

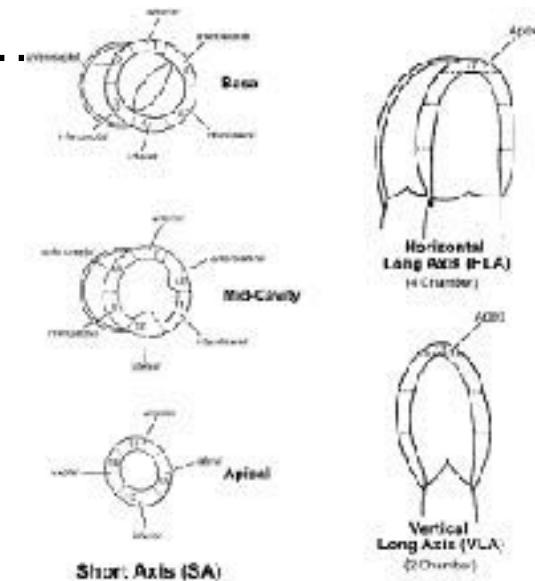
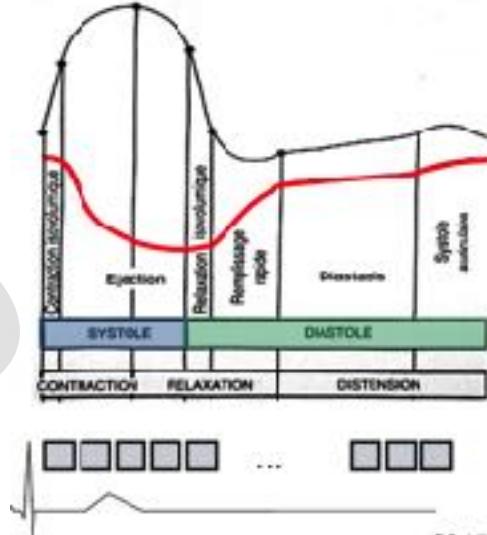
# Techniques d'imagerie en IRM cardiaque

*P.Croisille*

## B-A-BA de l'imagerie cardiaque...

Consiste à :

- Evaluer la fonction globale ventriculaire (VG)
  - analyse quantitative
  - résultats attendus: VTD / VTS, FE, Masse...
- Evaluer la fonction régionale VG
  - au repos
  - et/ou sous stress inotrope...



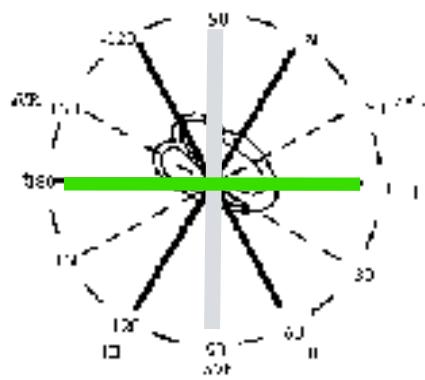
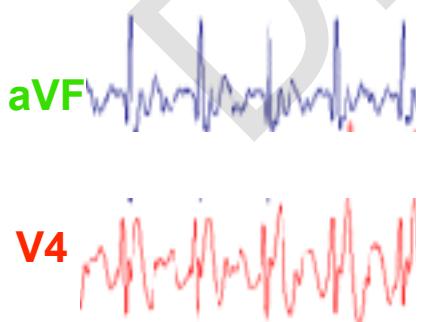
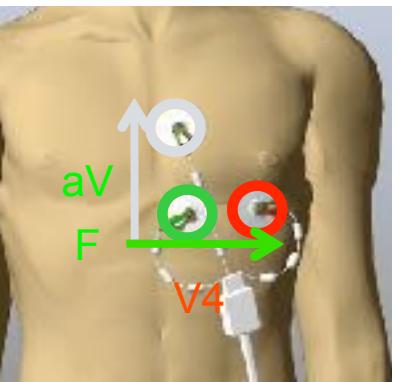
# Synchronisation ECG/Electrodes:



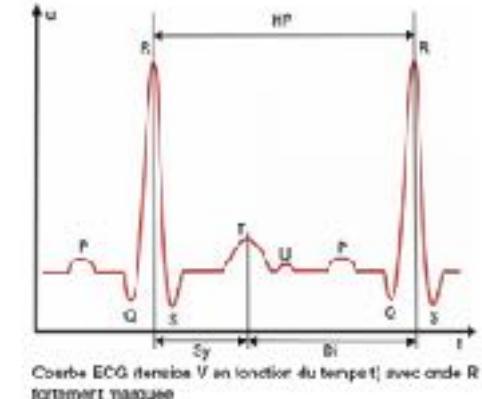
Electrode Actives



Electrodes Classiques

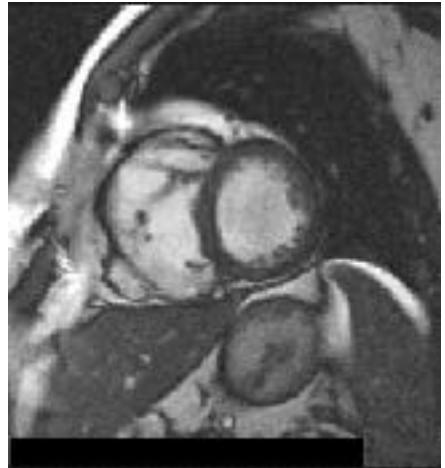


VCG

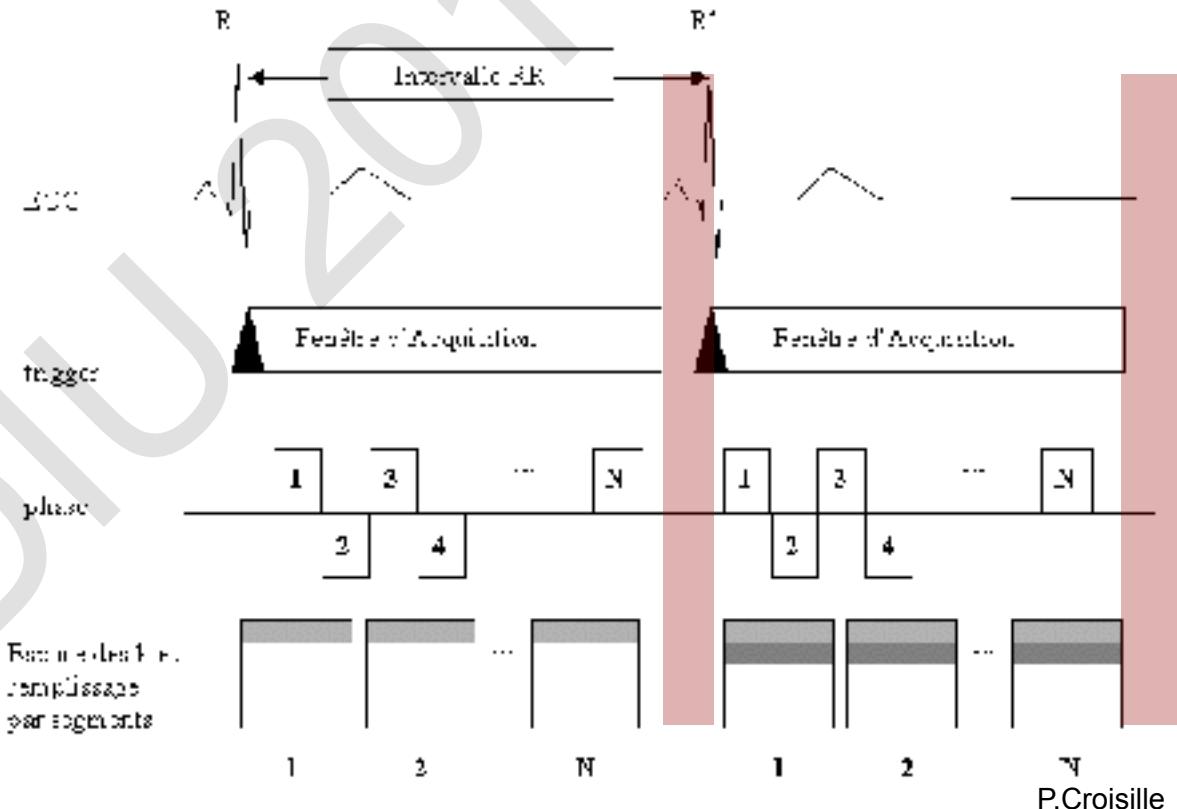


# Acquisition segmentée synchronisée à l'ECG





## Synchronisation prospective.

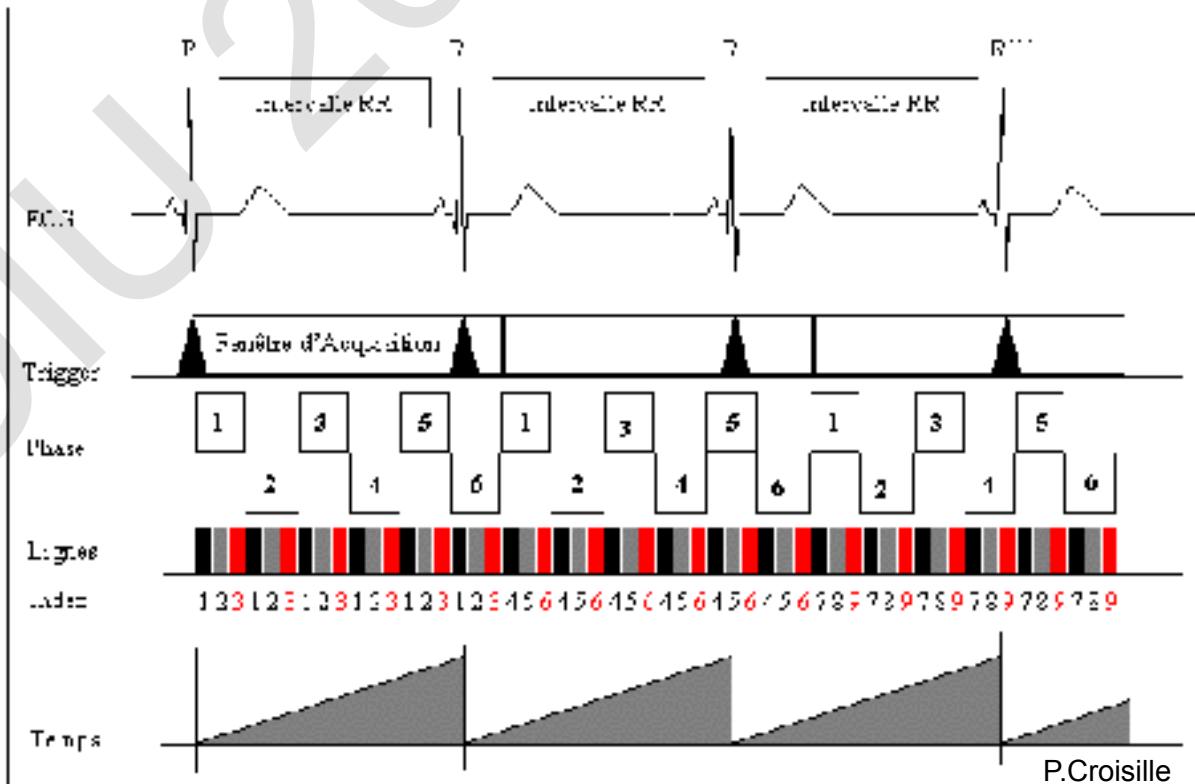


# Synchronisation rétrospective.

Réservée à l'imagerie ciné, la synchronisation rétrospective est le moyen optimal pour enregistrer le mouvement cyclique du cœur sur la totalité du cycle cardiaque. L'acquisition du signal est effectuée en continu, et sans délai entre la fin de l'acquisition et la prochaine onde R.

