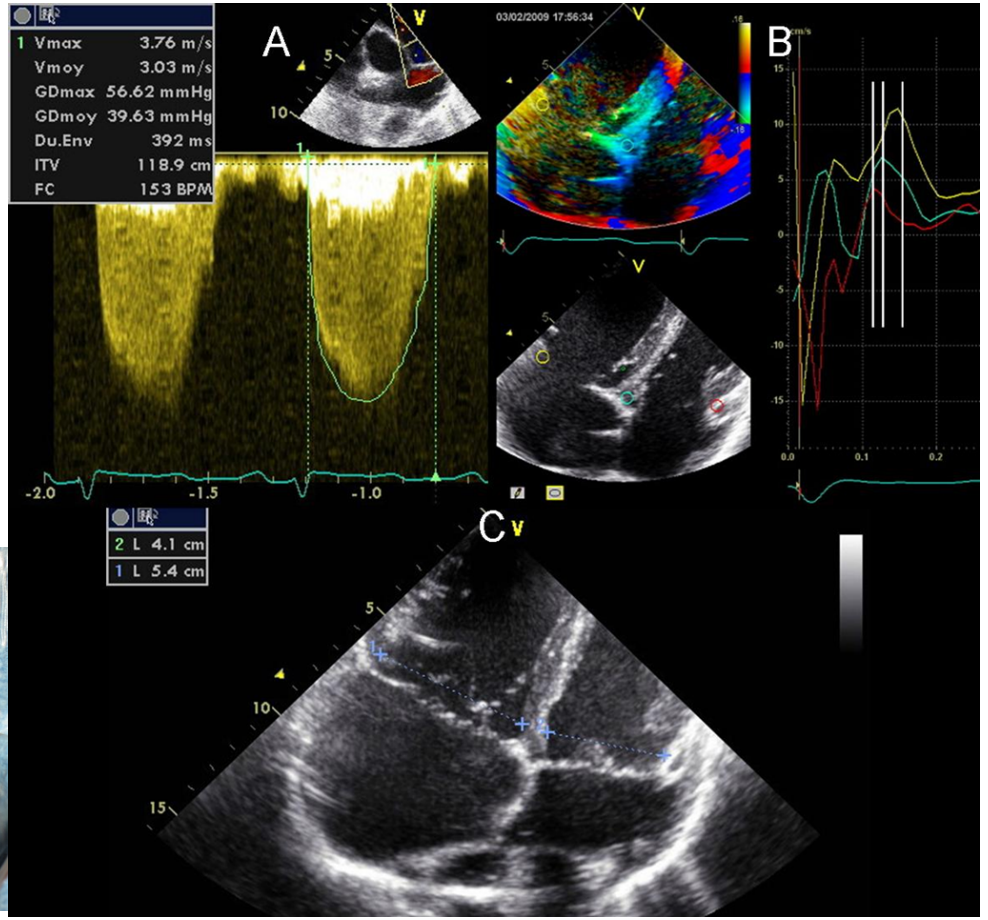
Elaboration et validation du modèle animal

