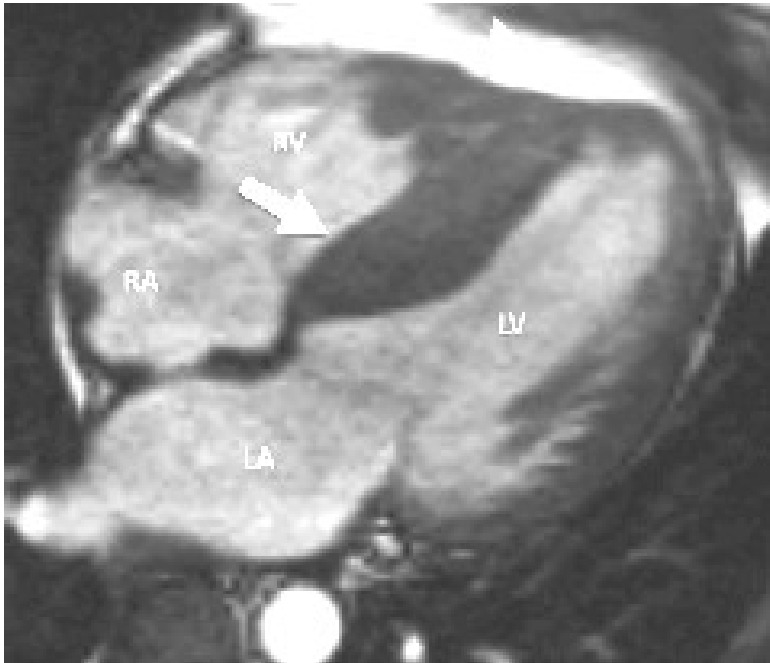


CMH et IRM

T. Letourneau, JM Serfaty

Diagnostic positif : CINE

IRM vs echo, CMH segmentaires



Atteinte septum + pointe VD

→ Protocole cinétique complet

Maron MS, JACC 2009

333 CMH

12 % de CMH segmentaires sous-estimées ou non identifiées en ETT :

Paroi ant-lat VG

Paroi postéro-basale

Paroi apicale

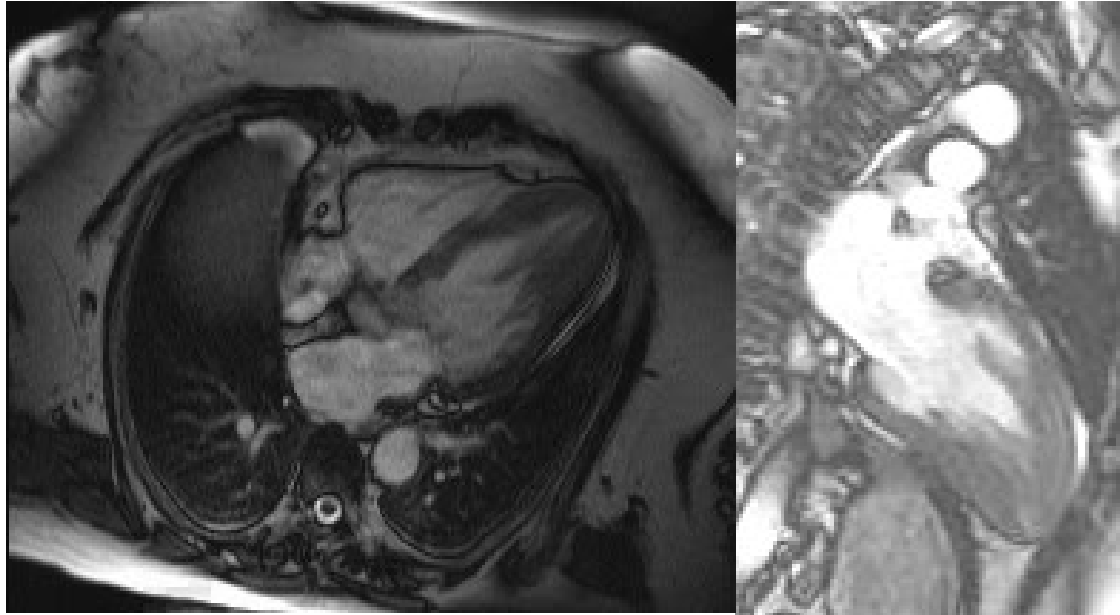
Moon JCC, Heart 2004

10 patients ondes T- en ant-lat

Echo → 0 +

IRM → 10 + formes apicales

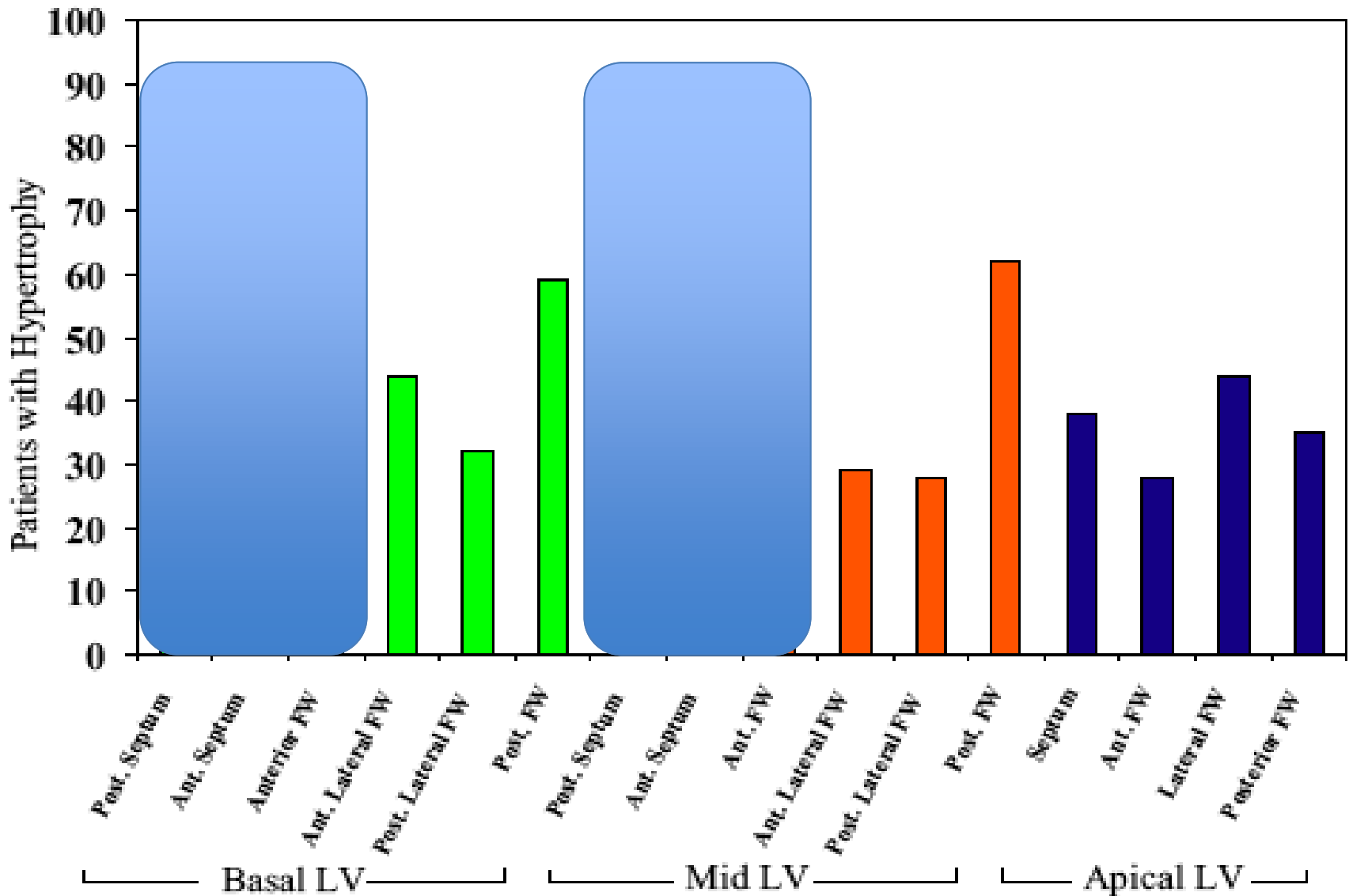
CMH Apicale (Type IV)



Fonction VG: VTD(113ml), VTS(35ml), FE(69%)
Masse myocardique (165ml), VTD/Masse: 0.68

Limites de l'échographie sur la paroi ant et l'apex
Circulation 2005; 112: 855-61

Localisations des CMH



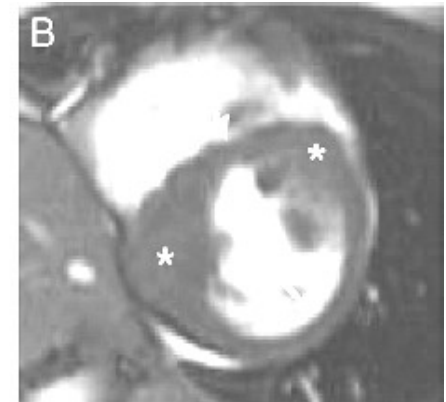
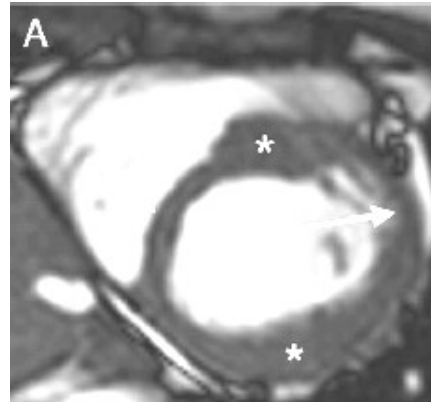
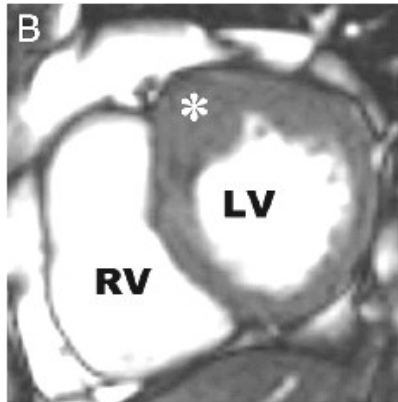
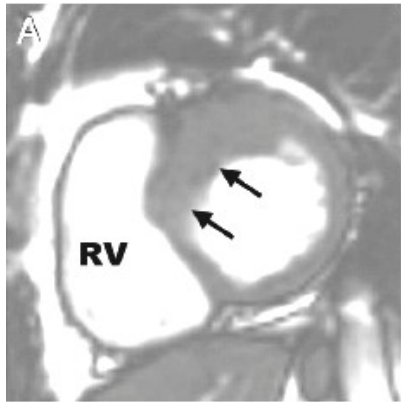
Localisations des CMH : atteintes discontinues

→ Intérêt d'une imagerie 3D

86%

80%

13% d'atteintes discontinues



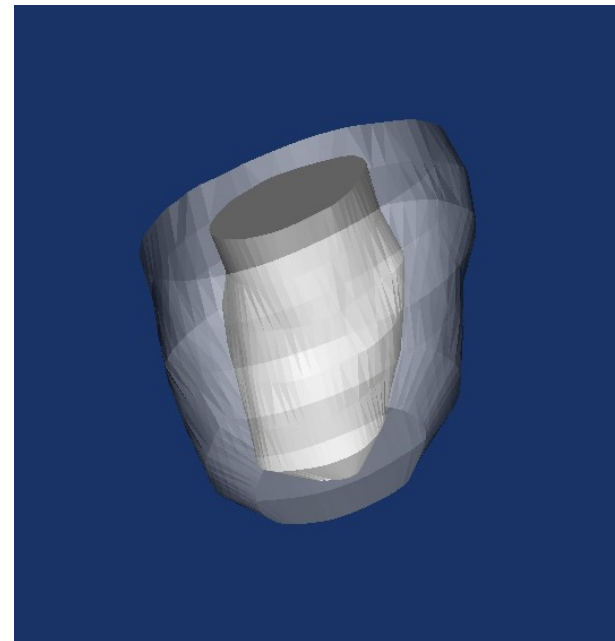
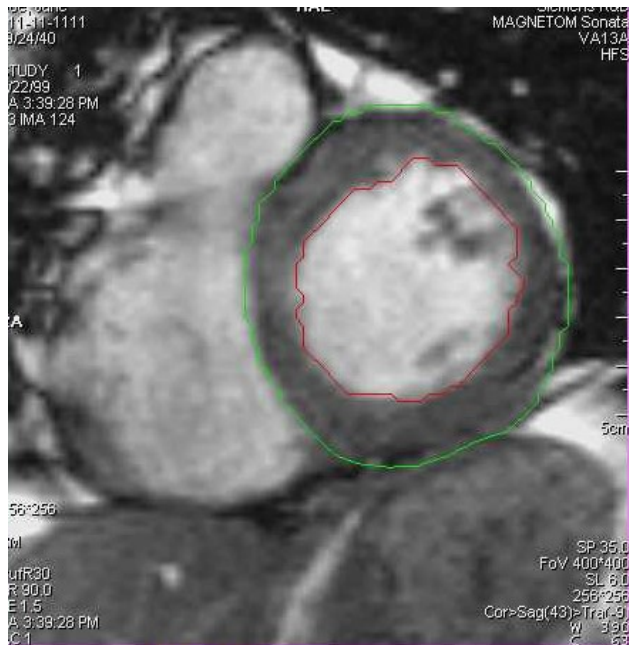
Mesure de la masse : évaluer l'évolution

Quantification de la masse myocardique si évolution clinique ou échographique

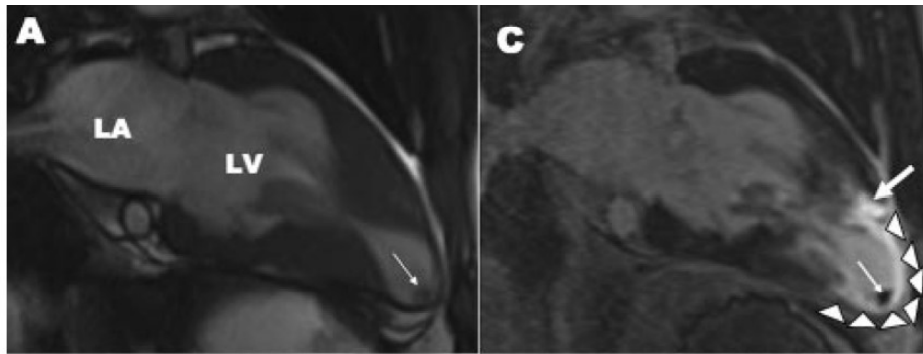
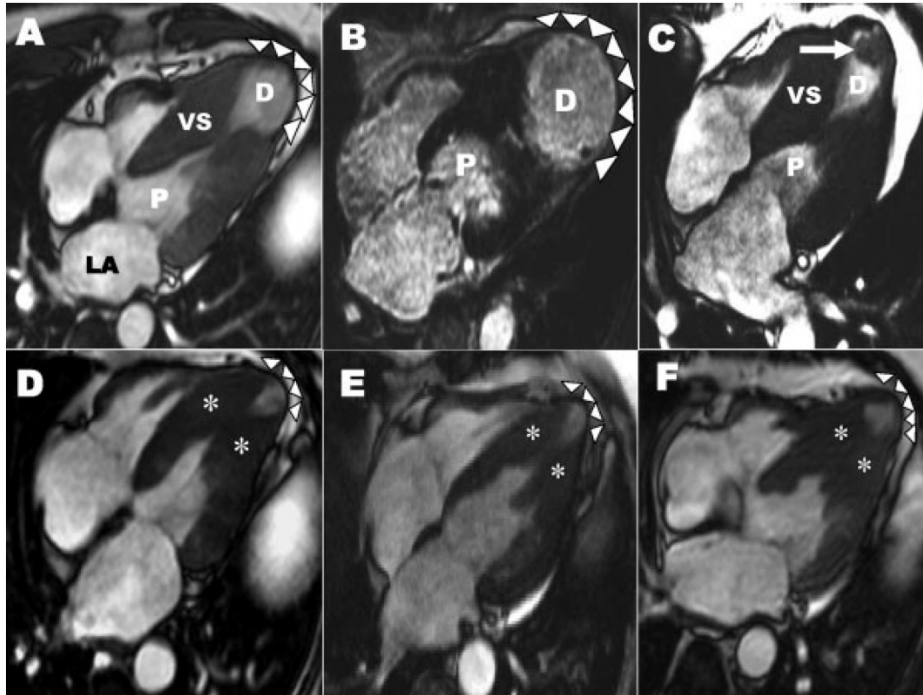
	Male < 35 years	Male ≥ 35 years	Female < 35 years	Female ≥ 35 years
LV mass (g)	131 ± 21 (89–173)	120 ± 23 (74–166)	92 ± 20 (52–132)	92 ± 19 (54–130)
LV mass index (g/m ²)	67 ± 10 (47–87)	60 ± 9 (42–78)	53 ± 9 (35–71)	52 ± 9 (34–70)

Values given as mean ± SD, reference ranges in brackets calculated as ±2SD of mean, from Hudsmith et al.⁶ LV mass index is the myocardial mass relative to body surface area.