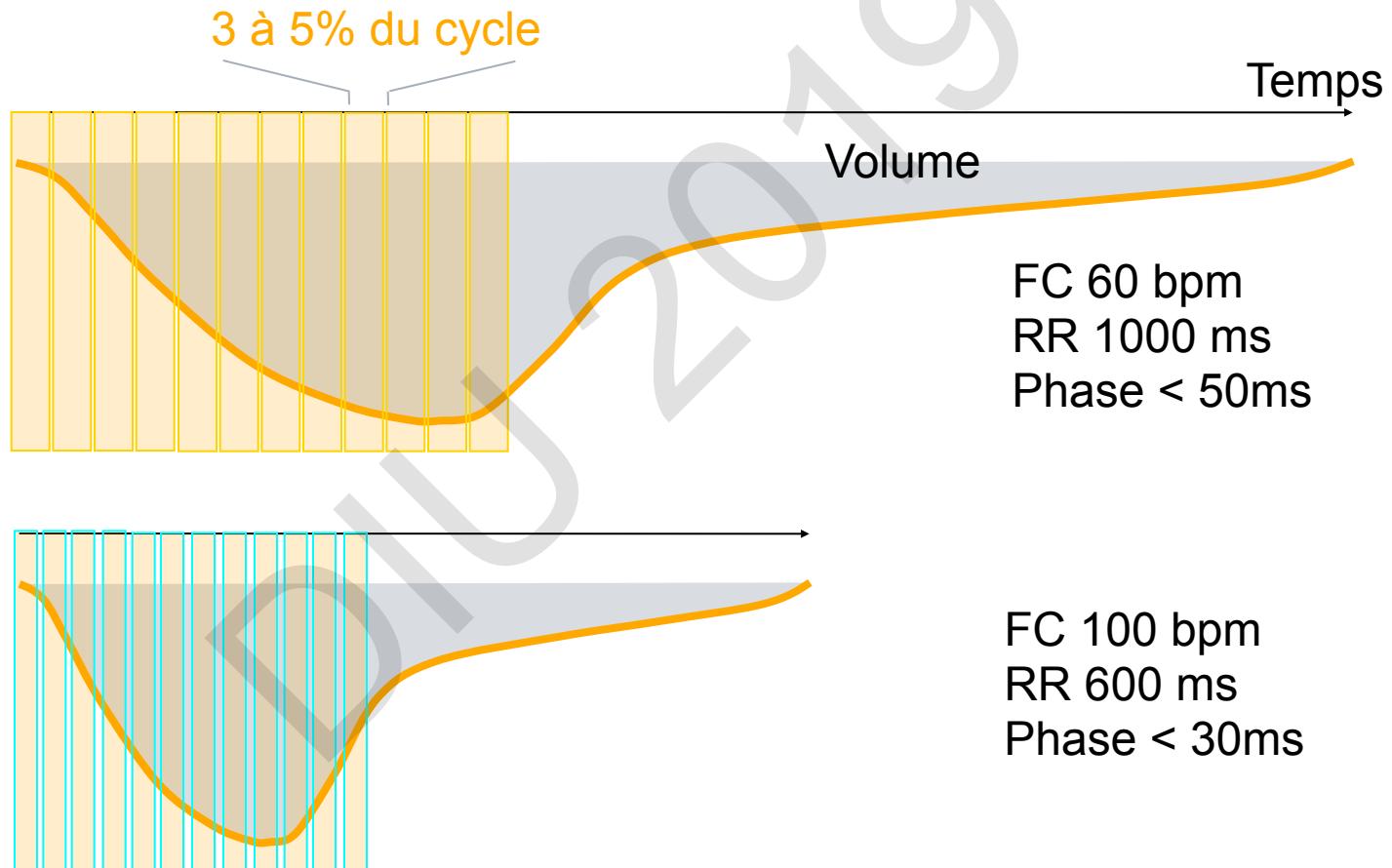
- RR  
->  $F.Acq = RR - \Delta RR$

- $F.Acq$  et RR cible  
->  $RT = 5\% (RR)$   
-> # phases min

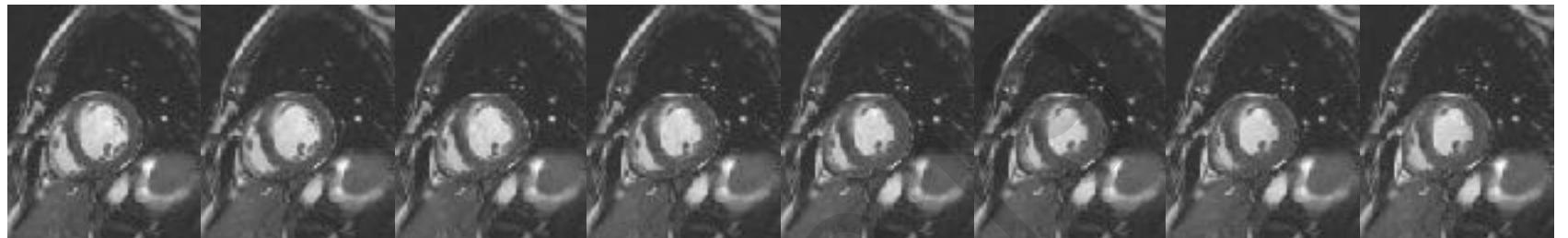


## Choix de résolution temporelle

Ajuster la résolution temporelle à la Fréquence Cardiaque!