15 cochons nouveau-nés: modèle chronique

- fuite pulmonaire
- sténose pulmonaire
- patch infundibulaire

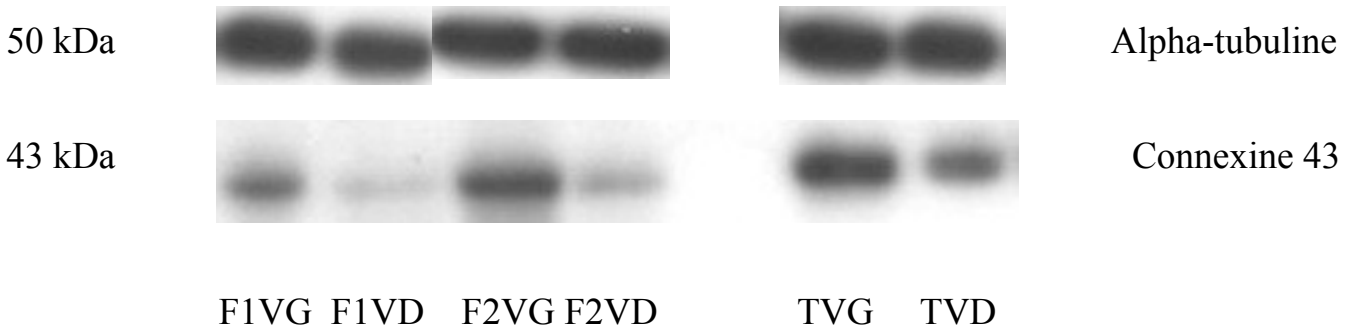






Thambo JB, Int J Cardiol, 2010

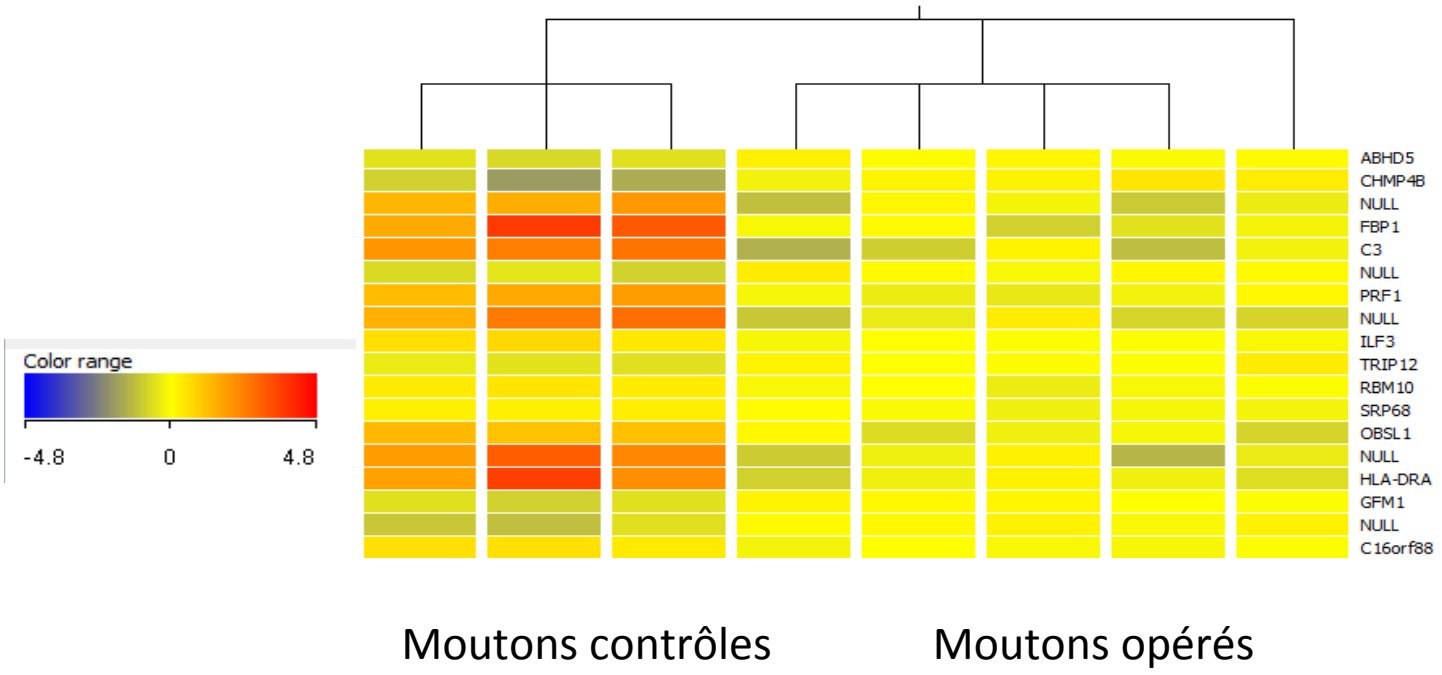
Résultats : Western Blot



Tendance vers une diminution d'expression dans le VD, plus importante chez les cochons du groupe Fallot.

Etude du substrat de l'insuffisance cardiaque et de la mort subite dans T4F

Signature transcriptomique du cœur de mouton défaillant

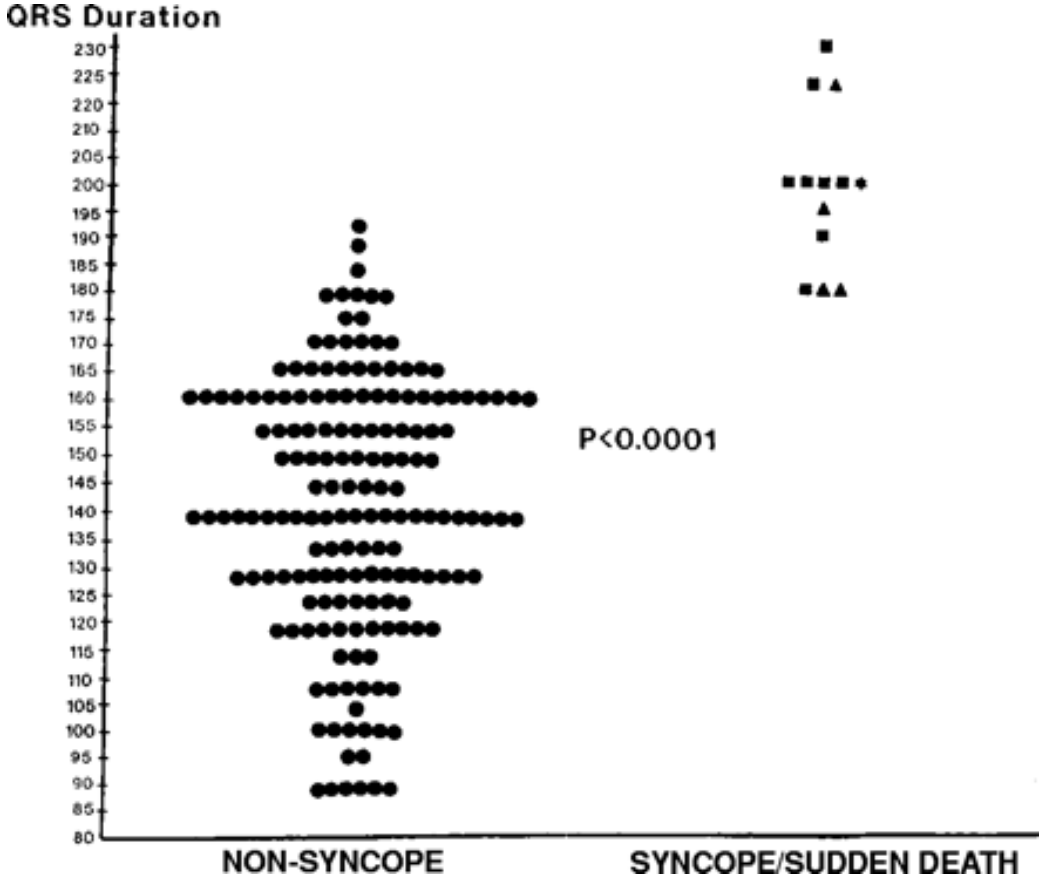


15008 spots d'intérêt sur la puce dont 7700 gènes annotés et 7308 non annotés
209 gènes significativement différents entre les moutons sains et opérés dont 107 gènes annotés

UN EFFET ANTIARYTHMIQUE DE LA RESYNCHRONISATION?

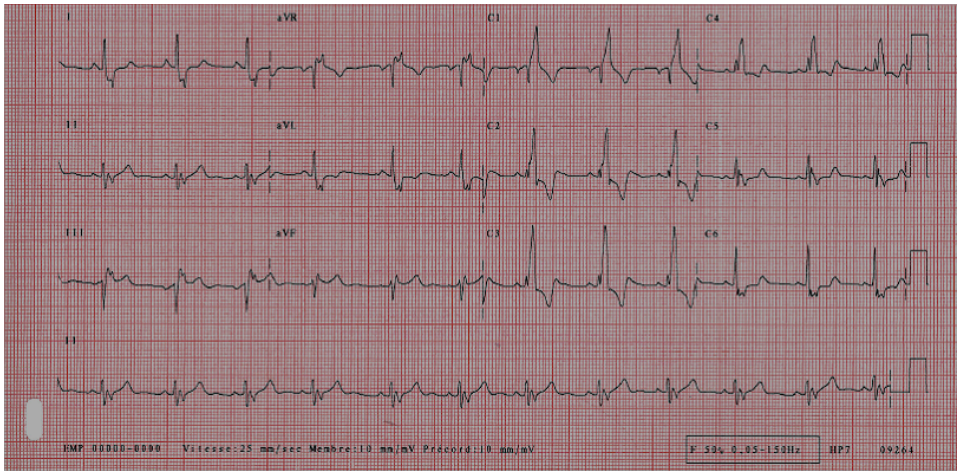
Tétralogie de Fallot

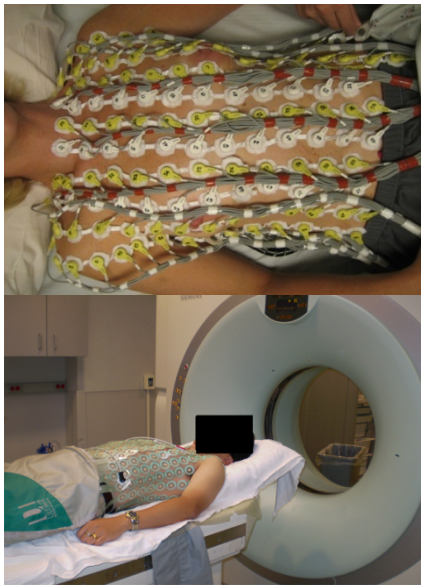
Corrélation largeur du QRS et mort subite