Hudsmith LE et al, JCMR, 2005;7:775e82



Prévalence des anévrysmes apicaux

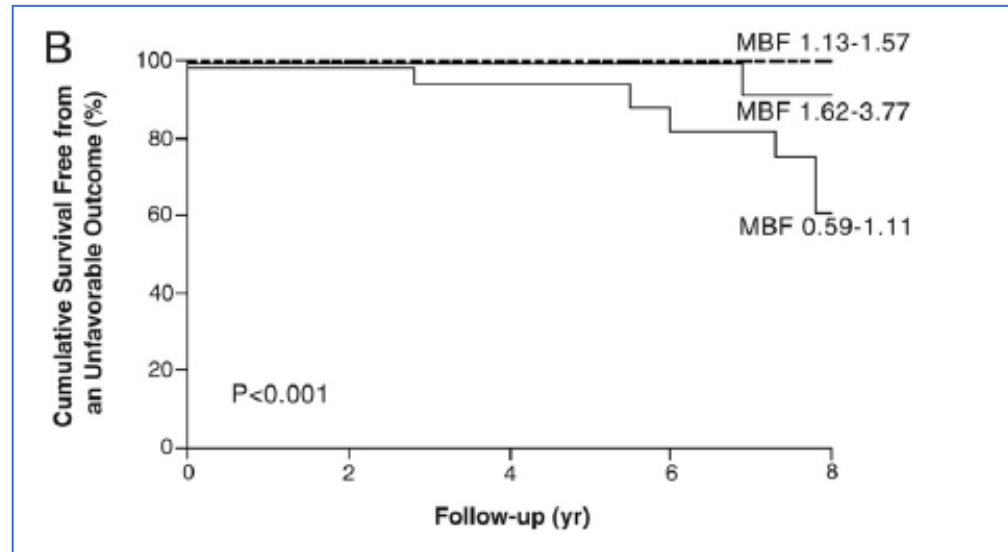
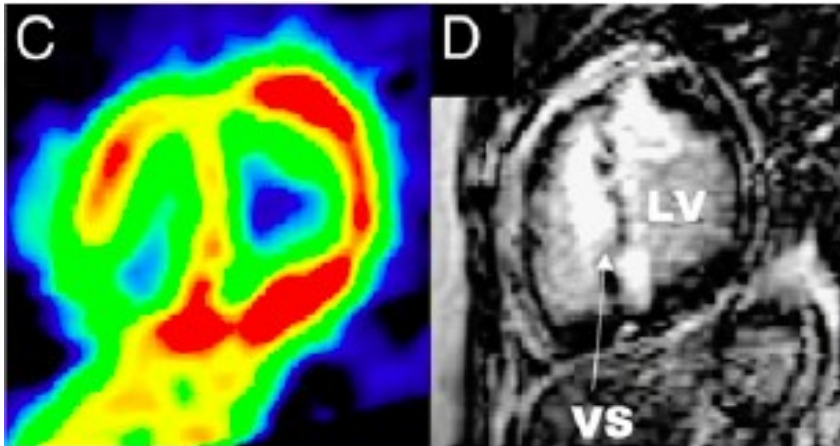
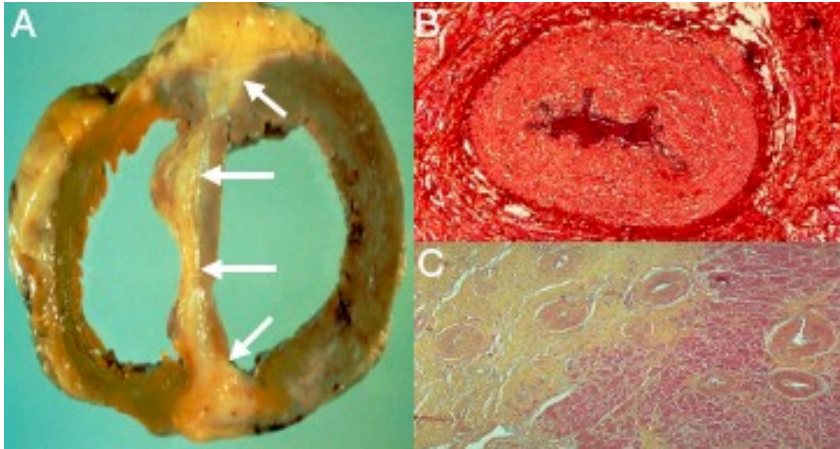


1299 CMH → 28 + (2%)
57% détectés en écho
70% avec CMH 1/3 moyen sténosant
35% avec gradient +

Suivi 4 ans
43% se compliquent :
- Insuffisance cardiaque
- TV
- AVC
- Mort

Soit 10% d'événements / an !

Perfusion de 1^{er} passage : adénosine



Zone à risque

Rehaussement tardif

440 patients

	LGE: frequency	LGE: patterns	representative images
AS			
AH			
HCM			

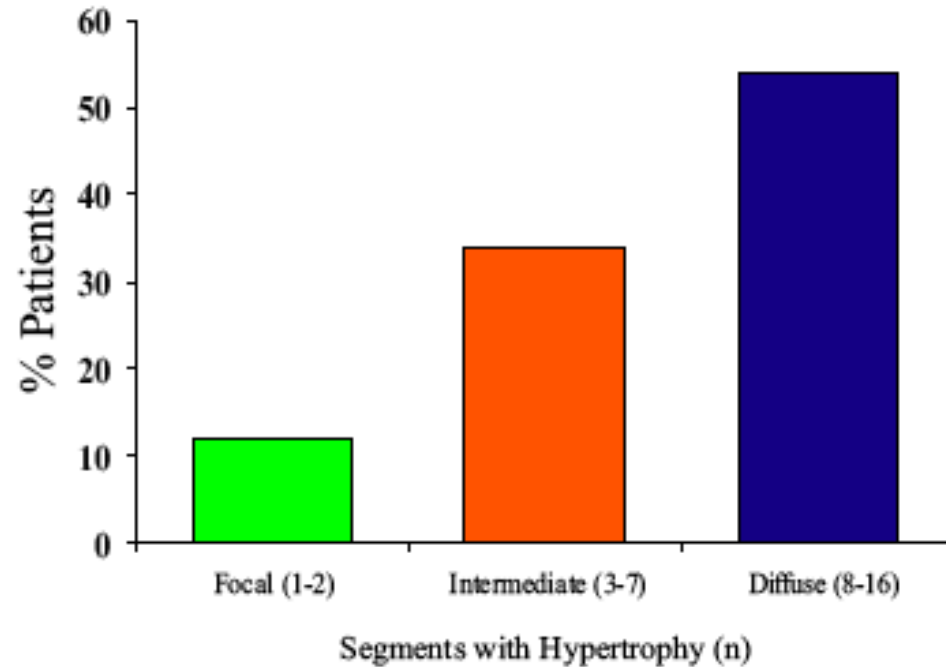
Aortic Stenosis

HTA

CMH

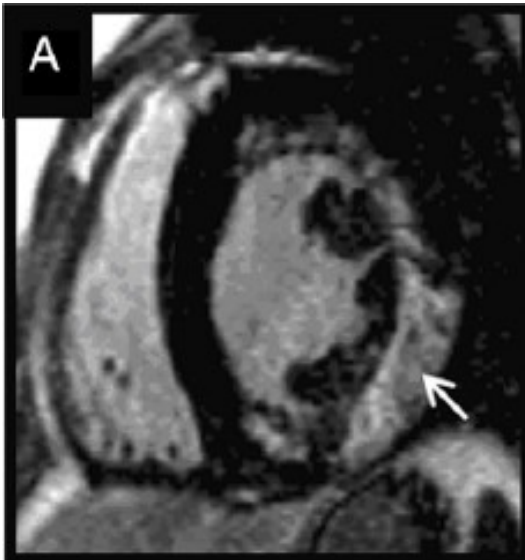
84% RT sur épaisseur max
Localisation préférentielle à l'insertion VD

Le % de RT est corrlé à la masse totale du VG



P<0.001

Importance du Rehaussement tardif

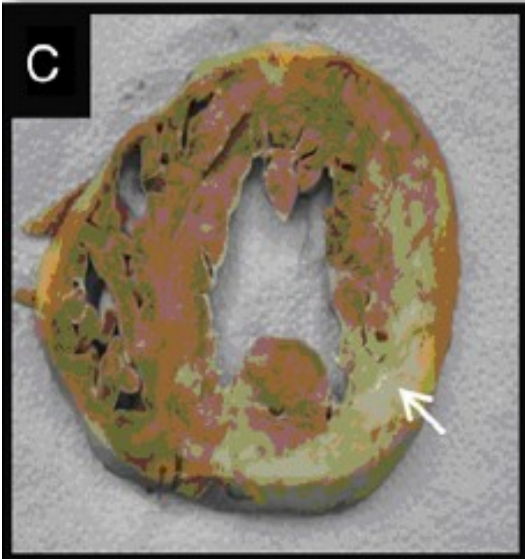


217 patients consécutifs avec CMH
Suivi : 3 ans +/- 1.7

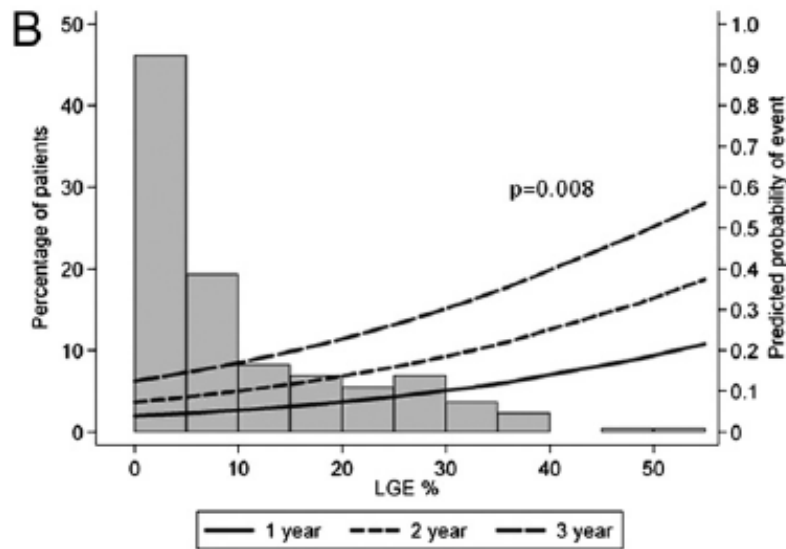
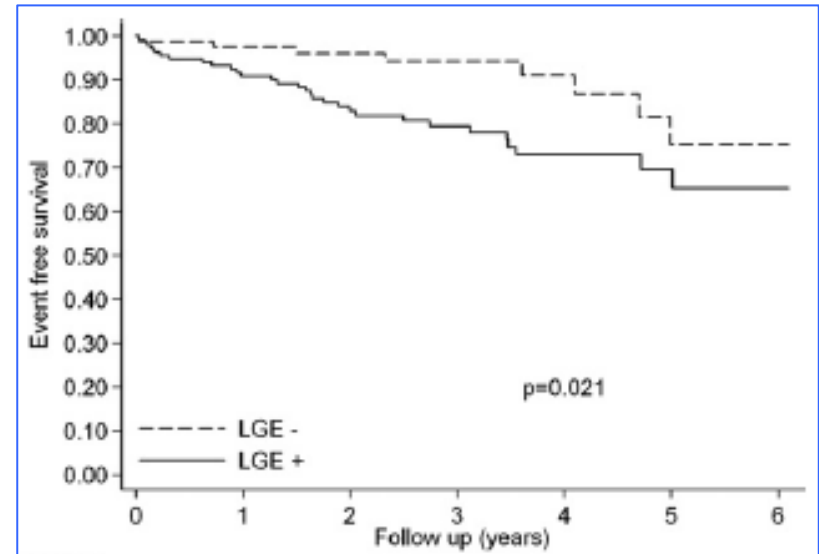
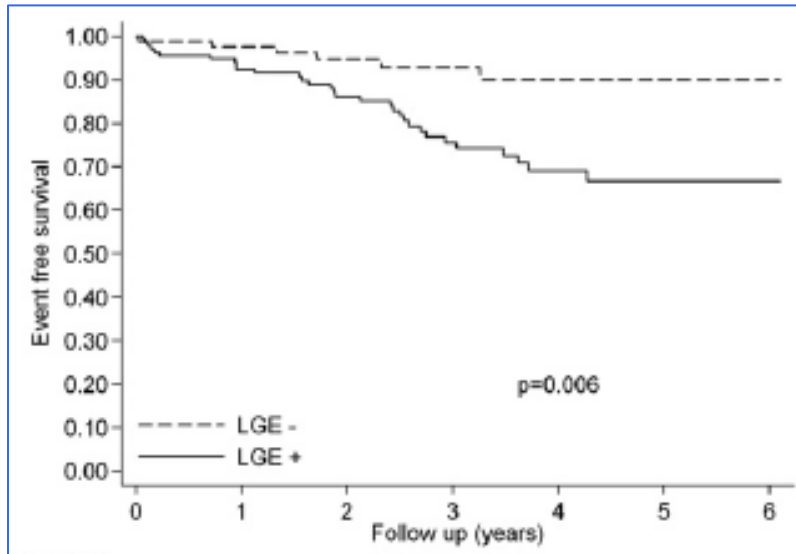
Evénement principal:

- Mort CV, USIC non prévue,
- TV ou FV soutenues,
- décharge adaptée défibrillateur

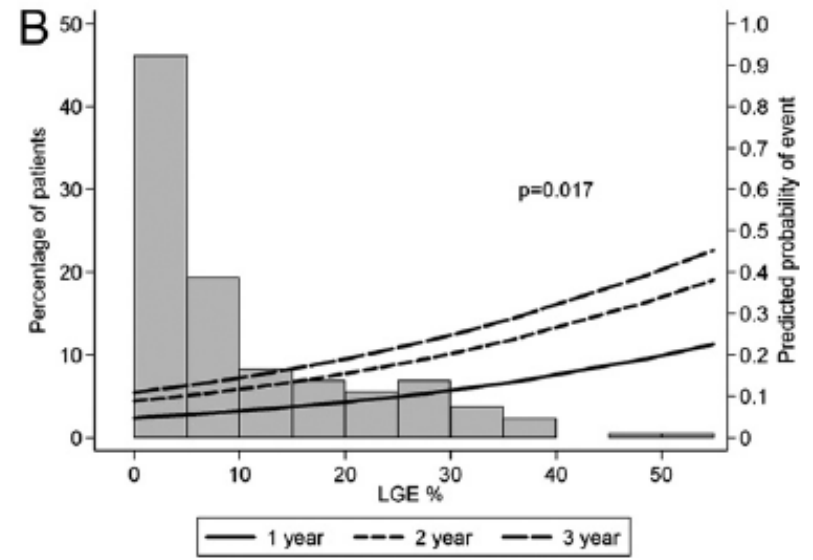
63% ont une fibrose



	No Fibrosis (81)	Fibrosis (136)	p Value
Evenement Principal	7.4%	25%	0.006



MACE



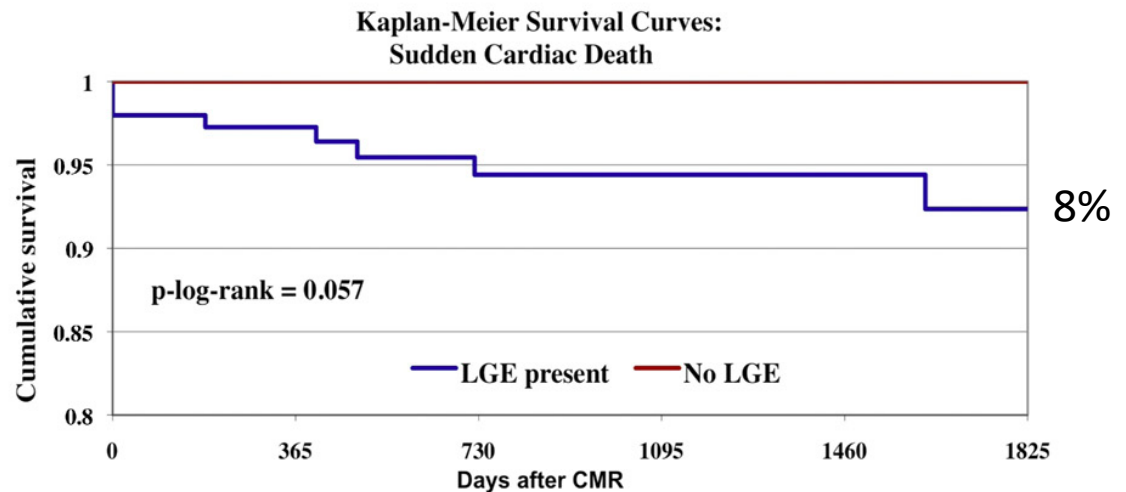
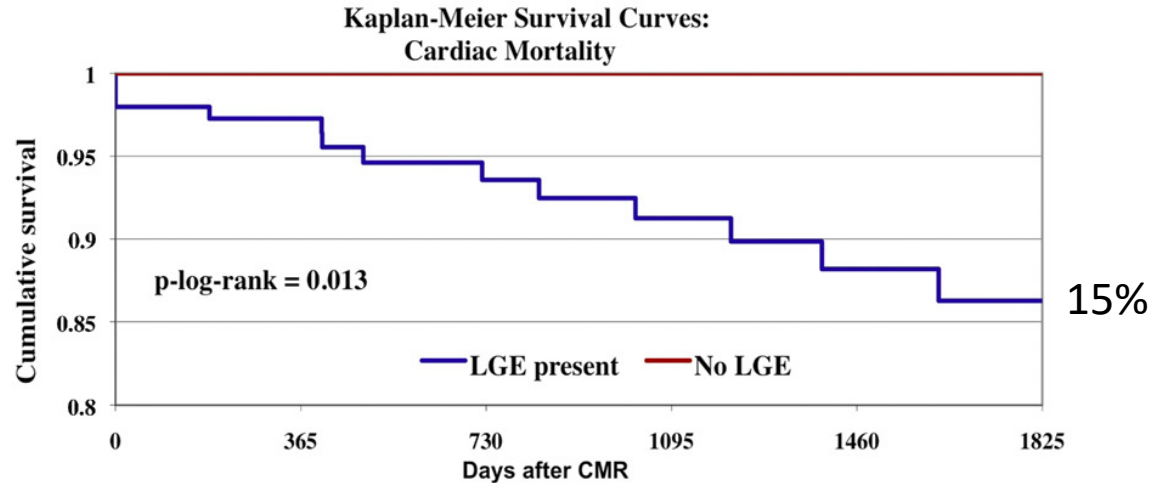
Insuffisance cardiaque

MDE et pronostic

220 patients
Asymptomatique ou low
Suivi moyen 3 ans

72 patients : pas de LGE
148 patients : LGE

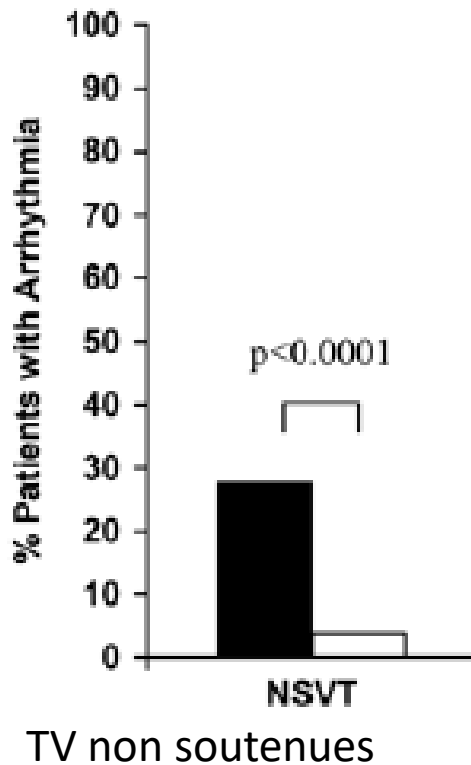
Odd ratio for Cardiac death
MDE : 8.01 > 2 FDR : 2.2



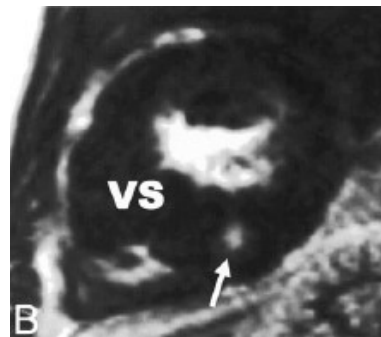
Occurrence and Frequency of Arrhythmias in Hypertrophic Cardiomyopathy in Relation to Delayed Enhancement on Cardiovascular Magnetic Resonance