## Choix de résolution temporelle



*En pratique:*

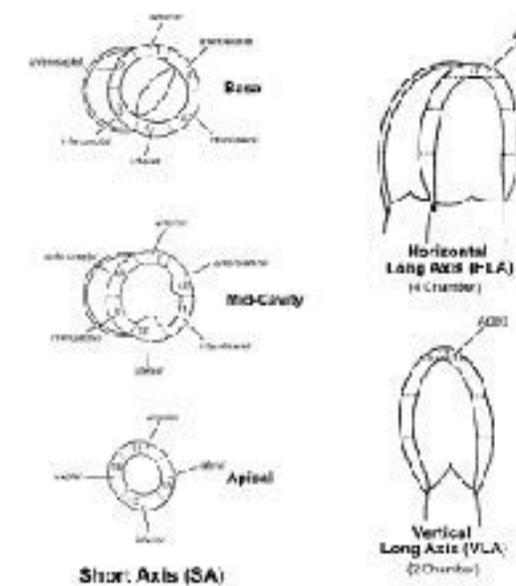
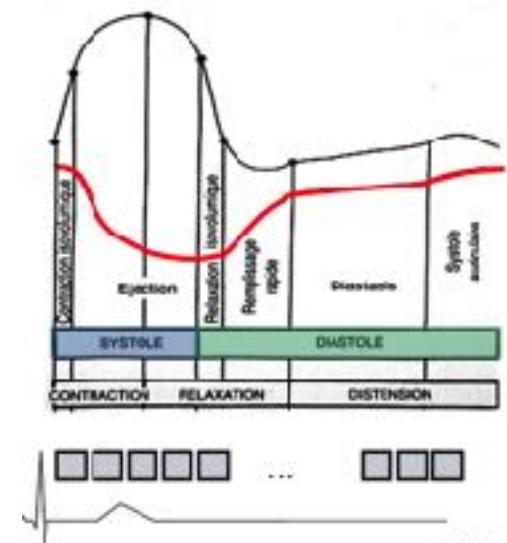
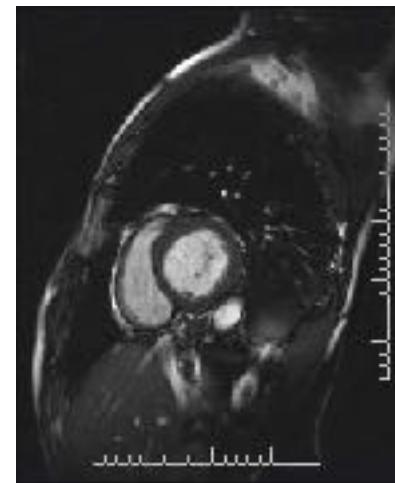
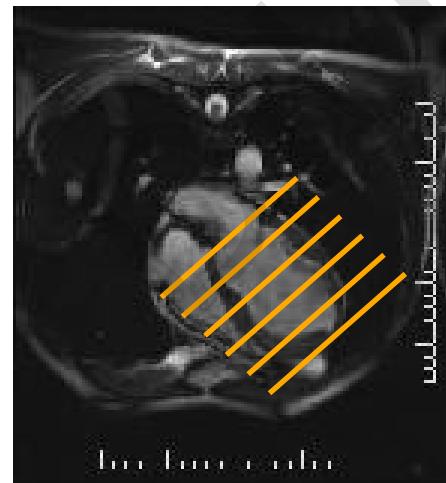
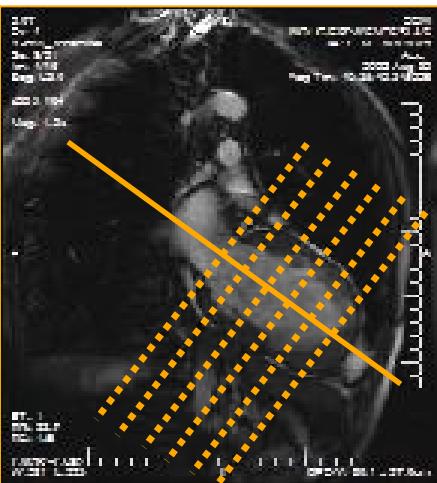
- Nombre de phase / résolution temporelle telle que résolution temporelle ne sous-estime pas VTS et FE !
- RT choisie telle que chaque phase représente 3-5% RR
- Ex: RR 1000ms      RT<50ms  
RR 600ms            RT<30ms