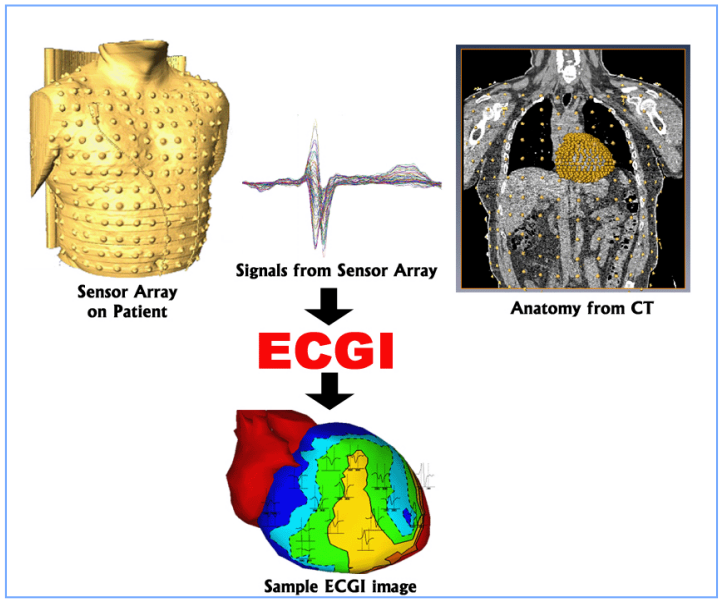


Gatzoulis Circ 1995

Activation électrique dans la tétralogie de Fallot





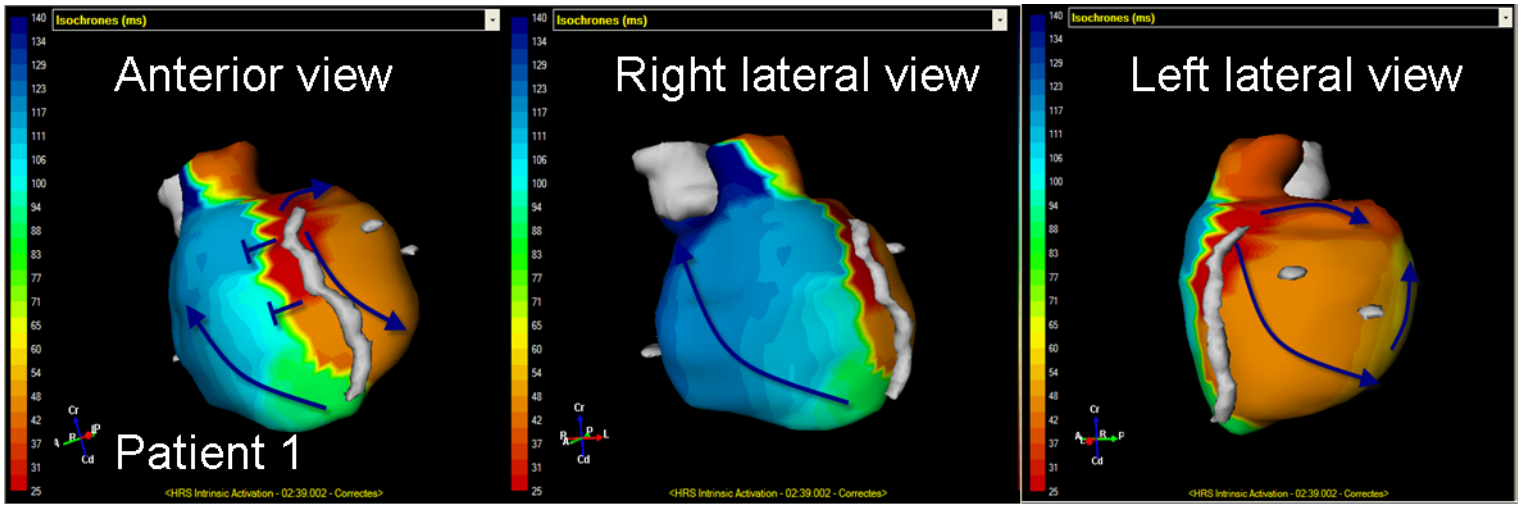


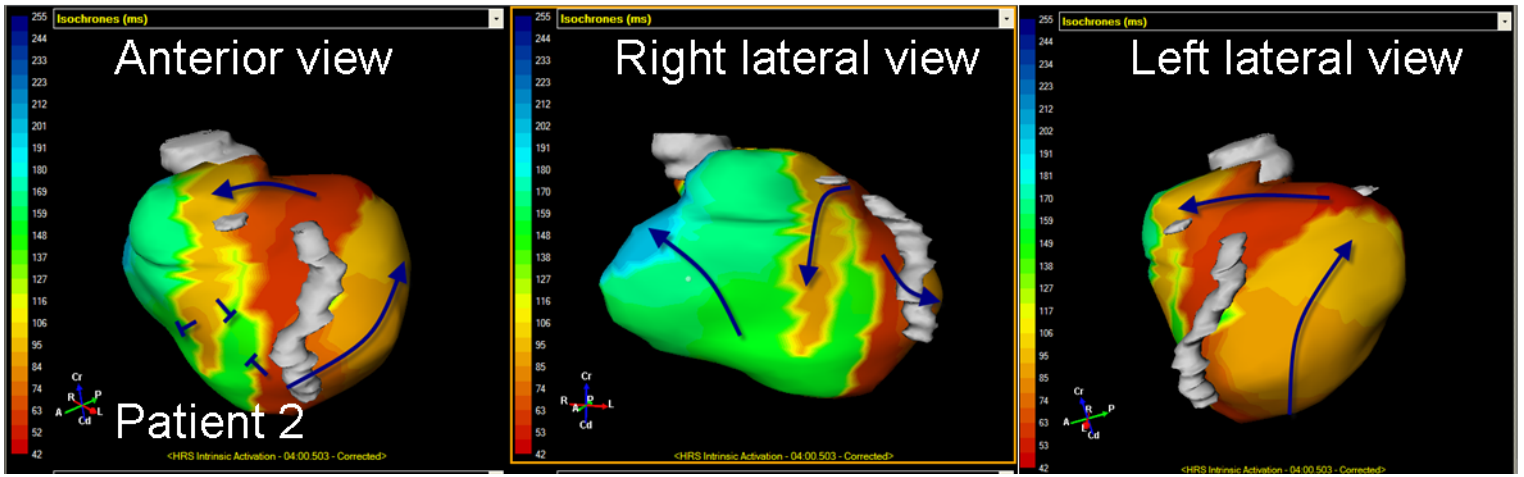
- 9 patients opérés d'une tétralogie de Fallot + CRT(+/-D)
- Utilisation d'un nouveau système de cartographie non invasive :

  le Cardioinsight®, (USA)
- Etude du profil d'activation électrique en RS, VD, BiV