A. Selcuk Adabag, MD, MS,* Barry J. Maron, MD,† Evan Appelbaum, MD,‡§

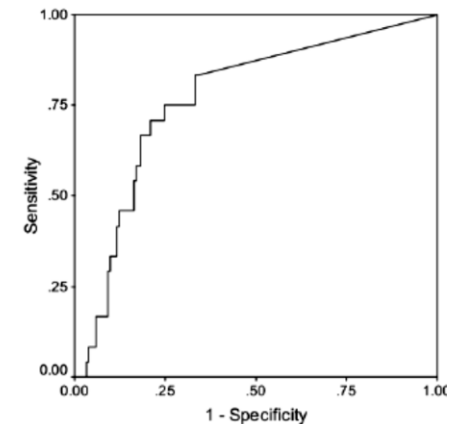
- 177 CMH (168 a ou peu symptomatiques)
- LGE + chez 40% des patients
- IRM puis Holter 24h



RR de TV x 7.3 $p < 0.0001$

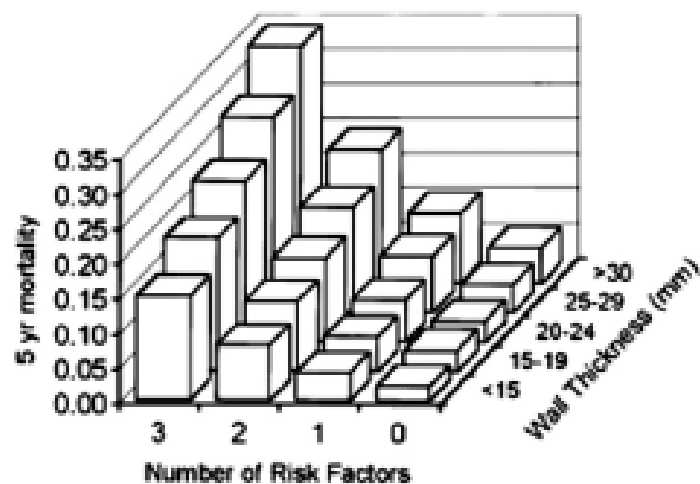
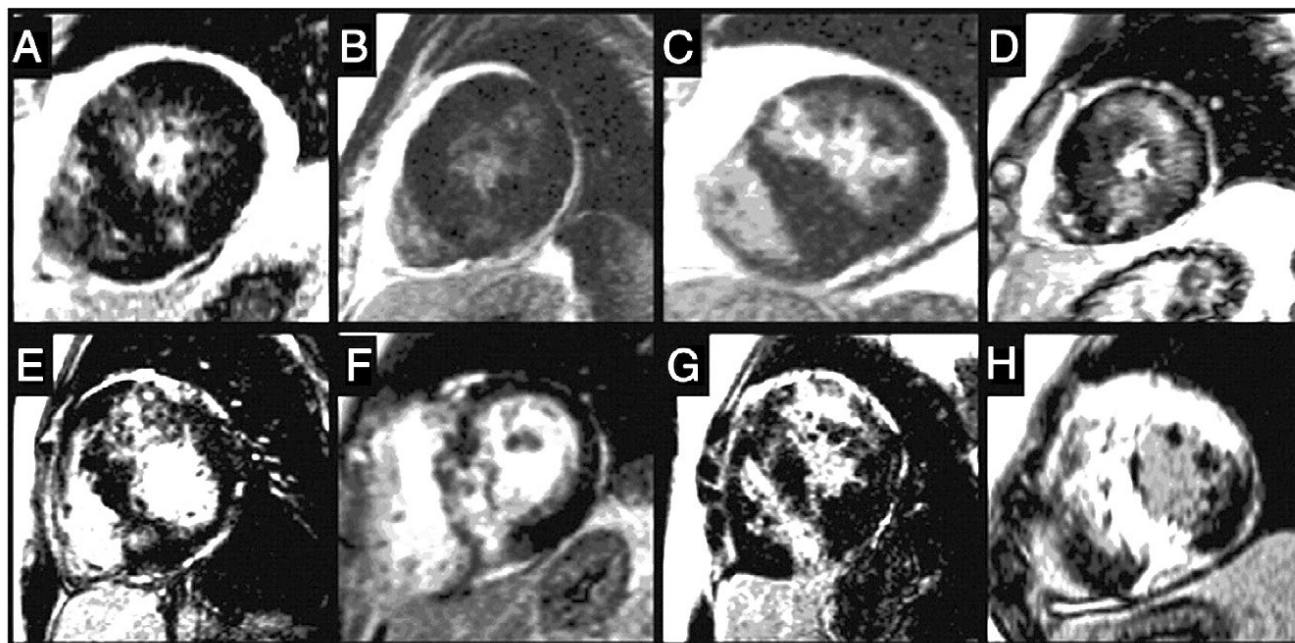


% LGE / myocarde non lié au risque

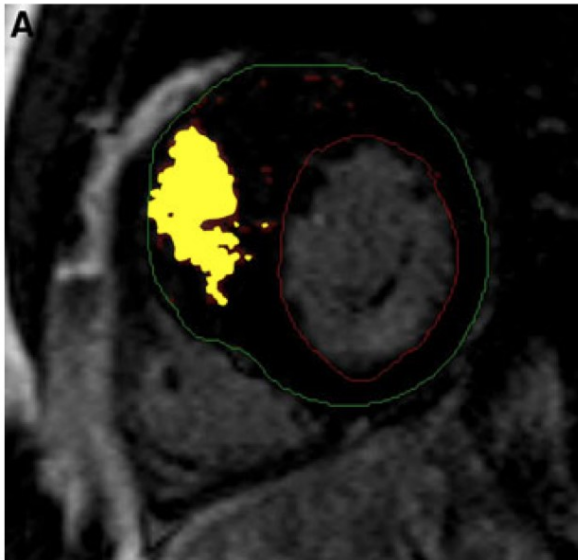


AUC : 0.77

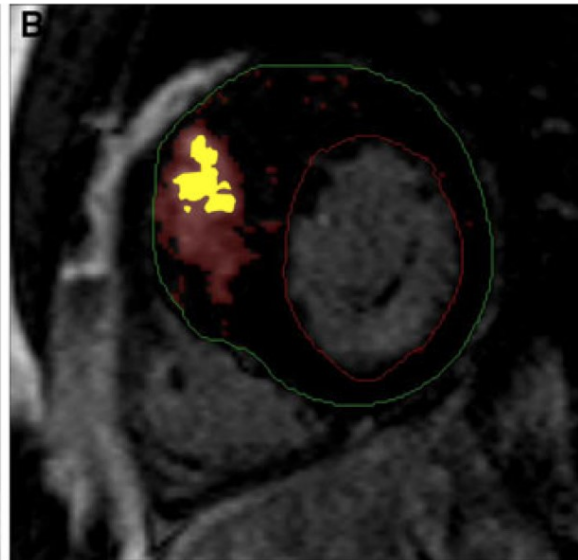
Risque et % de rehaussement tardif



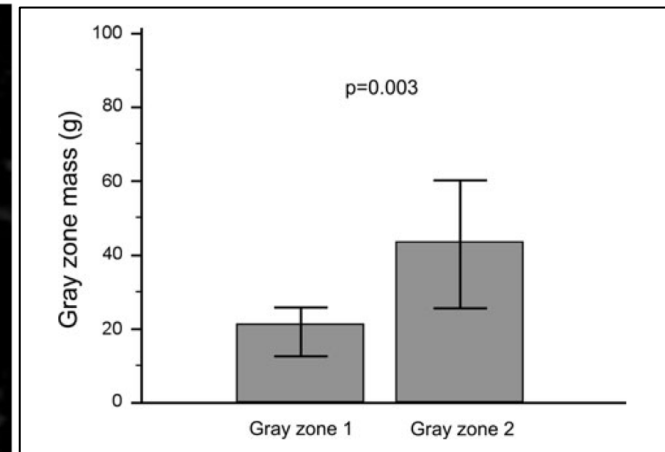
Limites : quantification du RT, Grey zone



>2 SD



Half width maximum



CMH : Diagnostic différentiel

CMH asymétriques

Sarcoidose
Hyperéosinophilie

Tumeur
Thrombus mural

CMH concentriques

CMH secondaires

- HTA
- RAC
- Patient sportif

Infiltratives :

- Amylose
- Sarcoidose
- Maladie de Fabry

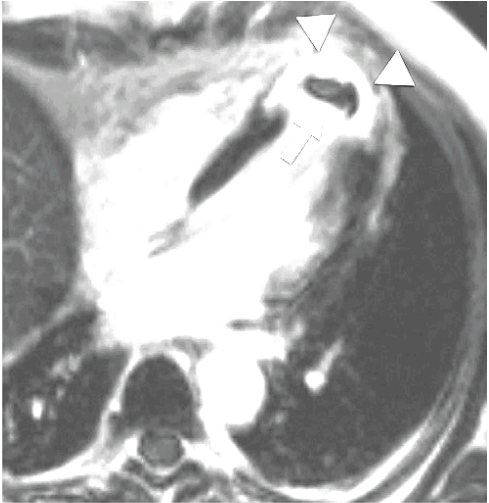
Dystrophies musculaires

Hypertrophie syndromique

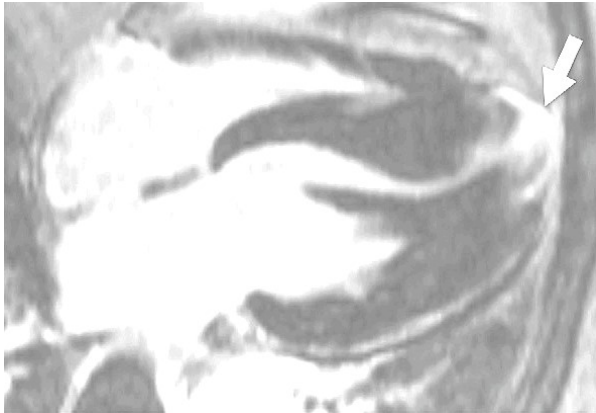
CMH asymétriques : tumeur, Sarcoidose, thrombus



(a)



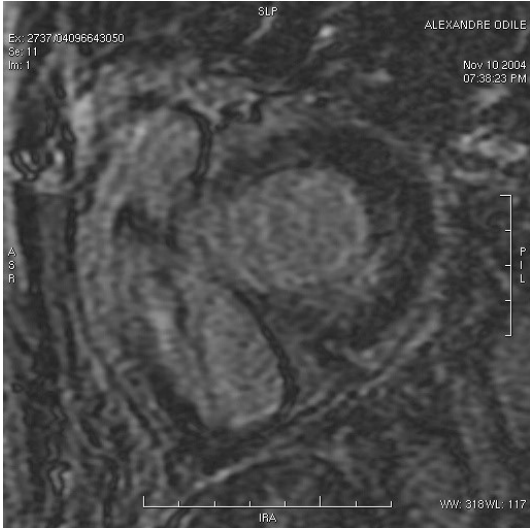
(b)



(a)



(b)



CMH concentrique et Sportifs de haut niveau

- Dilatation du VG (augmentation VTD)
- Pas de Fibrose
- Evite souvent l'épreuve d'arrêt de l'activité sportive

Petersen et al, JCMR 2005

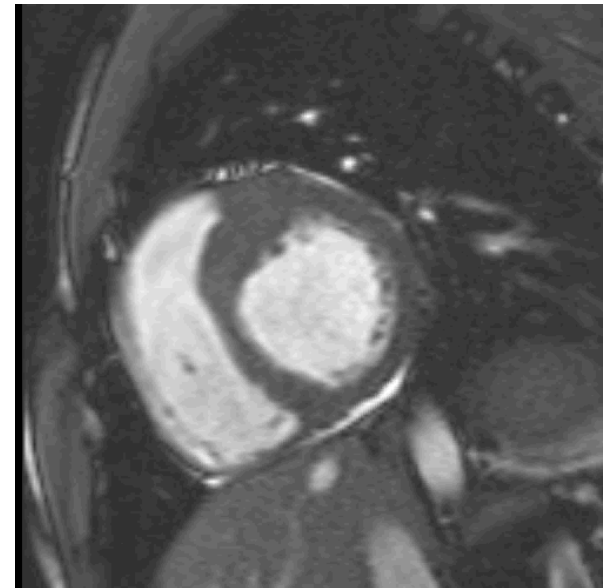
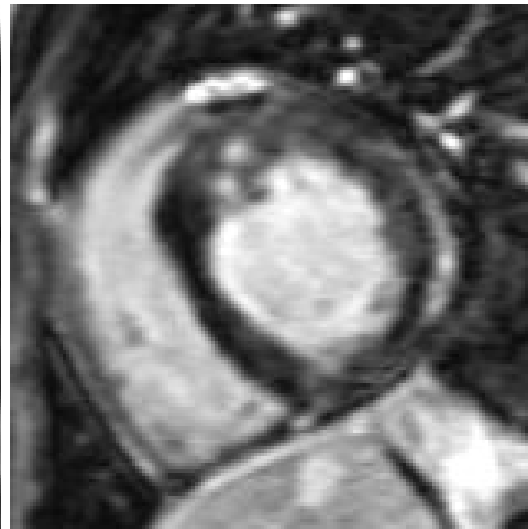
- 120 patients : 18 sains, 25 athlètes, 35 CMH congénitales, 24 sténoses aortiques, 18 HTA
- Se 100% Sp 99% pour différencier athlètes des autres CMH
- Maximum end-diastolic wall to volume ratio $>0.15 \text{ mm} \cdot \text{m}^2 \cdot \text{ml}^{-1}$



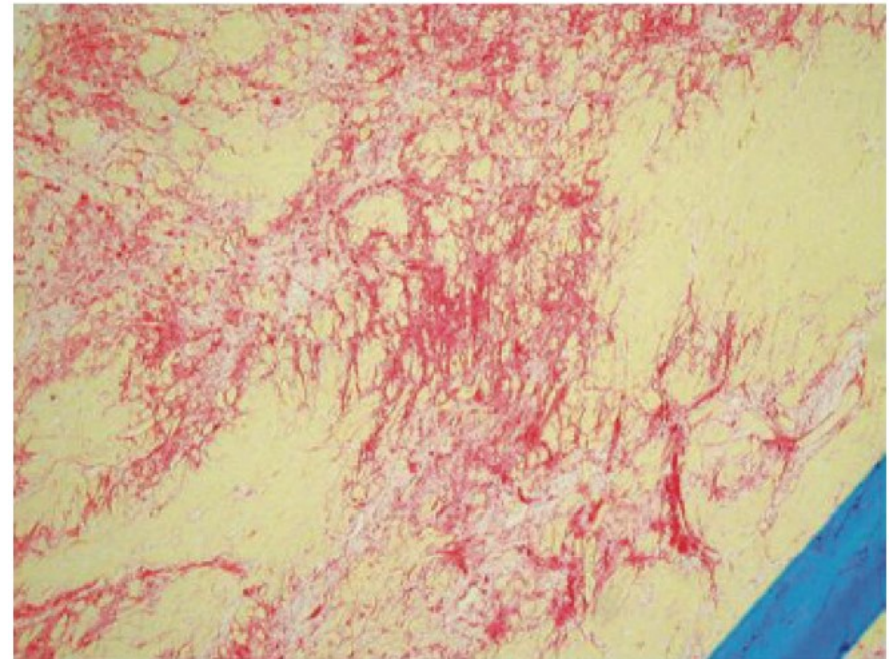
Courtesy, A. Jacquier

CMH chez un sportif

- Sportif de haut niveau (ski)
- 20 ans asymptomatique
- CMH très localisé
- Quel attitude vis à vis du sport ?



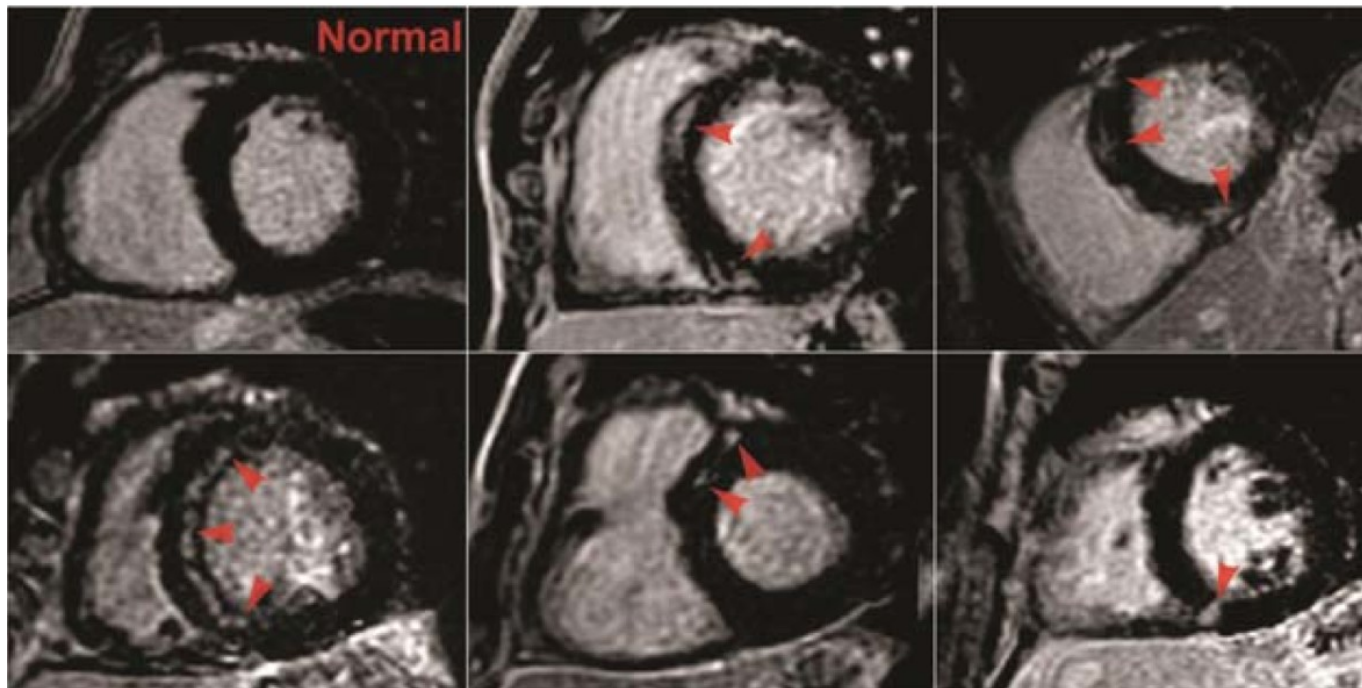
Fibrose, marathon, et mort subite : case report 57 ans



CMH circonférentielle, épaisseur 20mm (> normale), hypertrophie myocytaire mais sans désorganisation.

L'exposition à des efforts répétés et intenses peut aboutir à la formation de fibrose dans le myocarde.