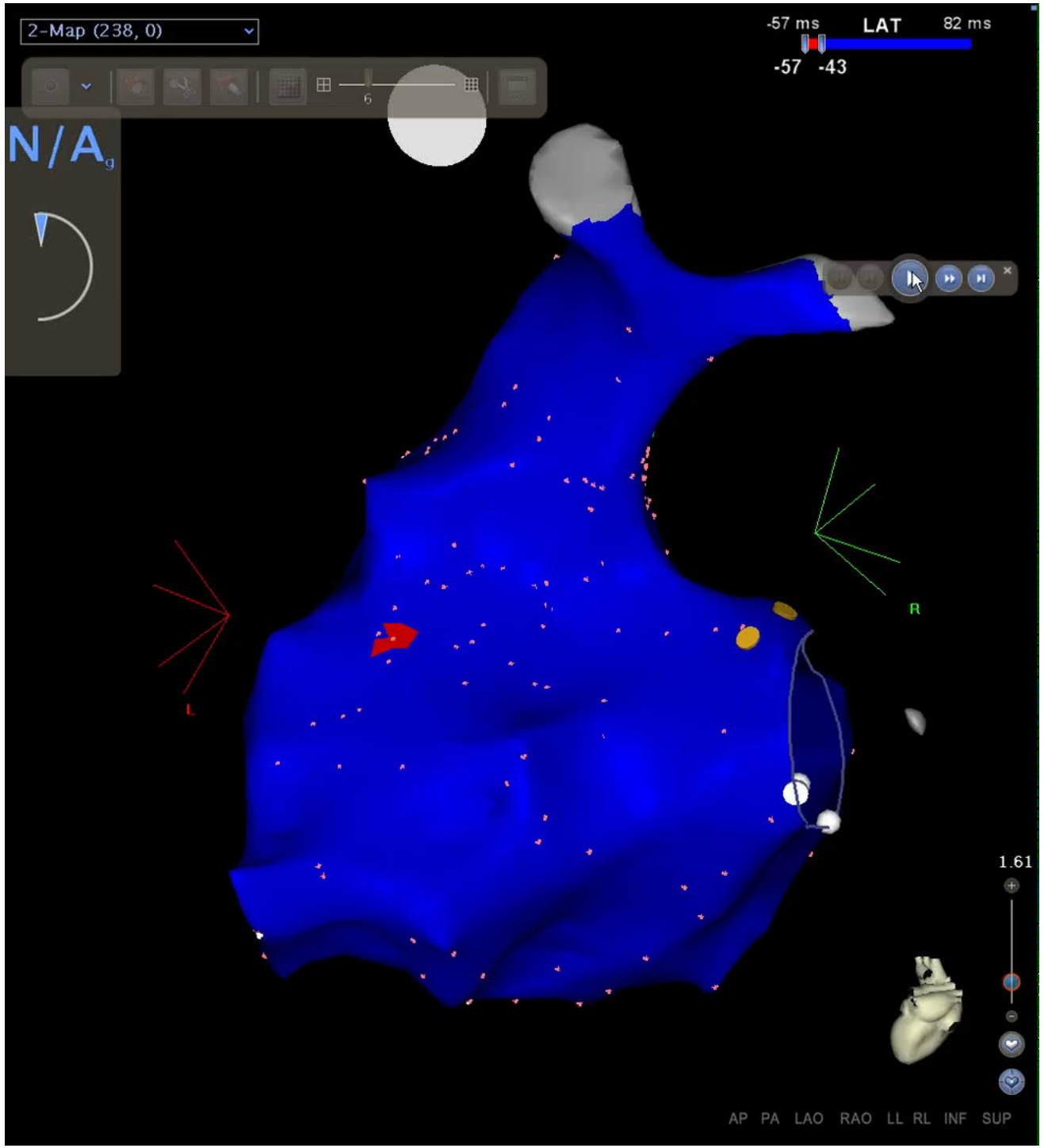
Thambo JB, Int J Cardiol, 2011

Pour le même aspect électrocardiographique, il existe en RS plusieurs profils d‘activation en fonction de la nature et du niveau de bloc.

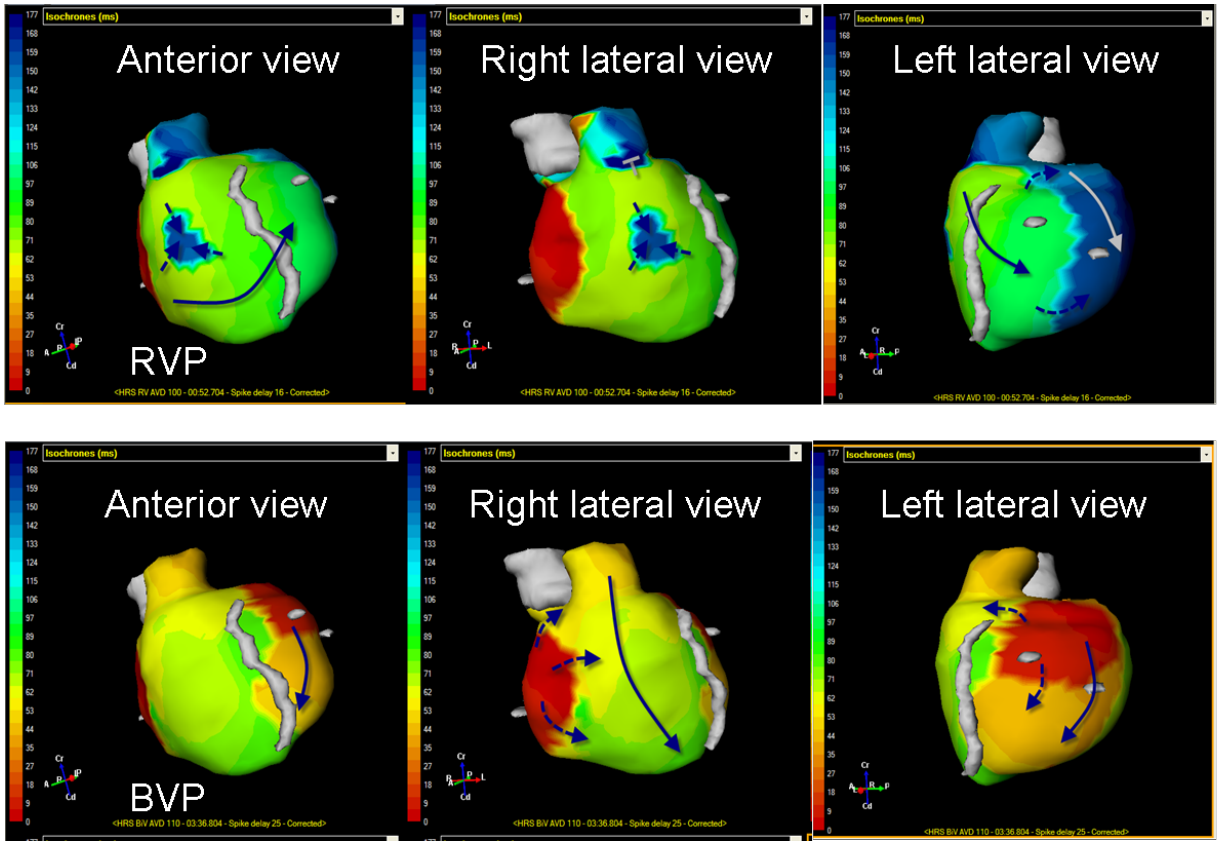




Thambo JB, Int J Cardiol, 2011


2-Map (238, 0)
-57 ms
LAT
82 ms
-57
-43
N/A
R
L
1.61
AP PA LAO RAO LL RL INF SUP

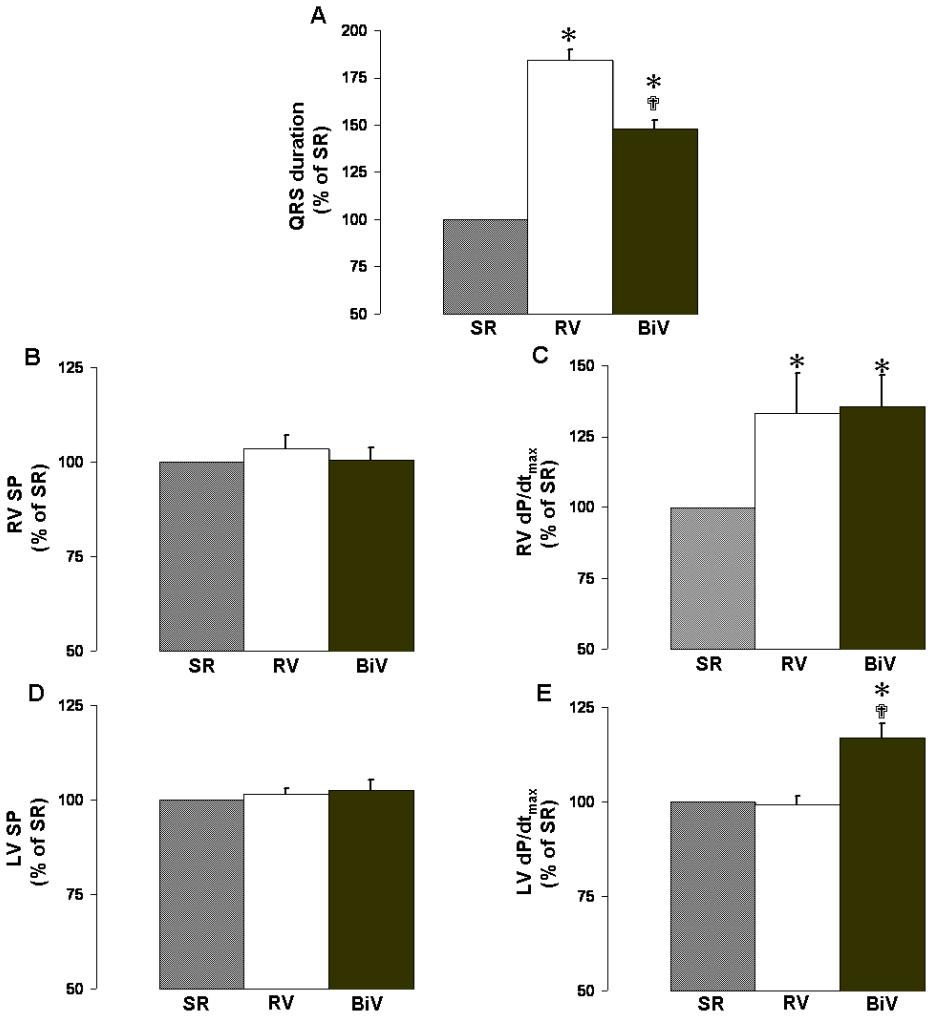
Le temps d'activation globale et les différents index d'asynchronisme sont significativement améliorés (p<0.05) par la stimulation BiV



Thambo JB, Int J Cardiol, 2011

Impact de la resynchronisation chez des patients avec tétralogie de Fallot opérée

- 8 patients
- Bloc de branche droit
- Dysfonction ventriculaire droite
- 1 sonde gauche
- 1 sonde droite