- 40 athlètes (7 marathon, 11 triathlon, 9 cyclistes montagnards, 13 ultra-triathlon), sans anomalie ECG ou échographie
- Age : 37 +/- 8 ans
- 5 patients avec pattern de RTardif



102 hommes marathoniens (> 5 courses complètes les 3 dernières années)

Age > 50 ans

Rehaussement tardif : 12% > témoins (5%)

5 sous-endo, 7 aspécifiques

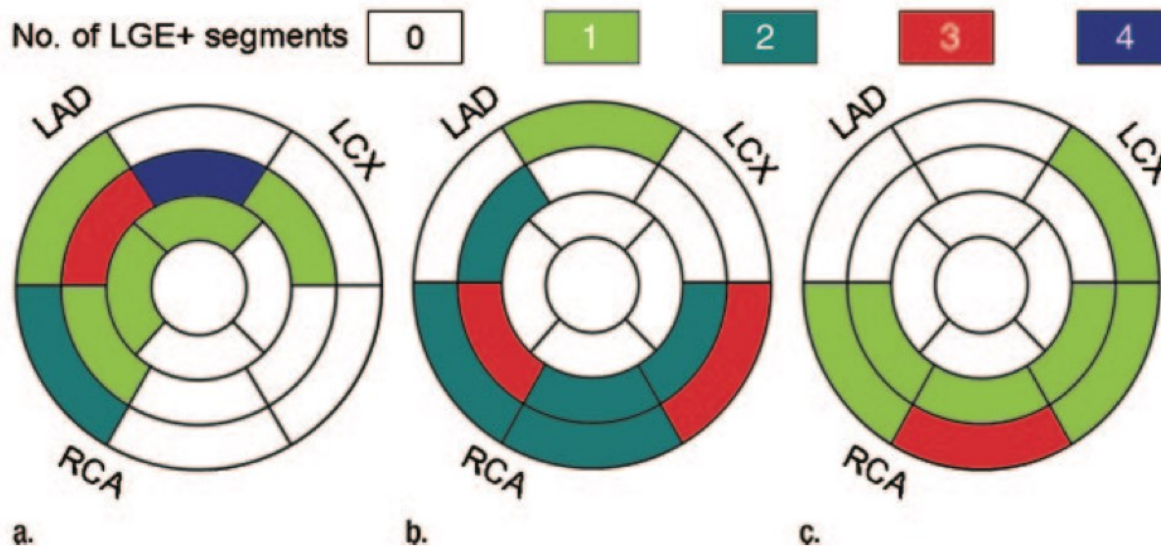
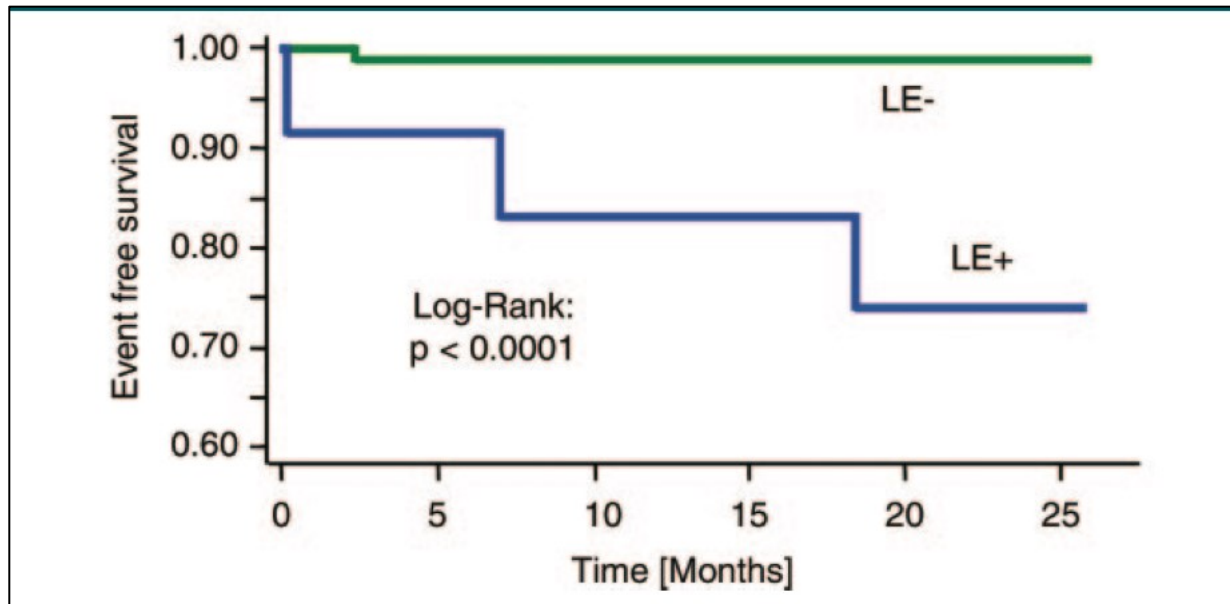


Figure 2: Bulls-eye plots show the number of runners with LGE in each segment in (a) marathon runners with a CAD pattern of LGE, (b) marathon runners with a non-CAD pattern of LGE, and (c) control subjects. More than one segment could be affected. The left anterior descending artery (LAD) perfusion territory was more frequently affected in runners with a CAD pattern of LGE than in runners with a non-CAD pattern of LGE or control subjects. This may indicate a different cause for different patterns of LGE. LCX = left circumflex artery, RCA = right coronary artery.

Survie selon la présence ou non de rehaussement tardif



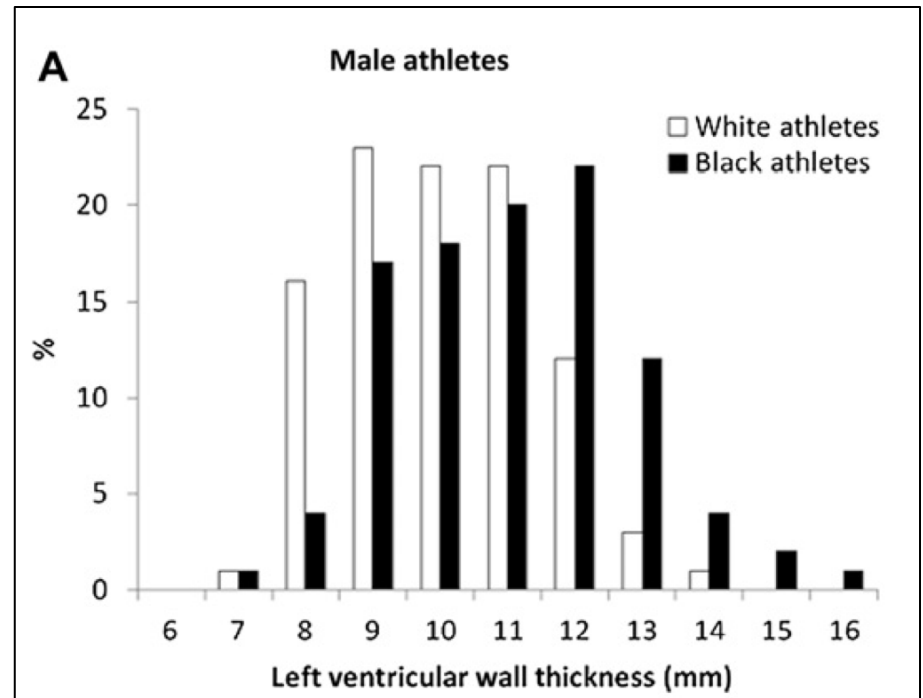
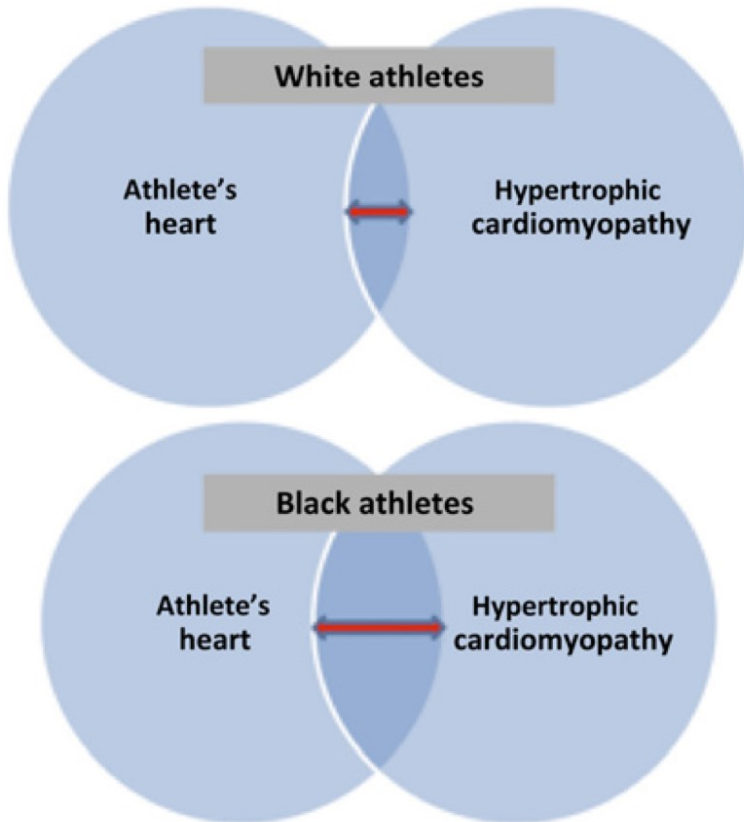
Valeurs normales chez le sportif vs le non sportif : Vol VG, VD, masse, diamètres, étude hollandaise

Table 2 Ventricular volumes and wall mass, systolic function

	Nonathletes		Regular athletes ^a		Elite athletes ^b	
	Absolute	Absolute/BSA	Absolute	Absolute/BSA	Absolute	Absolute/BSA
Men	56		83		46	
RV						
EDV	223 ± 40 (287)	111 ± 18 (139)	277 ± 36 (335)***	136 ± 16 (162)***	291 ± 48 (406)***	144 ± 20 (175)*****
ESV	108 ± 24 (153)	54 ± 12 (72)	135 ± 25 (182)***	66 ± 12 (85)***	148 ± 30 (210)*****	73 ± 13 (94)*****
Mass	23 ± 4.8 (32)	12 ± 2.3 (15)	29 ± 5.5 (41)***	14 ± 2.7 (18)***	30.0 ± 5.5 (43)***	15 ± 2.3 (19)***
EF	52 ± 4.7 (59)		51 ± 4.4 (59)		50 ± 4.4 (58)*	
LV						
EDV	201 ± 33 (257)	101 ± 15 (125)	250 ± 32 (305)***	123 ± 13 (145)***	261 ± 39 (332)***	129 ± 17 (155)***
ESV	87 ± 19 (125)	43 ± 9.5 (59)	108 ± 20 (140)***	53 ± 9.0 (67)***	117 ± 24 (166)***	58 ± 11 (78)*****
Mass	95 ± 20 (122)	48 ± 9.4 (59)	125 ± 22 (171)***	62 ± 11 (80)***	139 ± 28 (205)*****	69 ± 13 (91)*****
EF	57 ± 5.8 (67)		57 ± 4.7 (65)		55 ± 5.4 (64)	
Women	58		60		33	
RV						
EDV	166 ± 23 (205)	96 ± 12 (116)	209 ± 29 (257)***	115 ± 15 (140)***	219 ± 35 (292)***	118 ± 17 (145)***
ESV	75 ± 13 (99)	43 ± 7.0 (55)	102 ± 17 (128)***	57 ± 8.8 (71)***	103 ± 24 (144)***	56 ± 13 (76)***
Mass	18 ± 3.8 (26)	10 ± 2.2 (14)	23 ± 3.8 (30)***	13 ± 2.0 (16)***	25 ± 4.5 (37)***	14 ± 2.7 (18)***
EF	55 ± 4.8 (64)		51 ± 3.8 (57)***		53 ± 6.9 (67)	
LV						
EDV	156 ± 22 (197)	90 ± 11 (109)	194 ± 27 (234)***	107 ± 14 (128)***	199 ± 31 (264)***	107 ± 14 (131)***
ESV	65 ± 13 (89)	37 ± 6.8 (49)	86 ± 15 (112)***	48 ± 7.9 (59)***	85 ± 20 (127)***	46 ± 11 (61)***
Mass	60 ± 11 (79)	34 ± 6.2 (43)	84 ± 17 (124)***	46 ± 9.2 (64)***	92 ± 15 (117)***	50 ± 7.6 (64)***
EF	58 ± 5.3 (68)		55 ± 4.0 (62)*		58 ± 6.6 (68)	

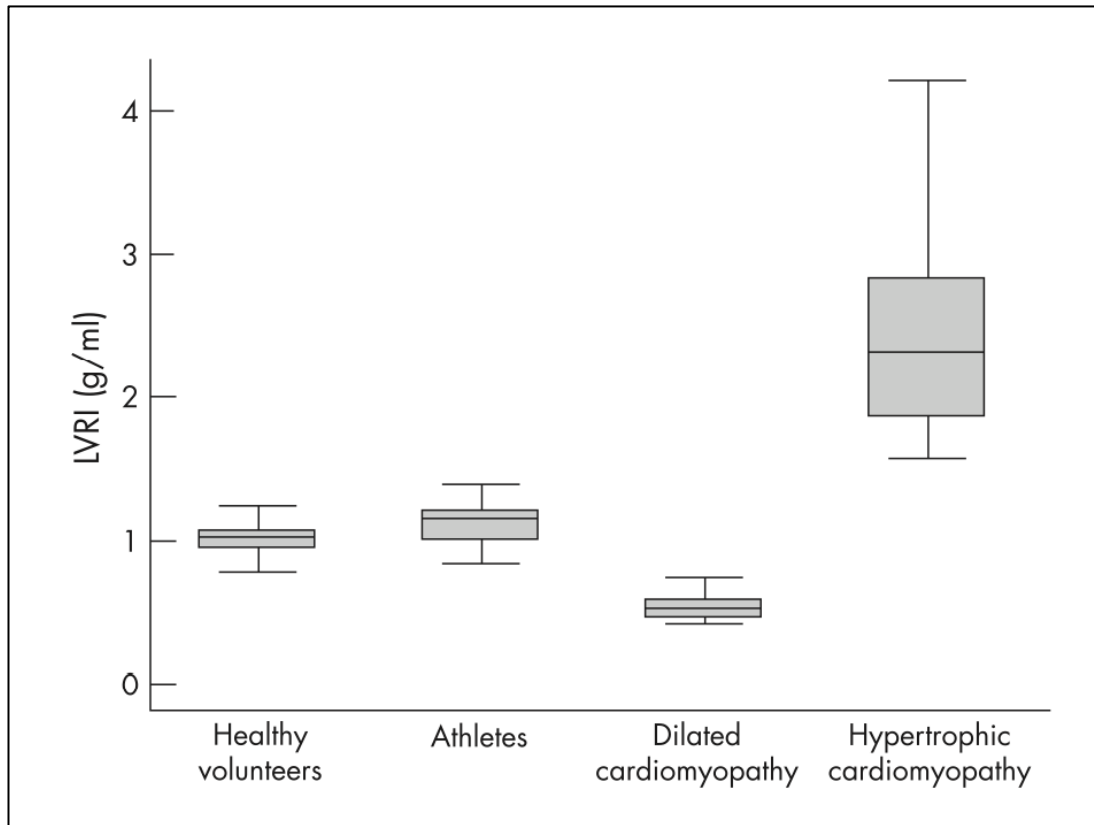
Data are expressed as mean ± SD (95th percentile). BSA, body surface area; EDV, ESV, end-diastolic and end-systolic volume (ml); EF, ejection fraction (%); mass, end-diastolic wall mass (g); RV, LV, right and left ventricle. ^a*P* values for significant differences between nonathlete controls and regular endurance athletes. ^b*P* values for significant differences between nonathlete controls and elite endurance athletes are marked: **P*<0.05; ***P*<0.005; ****P*<0.0005; *P* values for significance in differences between regular and elite endurance athletes after the comma: **P*<0.05; ***P*<0.005; ****P*<0.0005.