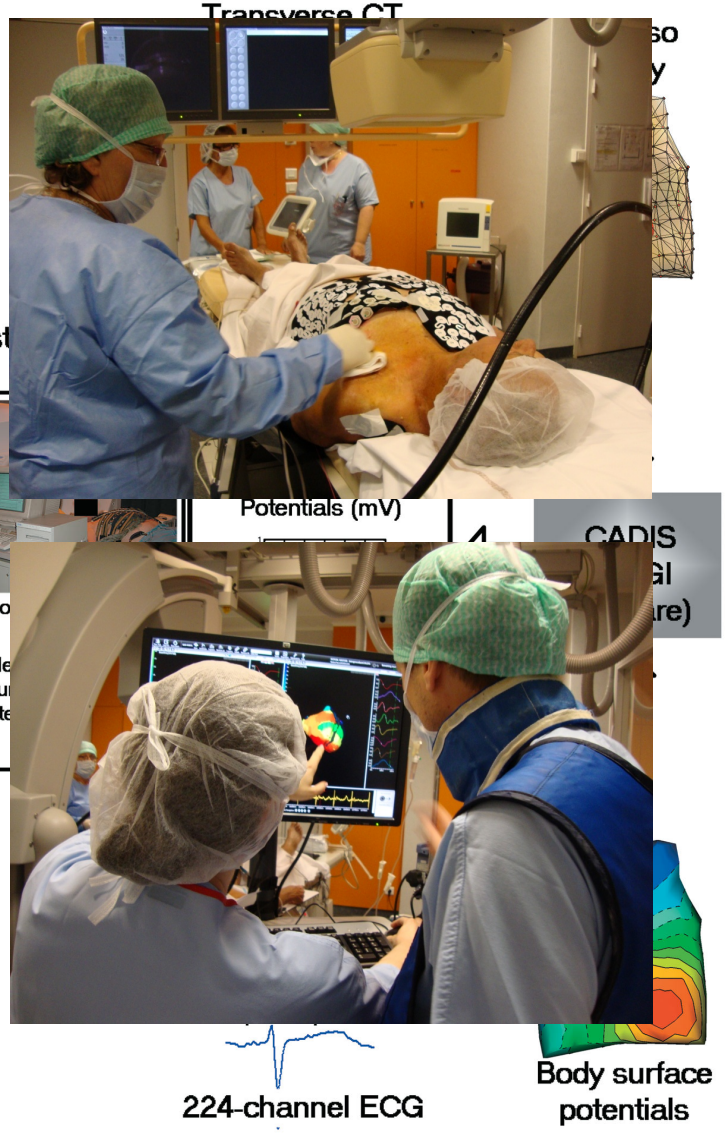


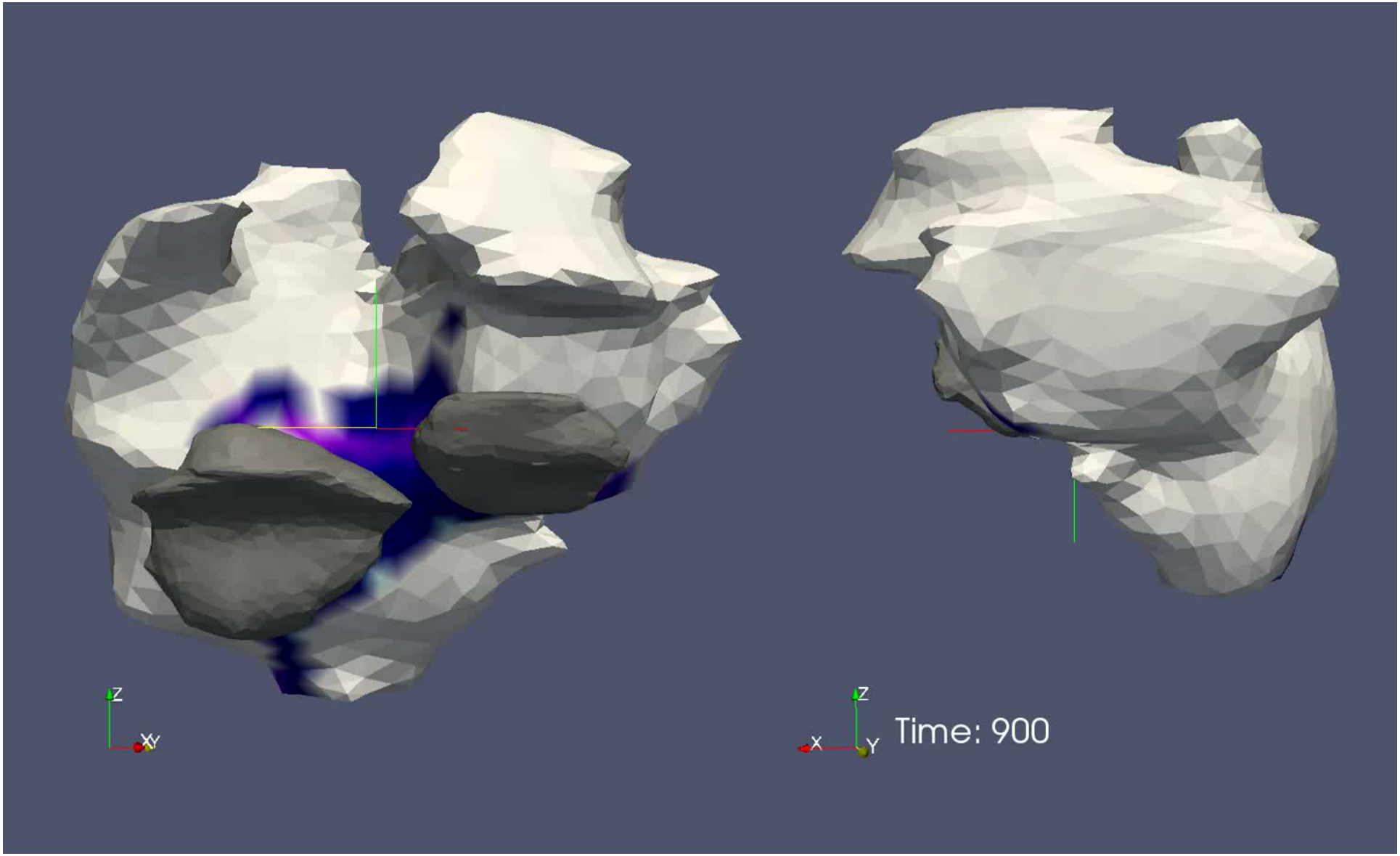
Thambo JB, Heart Rhythm, 2010

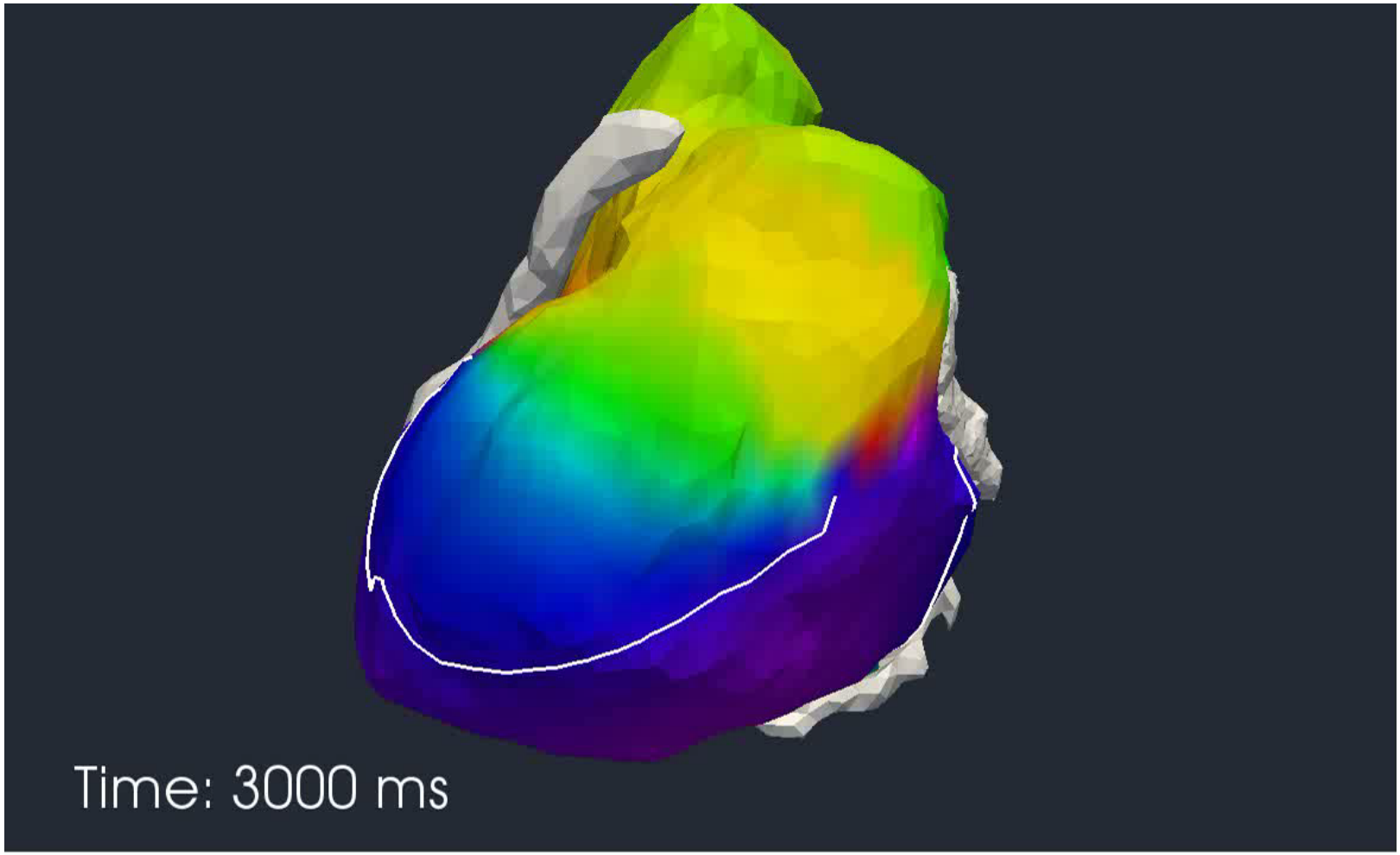