Athlètes noirs et blancs

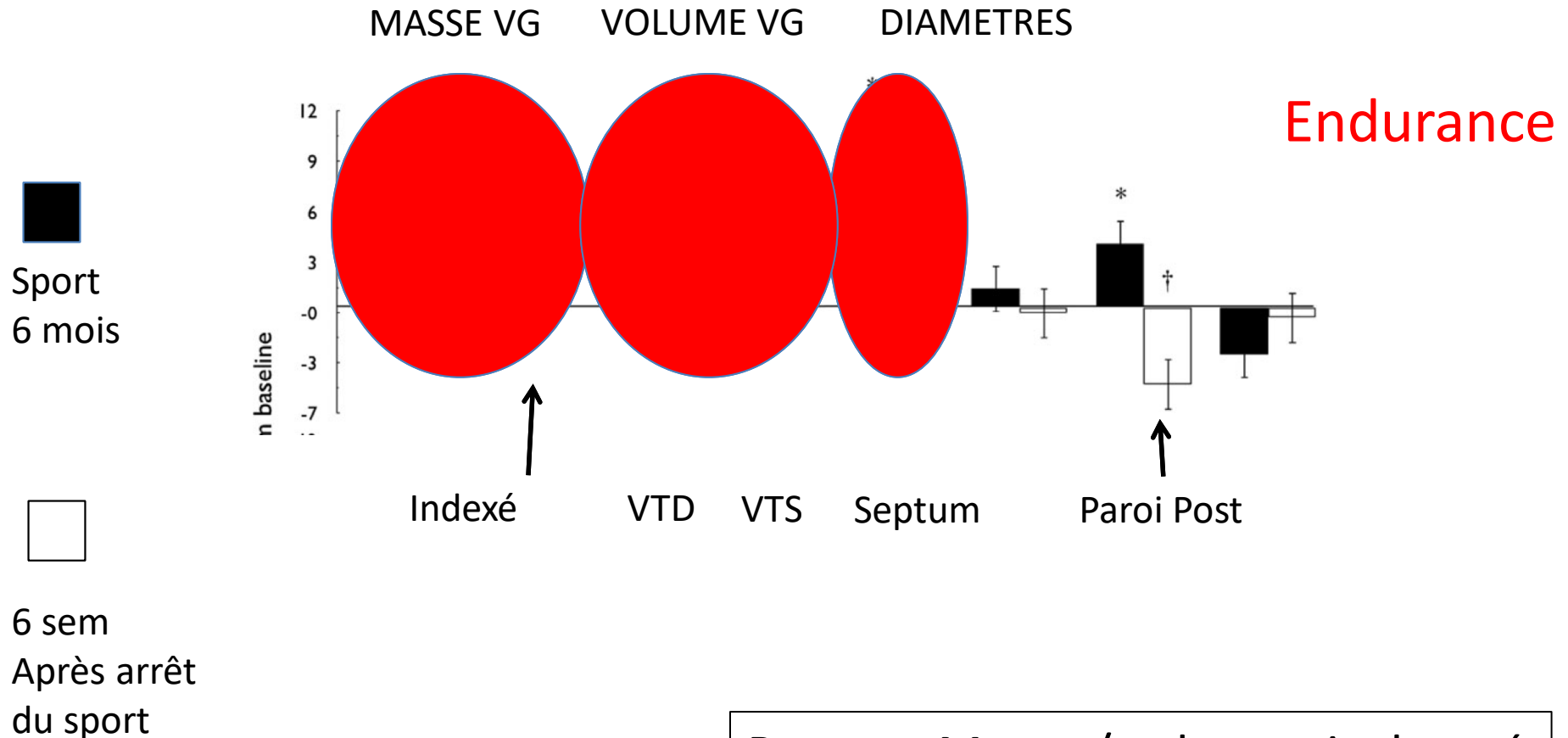


LVRI : Masse VG / volume TD

152 sujets sains, 19 aviron, 23 CMD, 26 CMH

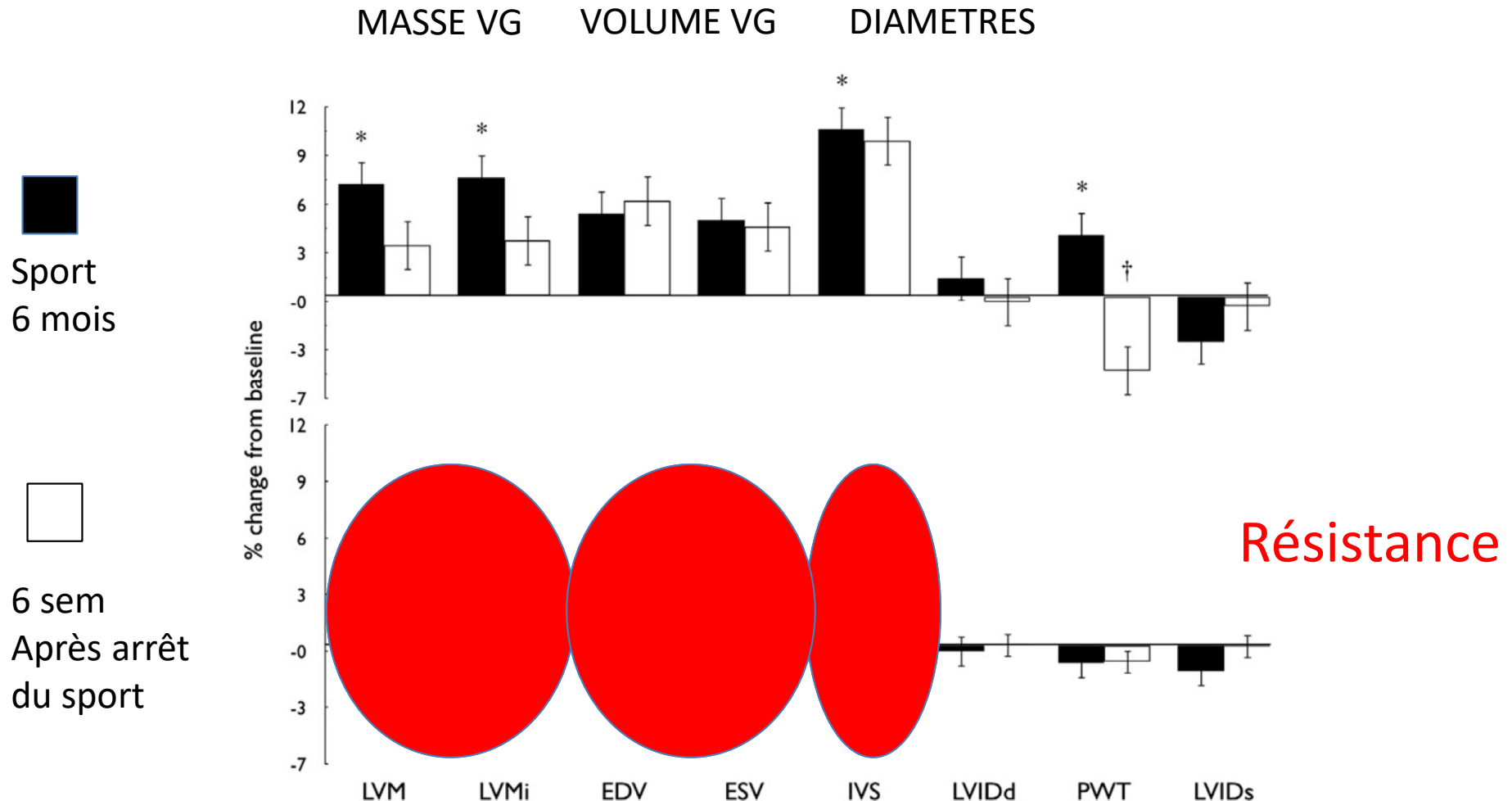


Facteurs se modifiant après la mise en place d'une activité sportive : étude prospective en IRM



Rapport Masse / volume : inchangé

Facteurs se modifiant après la mise en place d'une activité sportive : étude prospective en IRM



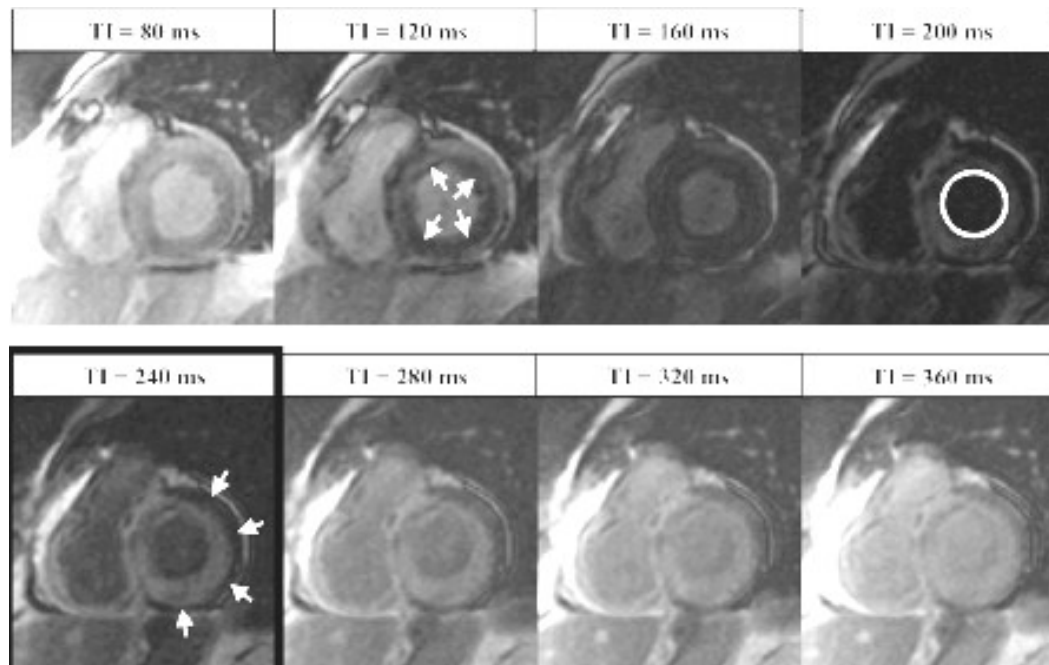
Cardiovascular Magnetic Resonance in Clinically Suspected Cardiac Amyloidosis

JACC, Vol51, 2008

Noninvasive Imaging Compared to Endomyocardial Biopsy

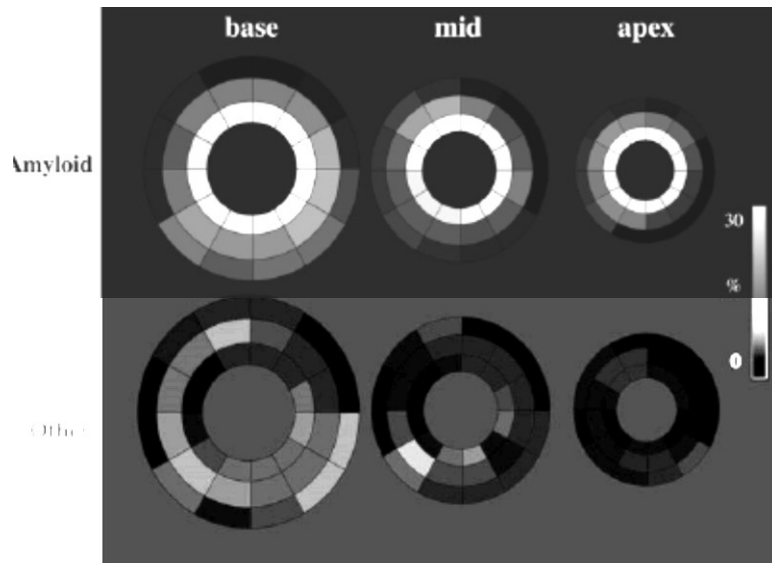
Holger Vogelsberg, MD,* Heiko Mahrholdt, MD,* Claudia C. Deluigi, MD,* Ali Yilmaz, MD,*

- 33 patients consécutifs :
 - 24 patients : Icardiaque + Sd restrictif sur CMH
 - 18 patients : Icardiaque + pathologies associées (myocardite/amylose systémique/ myélome/lymphome/Irénale terminale)



Evaluation and Management of the Cardiac Amyloidosis

Joseph B. Selvanayagam, FRACP, DPHIL,*‡ Philip N. Hawkins, PhD, FRCP, FRCPATH,†



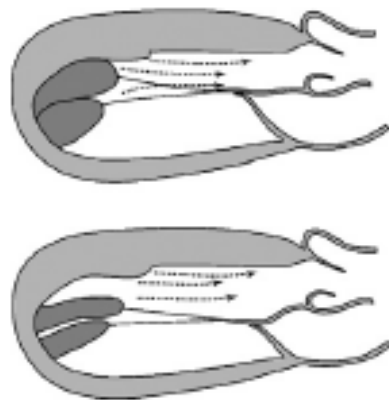
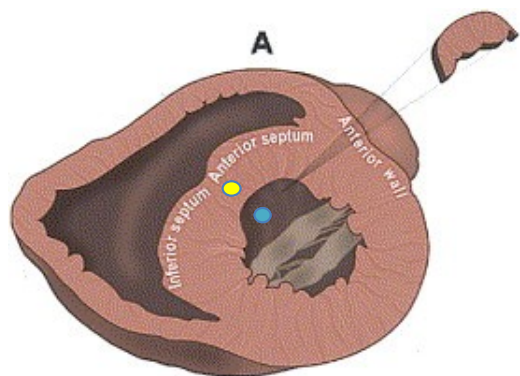
26 patients / 33 : rehaussement tardif

JACC Vol. 50, No. 22, 2007
15 amyloidoses cardiaques (biopsie)
IRM : Se : 80%, Sp : 94%

45% d'amylose cardiaque sur 29 patients
sans amylose systémique
→ sous-estimation ?

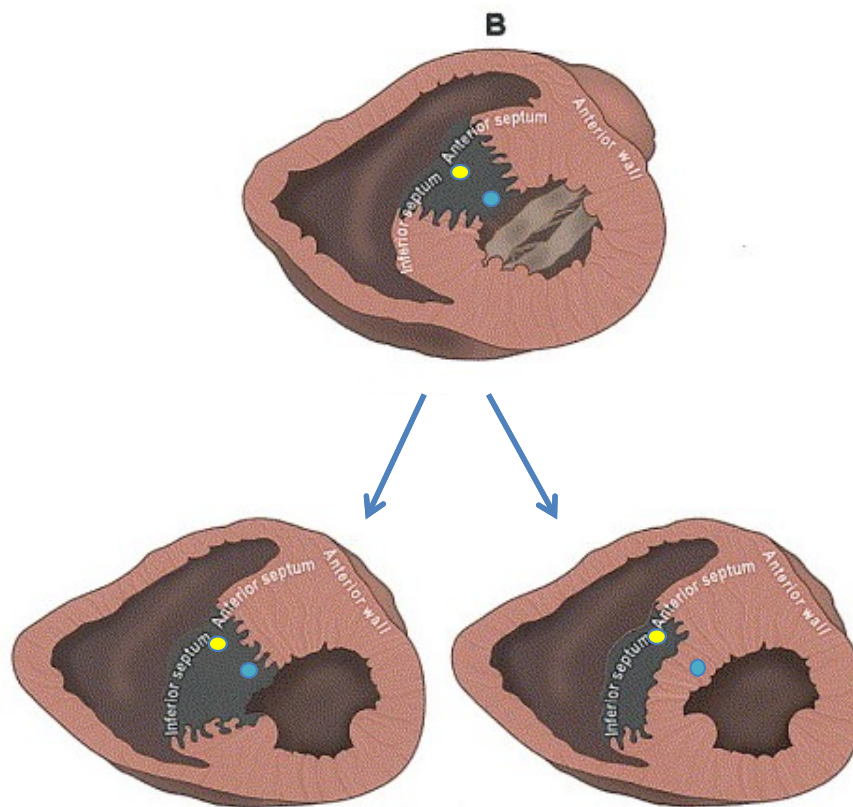
Evaluer la qualité du traitement

Myomectomie → BBG(46%)



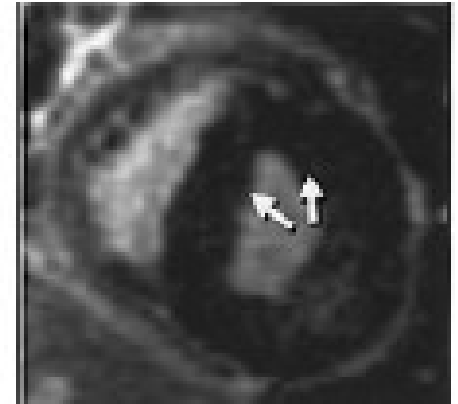
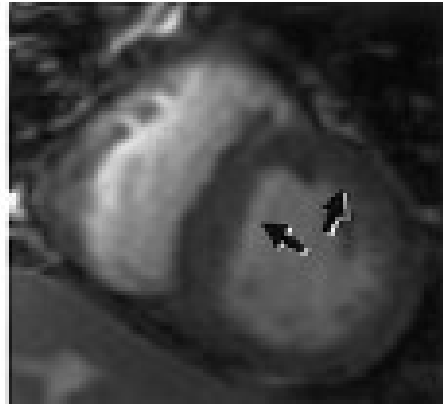
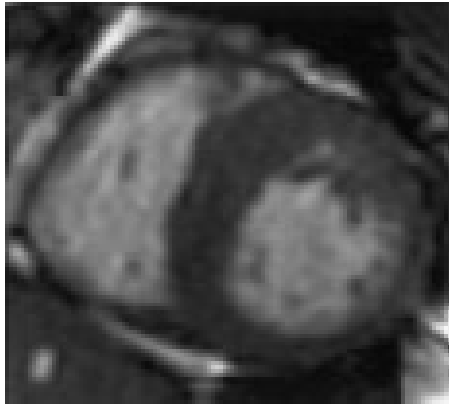
Ann Thorac Surg 2003;75:620-632.

Alcoolisation septale: BBD (58%)

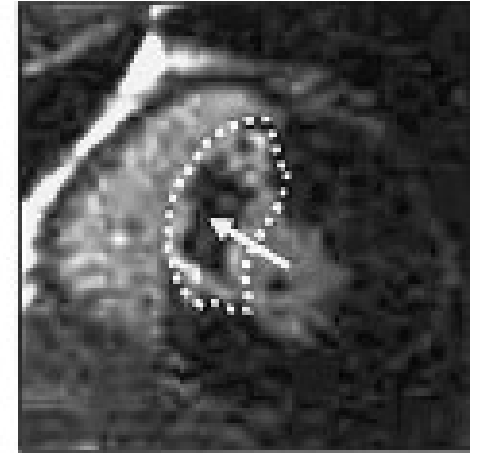
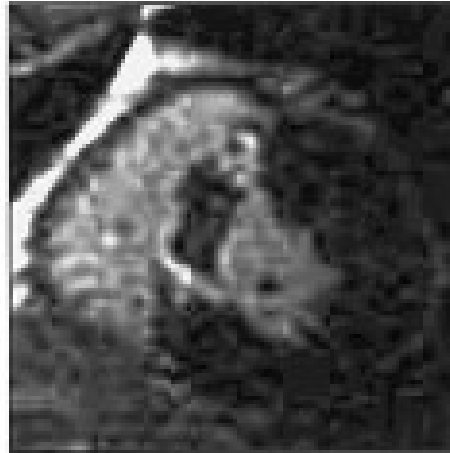
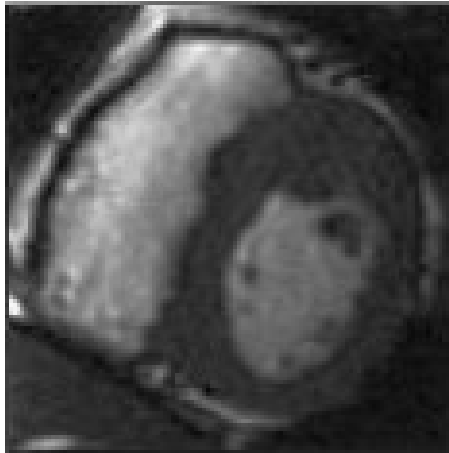


(*J Am Coll Cardiol* 2007;49:350-7)

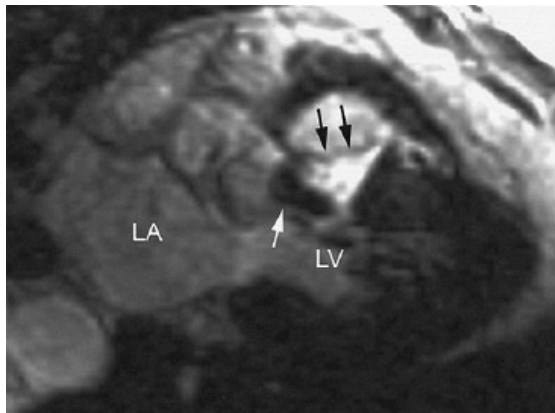
CHIR



Alcoolisation
complète



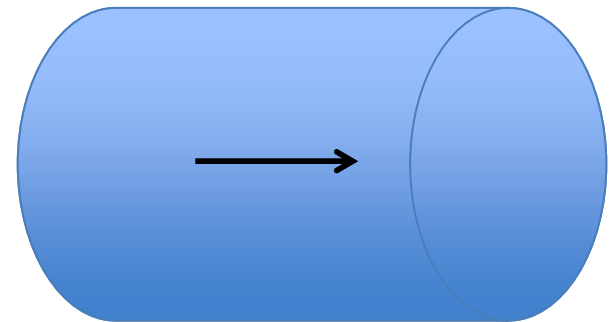
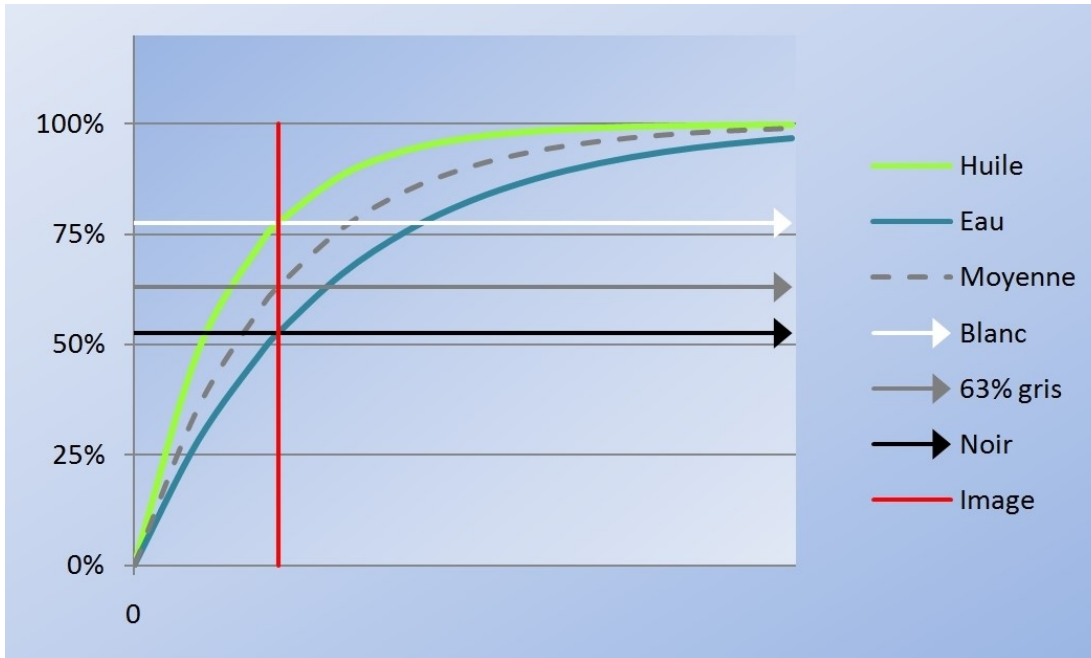
Alcoolisation
incomplète



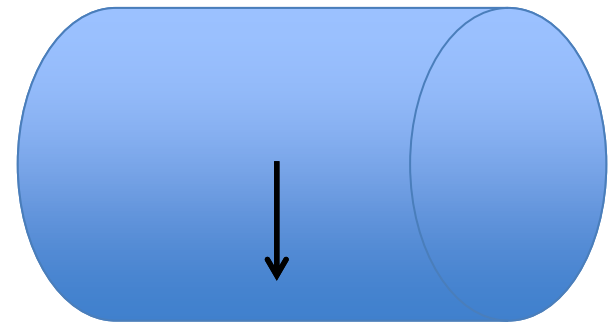
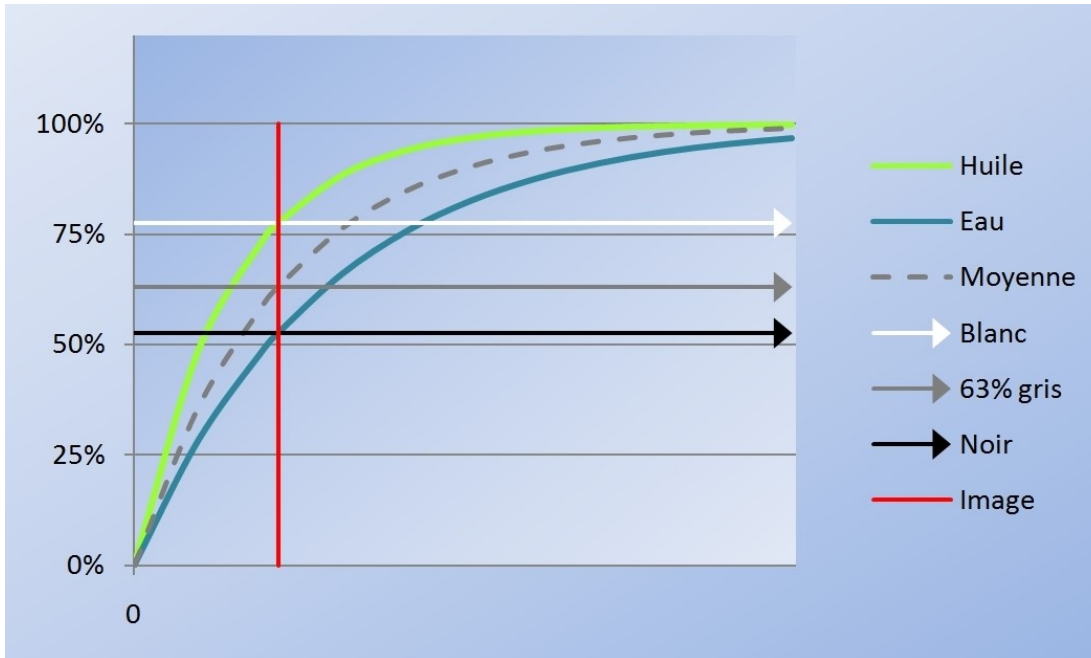
Apport potentiel du T1 mapping ?

- IRM
 - T1 natif
 - Volume extra-cellulaire

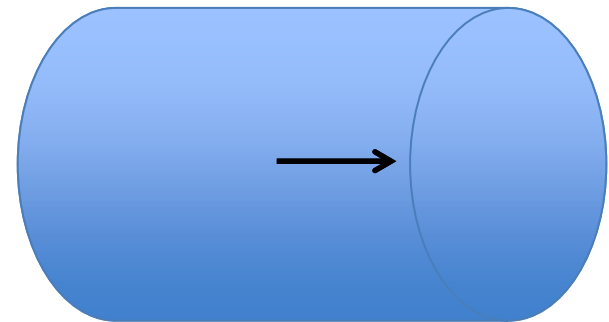
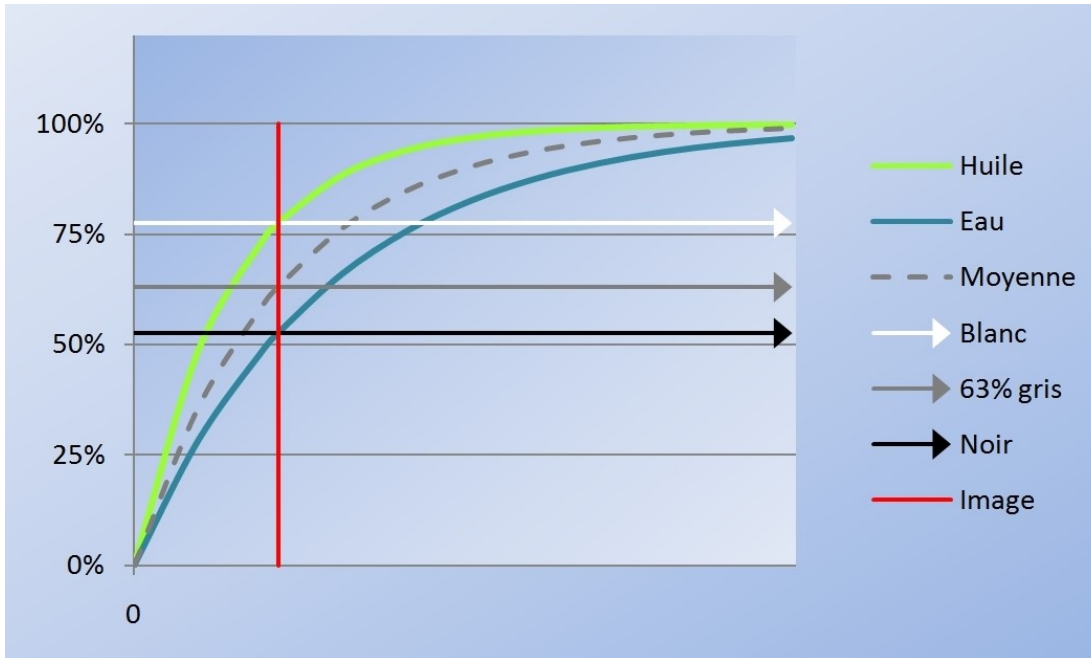
T1



T1

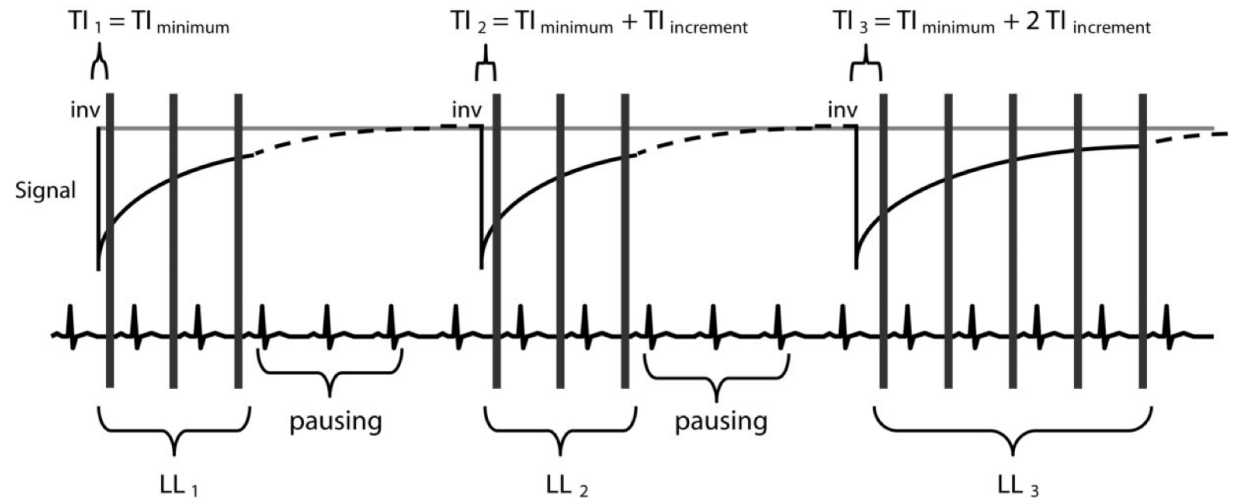
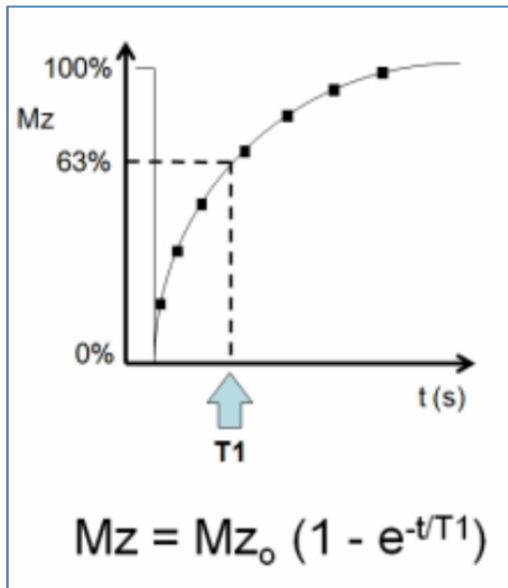


T1



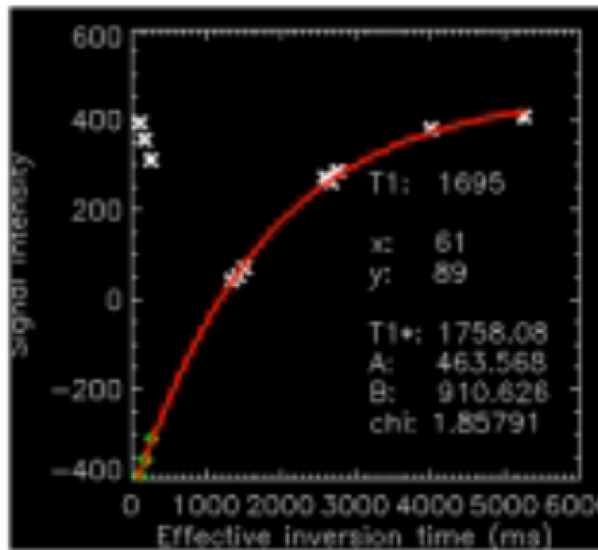
Cartographie T1

- Image T1 (signal): dépend du signal et de la vitesse de relaxation de ce signal après manipulation.
- T1 (ms) = mesure indépendante du signal, de la vitesse de repousse du signal. Différent pour le sang et le myocarde

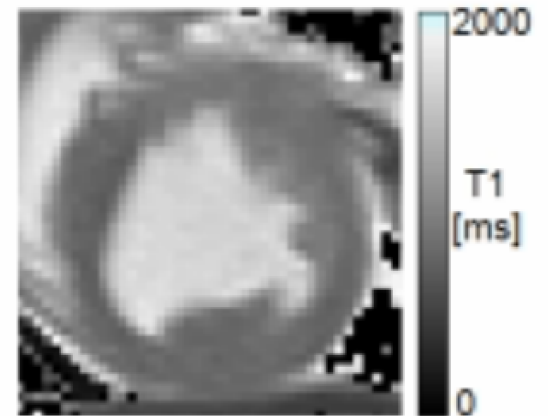
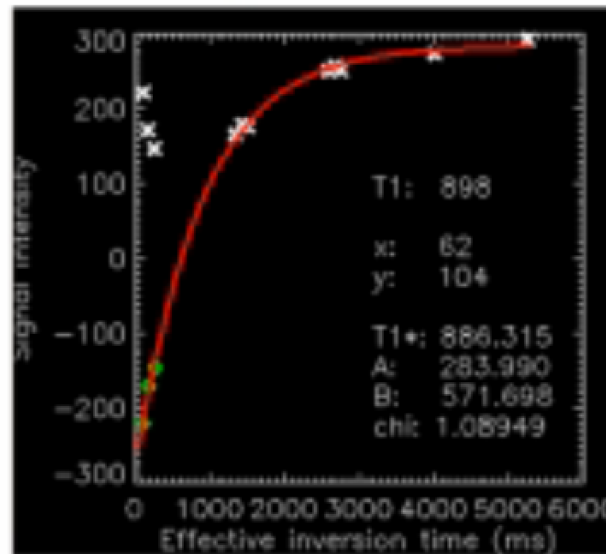