Mieux comprendre pour mieux traiter

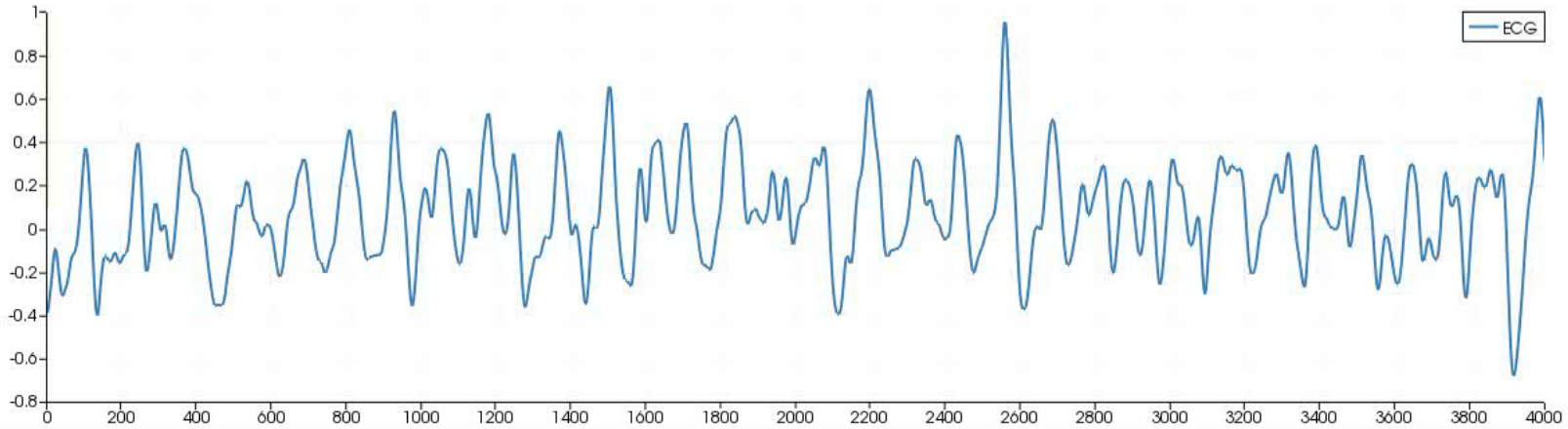
Noninvasive Electrocardiographic Imaging to optimize selection/implantation for CRT