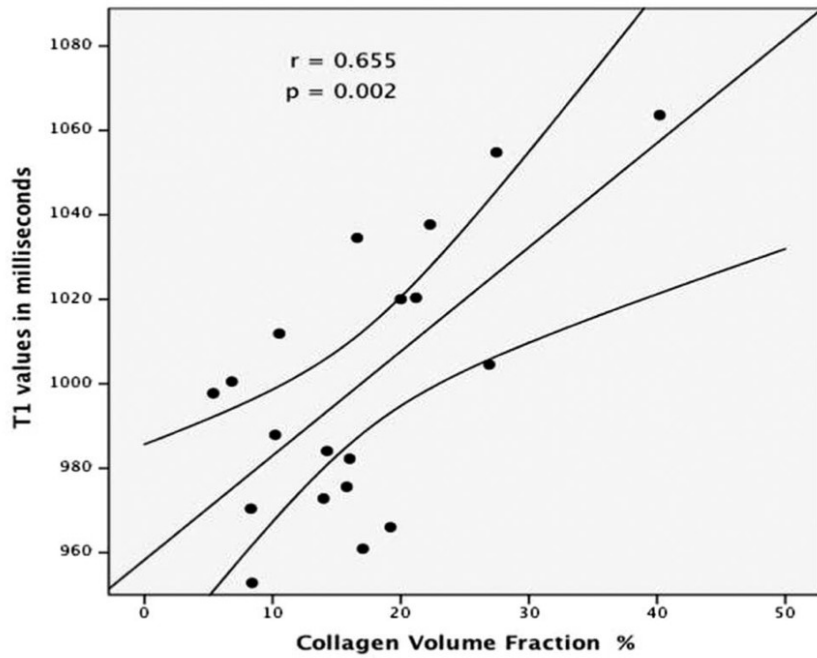
T1

Blood

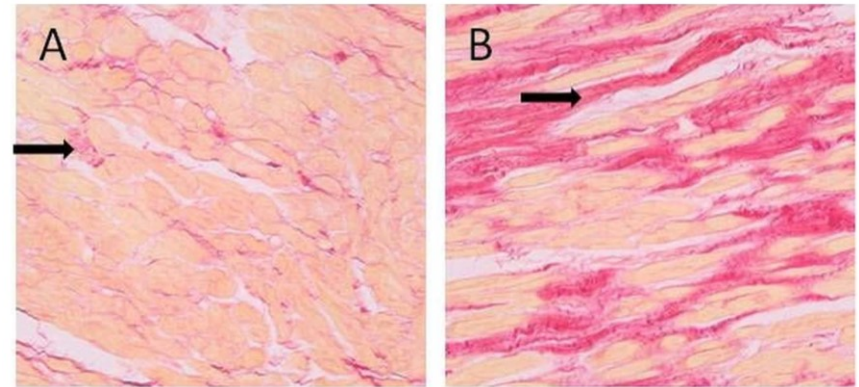


Myocardium



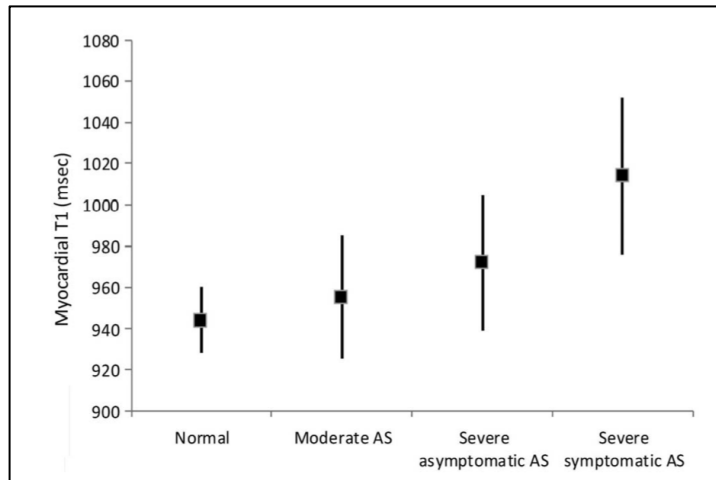


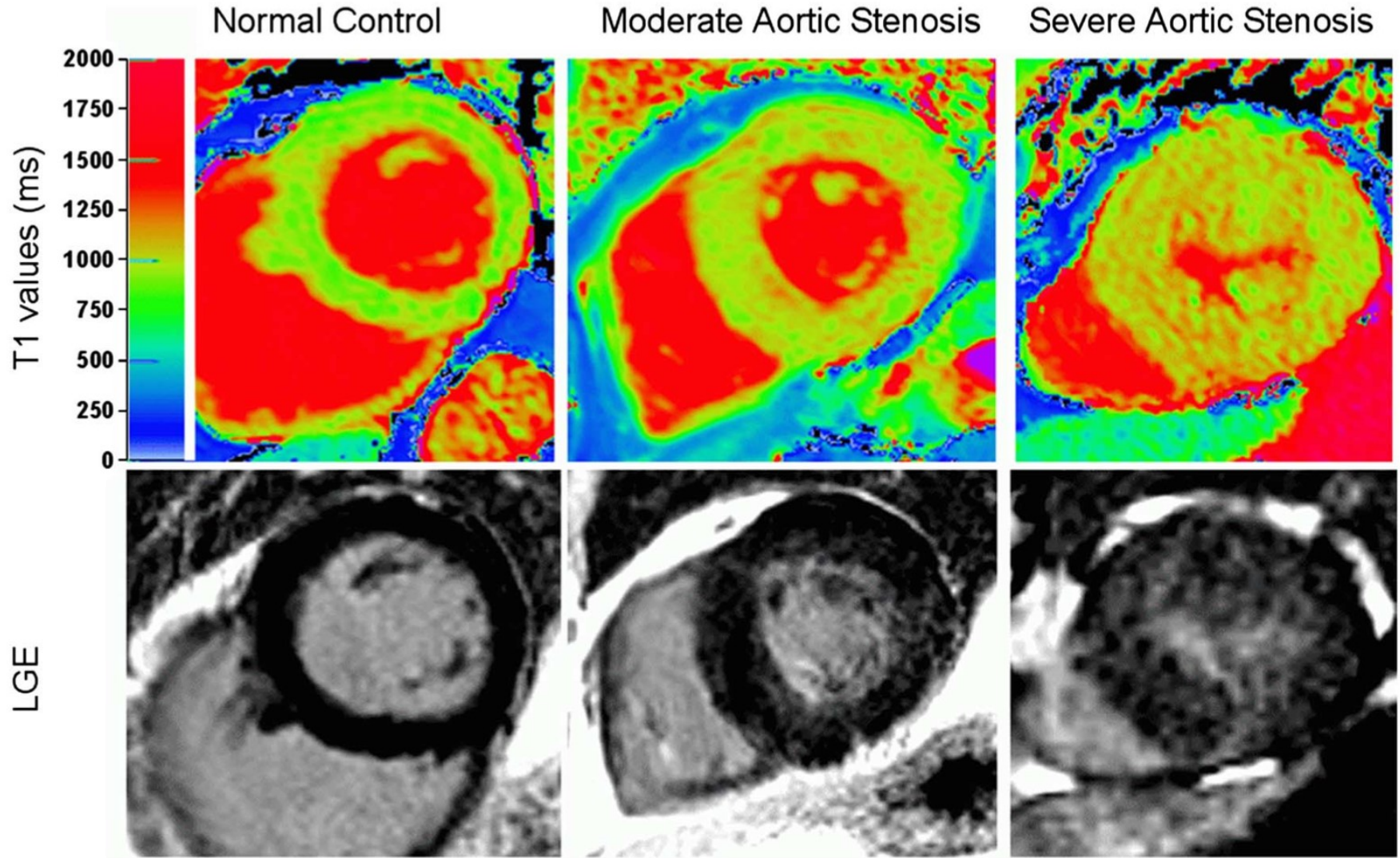
33 témoins
 24 RAC serrés symptomatiques
 84 RAC intermédiaires et serrés
 asymptomatiques



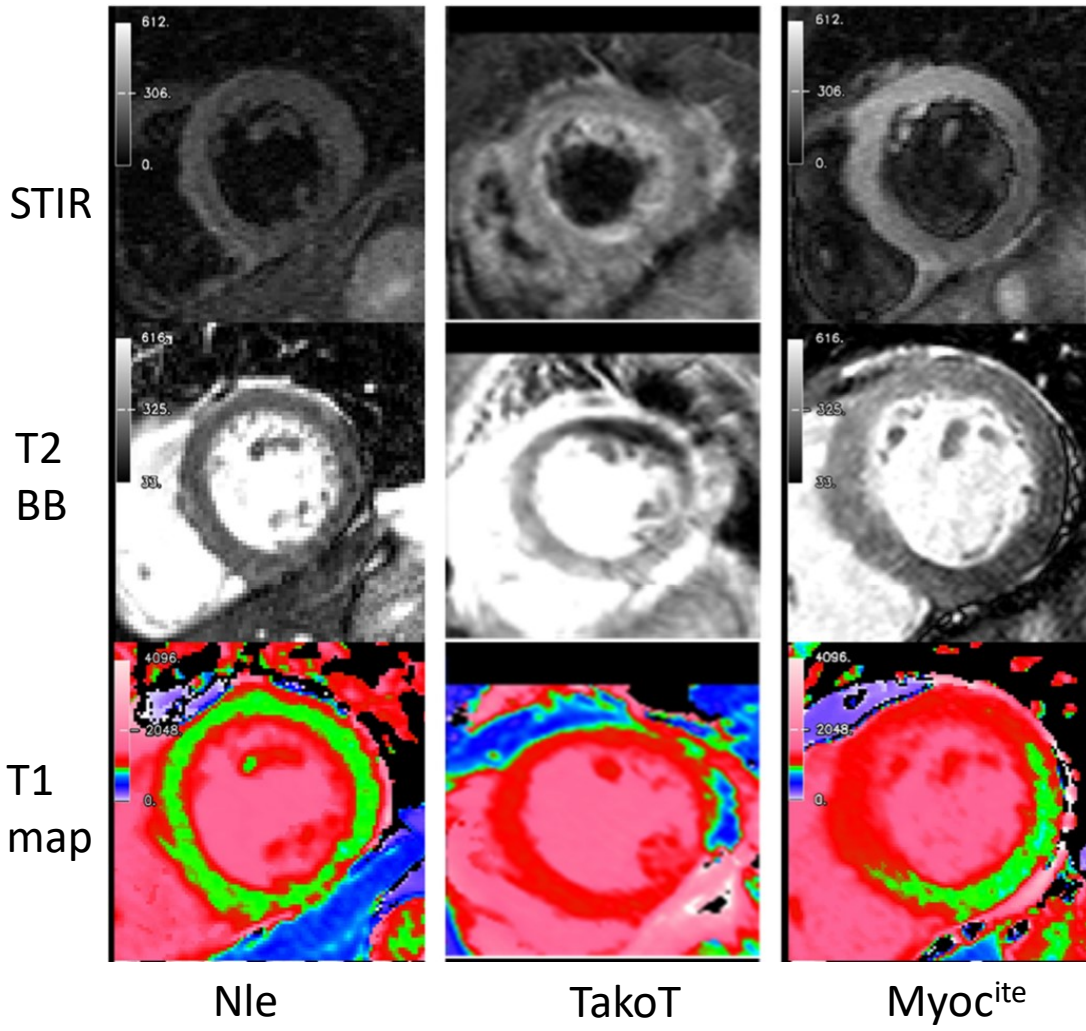
CVF = 8%

CVF = 27%

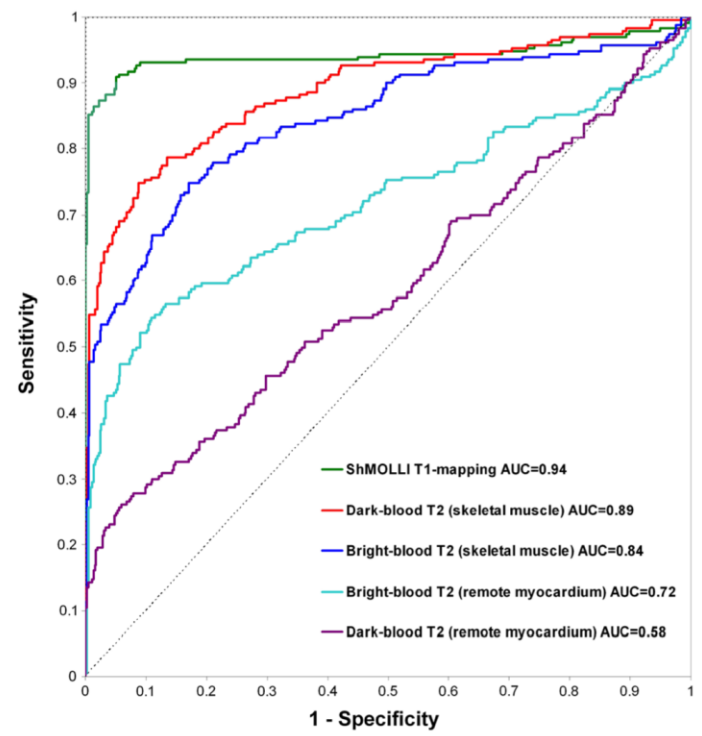




Le T1 natif est-il spécifique de la fibrose ?

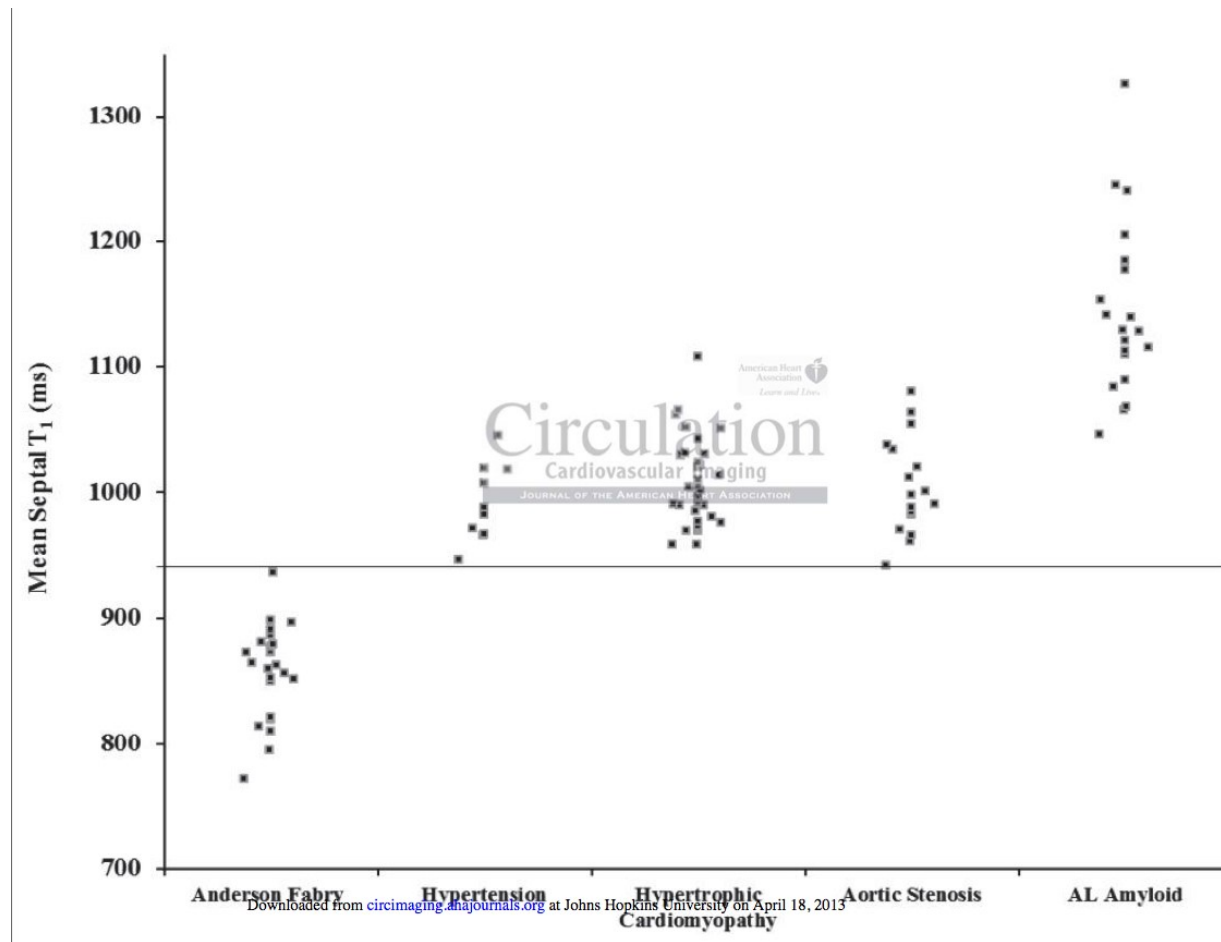


Oedème



Ferreira et al. Journal of Cardiovascular Magnetic Resonance 2012, 14:42

Les lipides et les chaines légères : Fabry et Amylose



Sado, Circ Im 2013

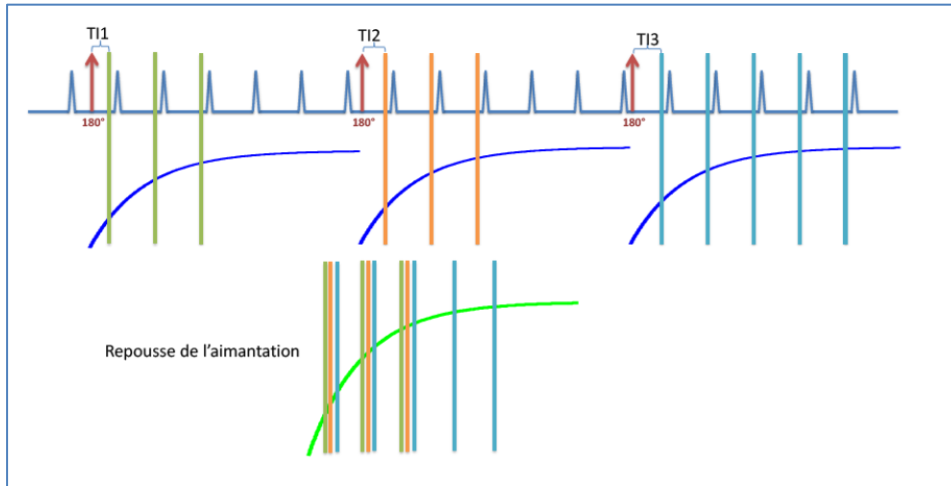
Karamitsos, Moon, JACC im 2013

T1 mapping et fibrose

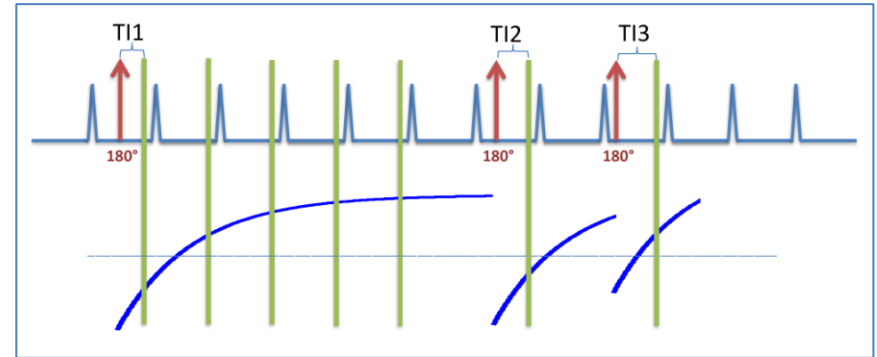
En l'absence de processus aigu oedémateux,
d'amylose ou de Fabry

L'élévation du T1 est très probablement le reflet
d'une élévation de la quantité de fibrose

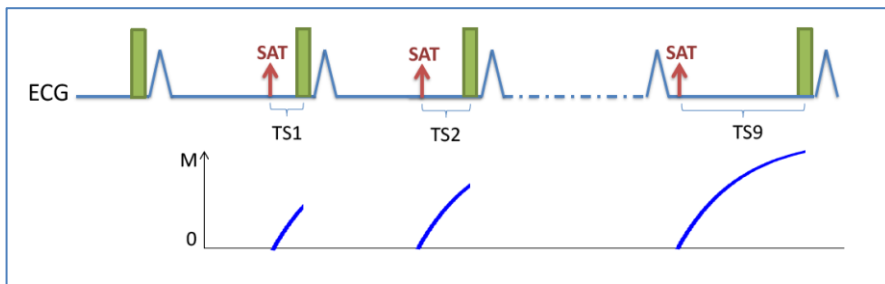
Limites



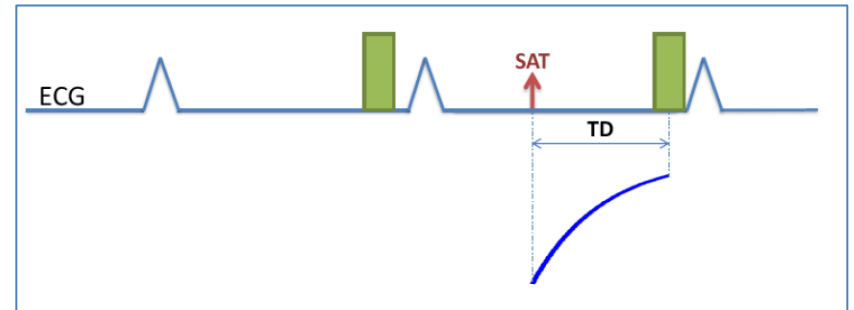
Molly



ShMolly



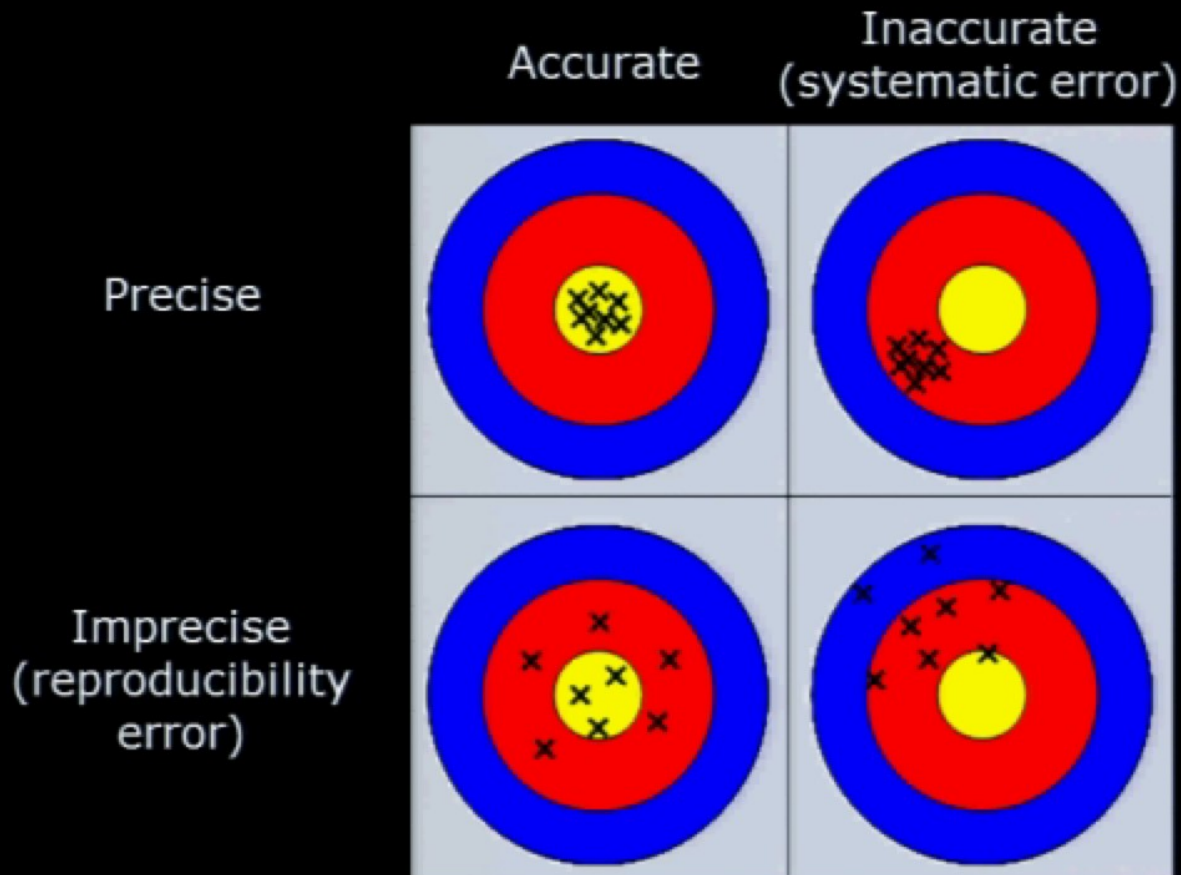
Sasha



AIR

Limites

Accuracy vs Precision:



- Séquence
- Fréquence cardiaque
- Champ 1.5 vs 3T
- Hétérogénéité champ
- Épaisseur de coupe
- Apnée – mouvement
- Flux
- Comparaison intercentres
- 2D

T1 mapping et pronostic (arythmies)



**TRAVAUX
EN COURS**

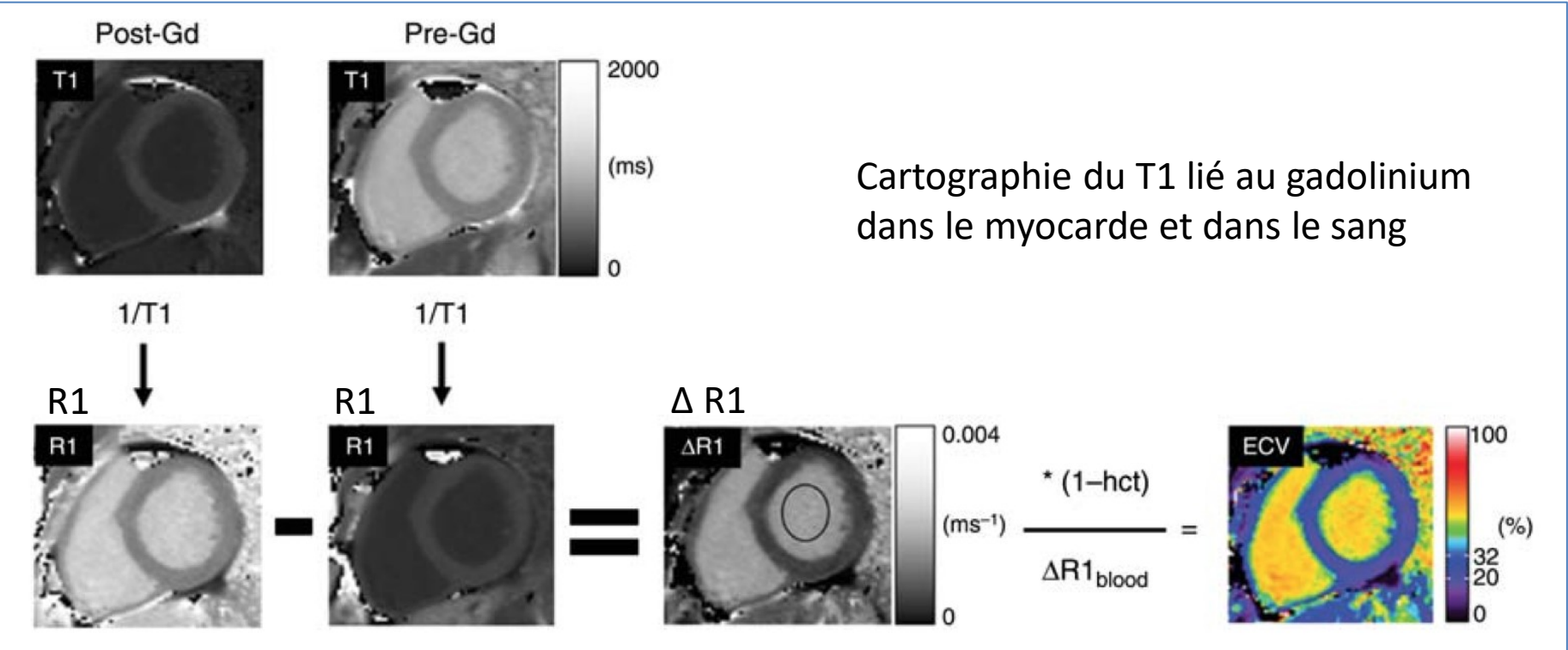
Volume extra-cellulaire : VEC

- $1/T1 = R1$
- Variation de $1/T1$ ($\Delta R1$) entre après Gd et avt Gd $\approx [Gd]$

- T1 (ms)
 - Œdème (% d'eau)
 - Cinétique du chélate de Gd
- Extracellular volume (% extracellular spa)
 - Fibrose, nécrose, inflammation, oedème



Myocardial Extracellular volume



Cartographie du T1 lié au gadolinium dans le myocarde et dans le sang

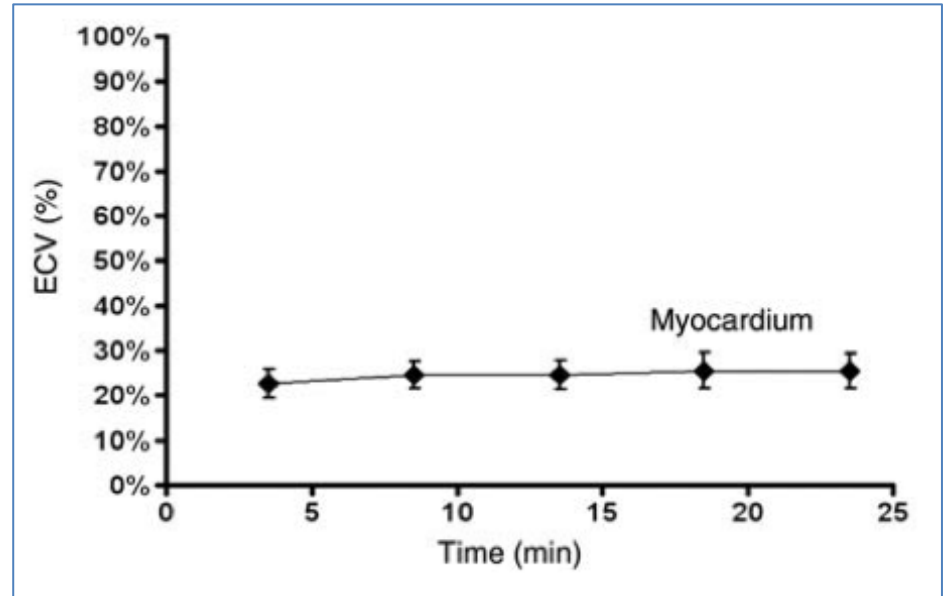
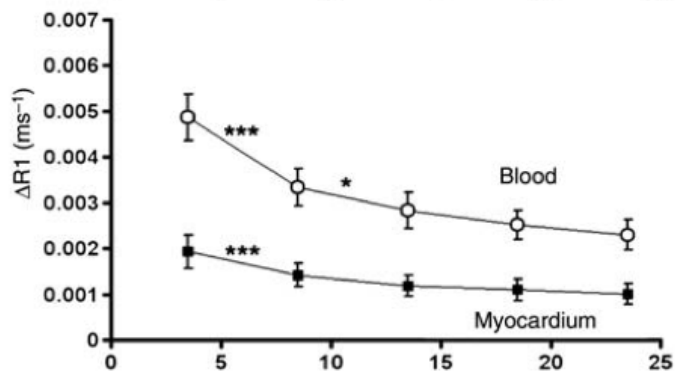
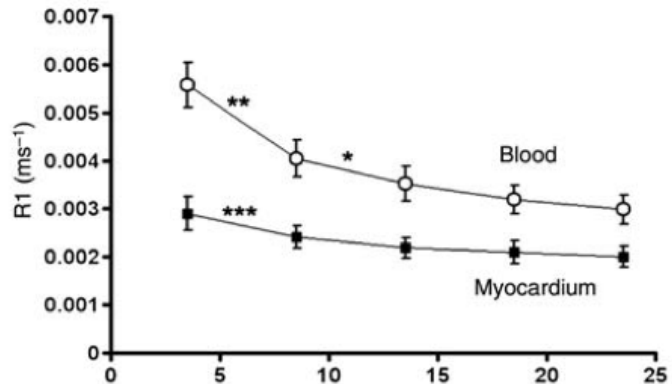
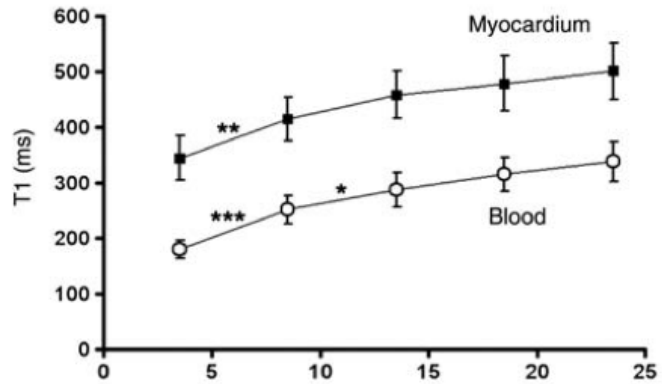
= relative [Gd]

ECV map

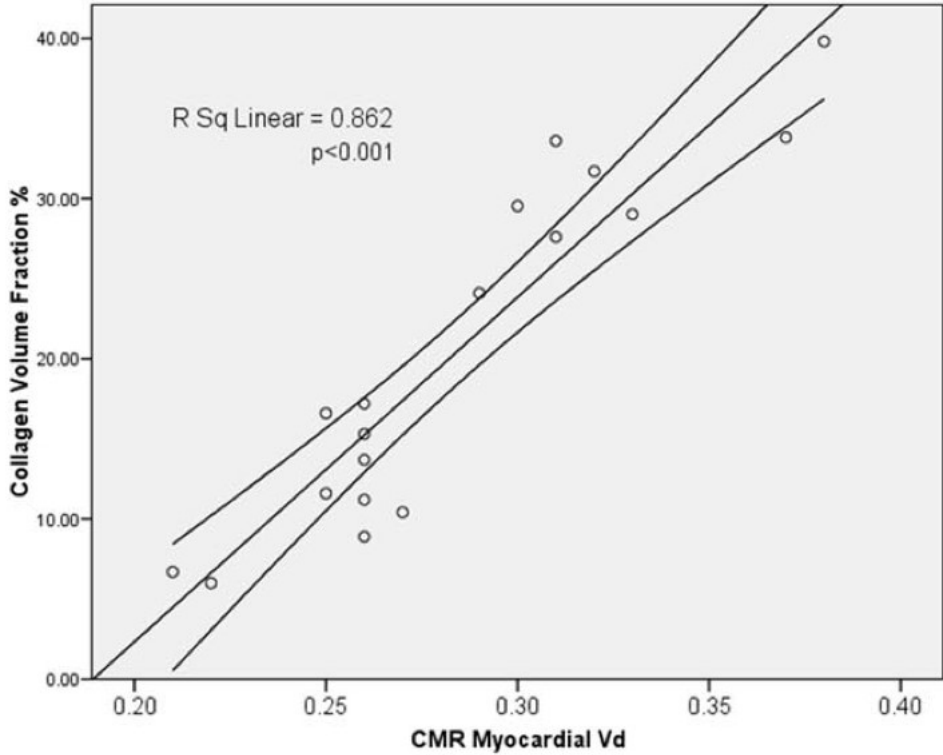
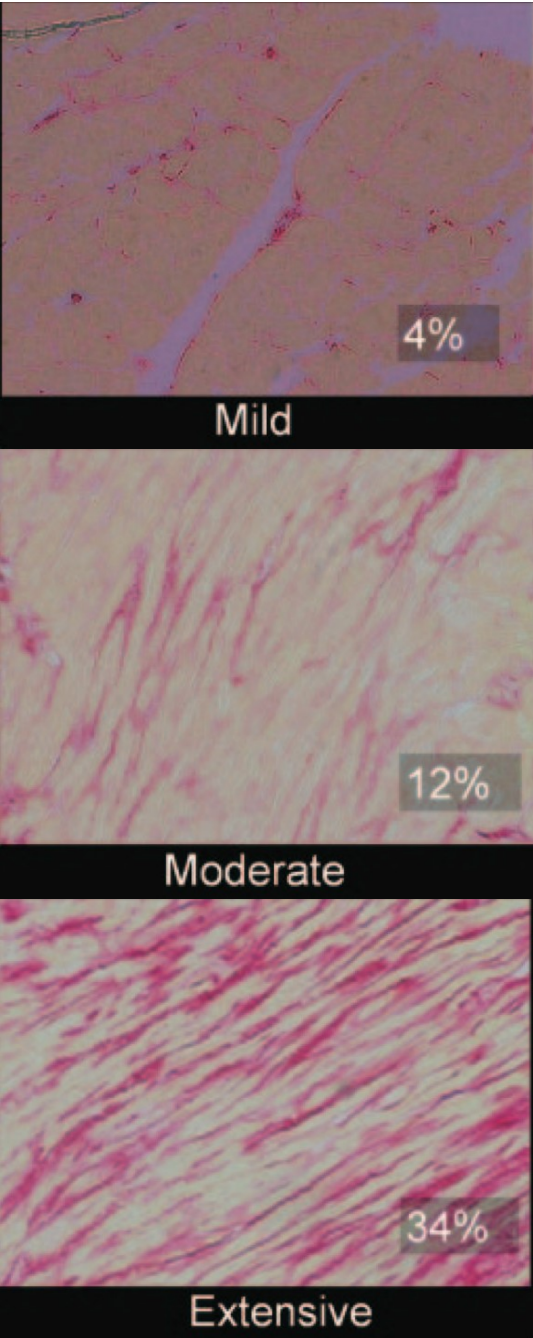
$$ECV = (1 - hematocrit) \frac{\left(\frac{1}{T1_{myo\ post}} - \frac{1}{T1_{myo\ pre}} \right)}{\left(\frac{1}{T1_{blood\ post}} - \frac{1}{T1_{blood\ pre}} \right)}$$

Ugander M, et al, Eur Heart J, 2012

Dans le myocarde sain et le sang

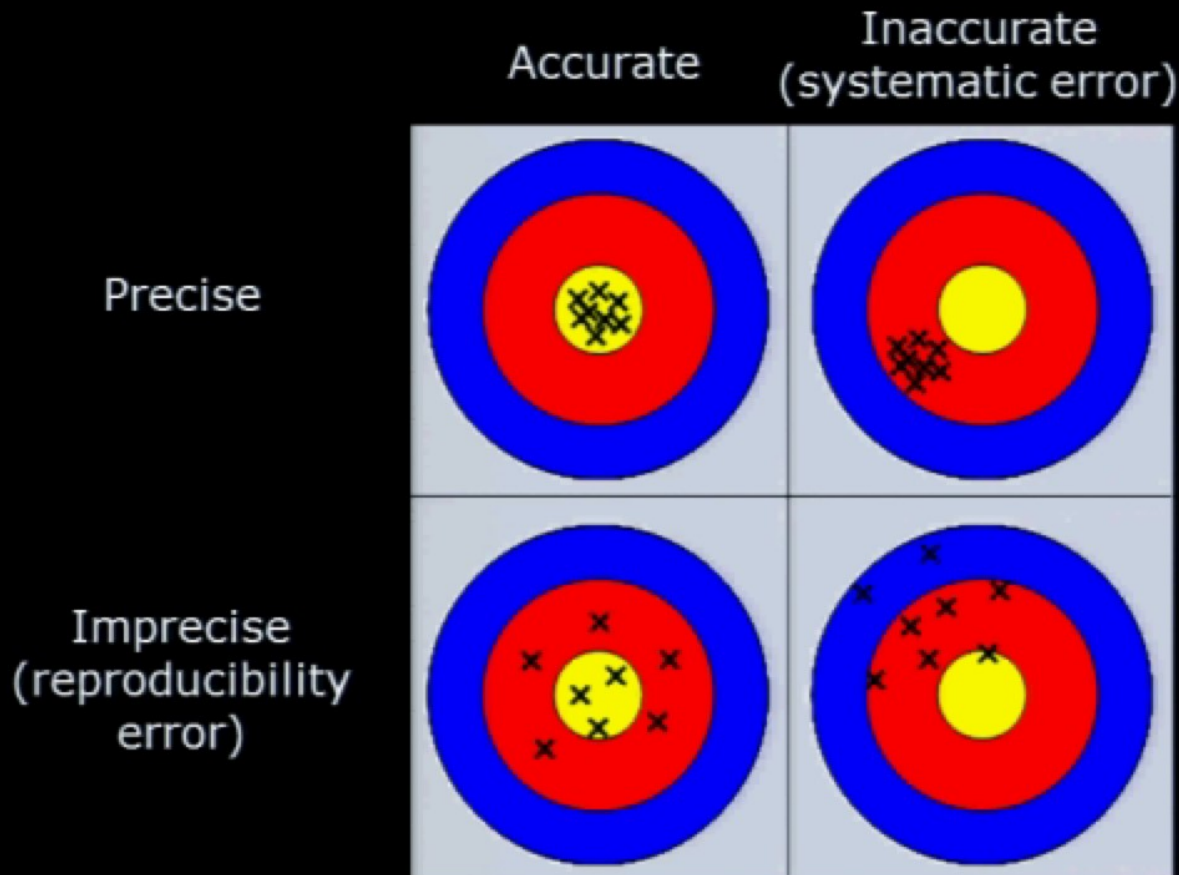


Hors situation aigue et hors amylose



Limites VEC : rapport

Accuracy vs Precision:



- Séquence
- Fréquence cardiaque
- Champ 1.5 vs 3T
- Hétérogénéité champ
- Épaisseur de coupe
- Apnée – mouvement
- Flux
- Comparaison intercentres
- 2D

- Nécessité Gd-DOTA

ECV et pronostic (arythmies)



**TRAVAUX
EN COURS**