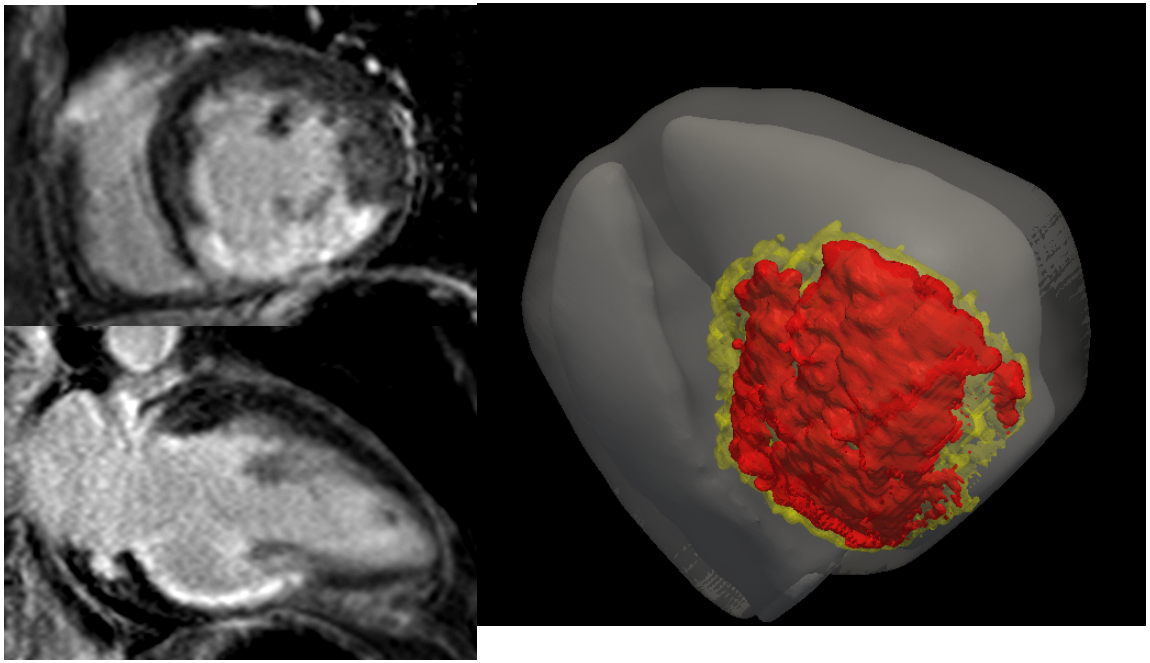
cardioInsight

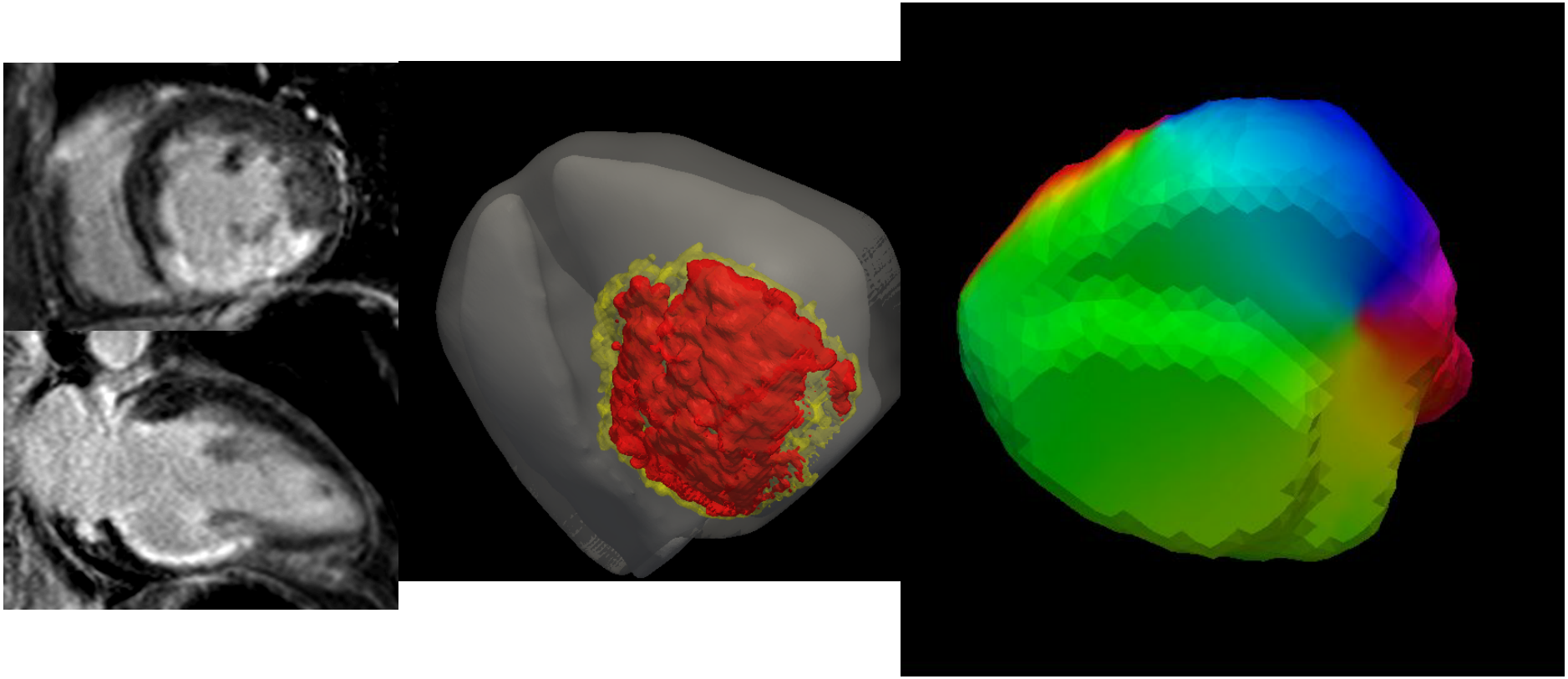


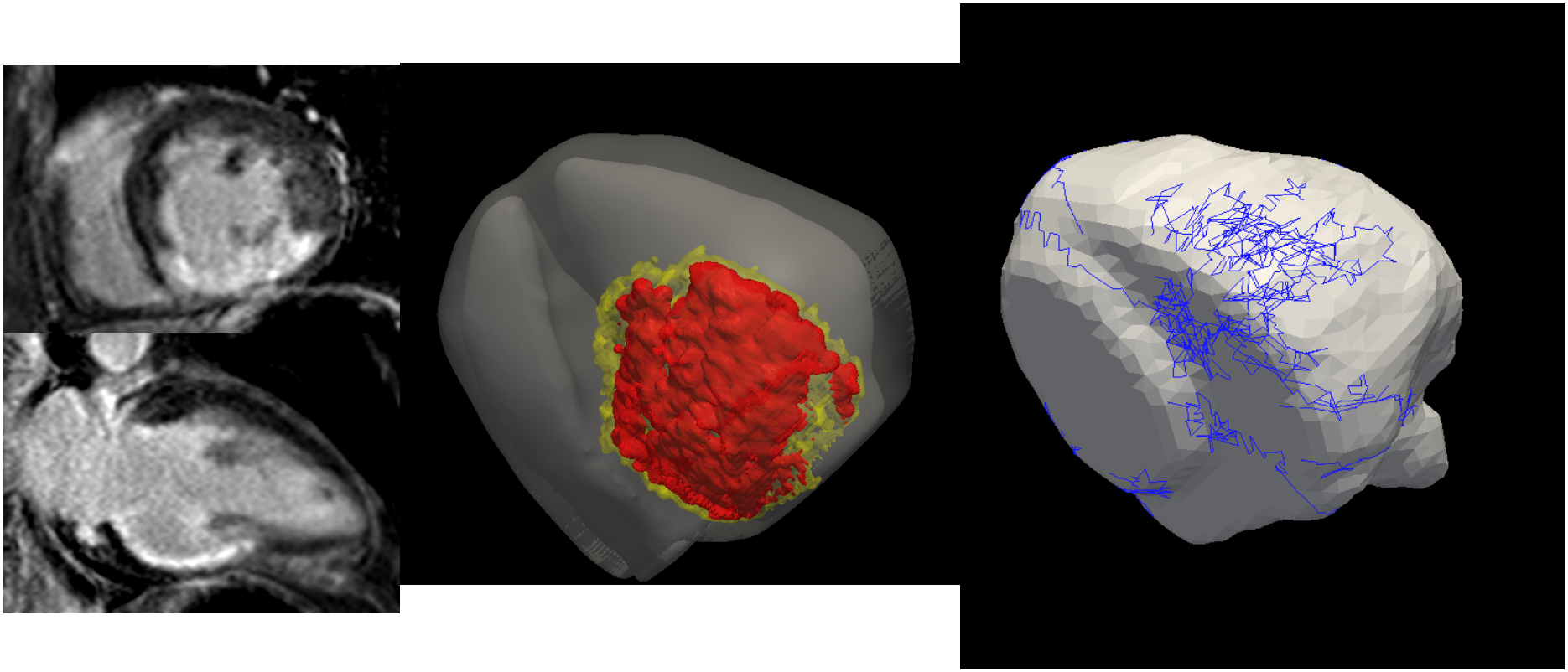

Z
Y
Z
X
Y
Time: 900


Time: 3000 ms


ECG
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000
3200
3400
3600
3800
4000







Conclusion

- **Traiter les troubles du rythmes**
  - **débute des la prise en charge initiale**
  - **Prévenir les complications**
  - **Eviter le remodelage voire le reverser ?**
  - **BiV pacing have beneficial hemodynamic effect on RV and LV dysfunction**
  - **Does early treatement of dysynchrony prevent remodeling with RV and/or LV dysfunction and decrease arrhythmias and/or sudden death incidence ?**