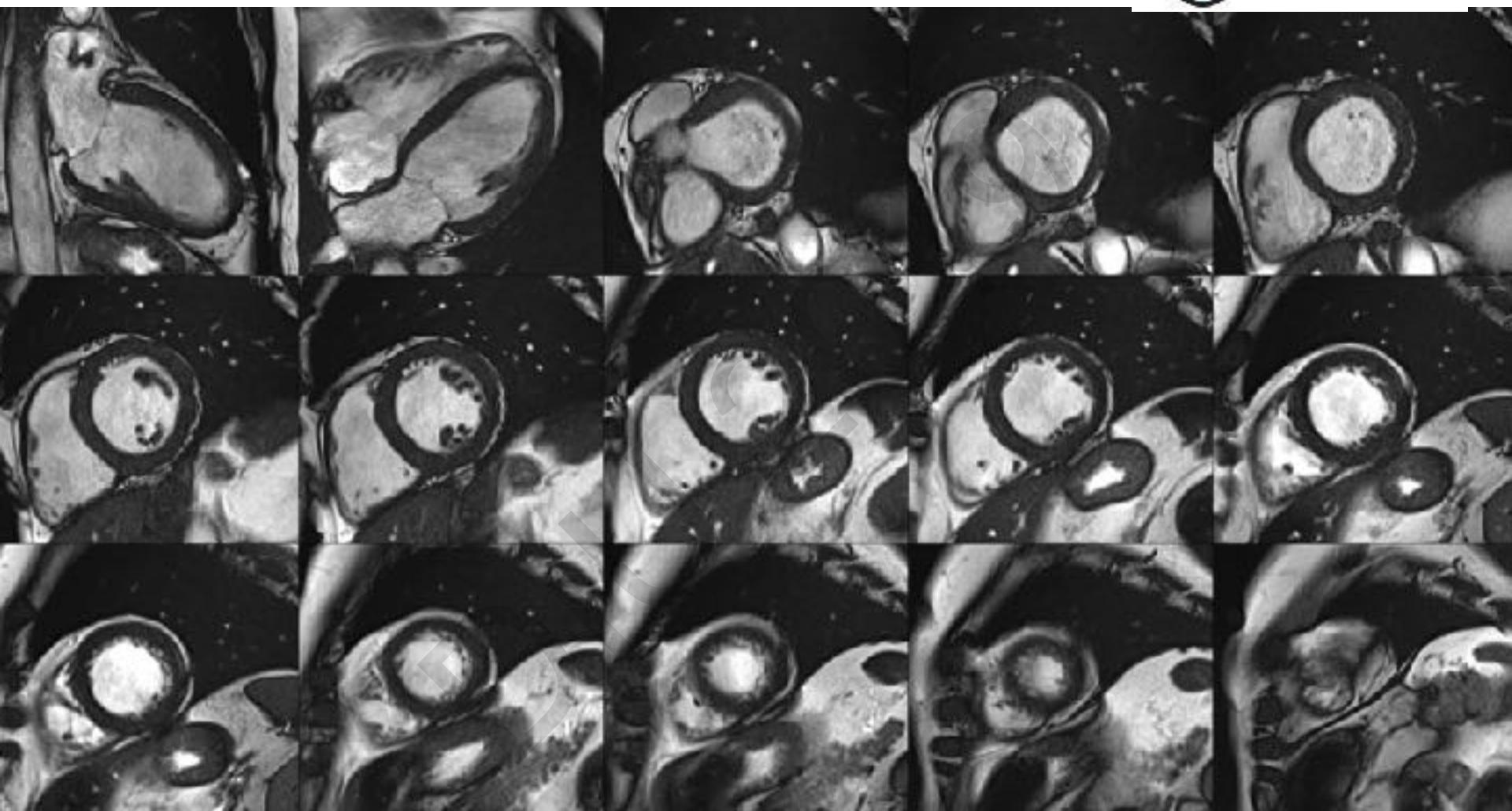
## Protocole 'Bilan de fonction VG'

Cine 2 cav

Cine 4 cav

Pile de PA: ~8 cine PA  
réparti de la base à l'apex.





ATTENTION AUX PLANS...!!!!

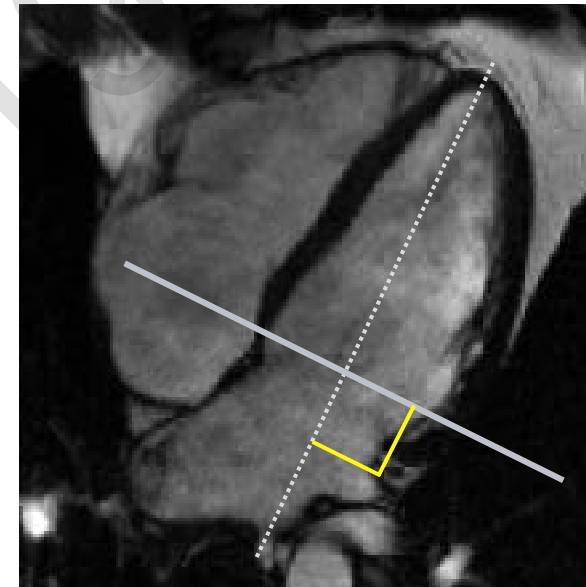
EXEMPLES.....

DIU 2019

# ATTENTION AUX PLANS...!!!!



NON



OUI

Risques encourus pour la quantification de la fonction VG:

- Surestimation de la masse (effet de volume partiel)
- Mauvaise reproductibilité des résultats

AFFICHER 2cav ET 4cav en diastole!!!!.....

DIU 2019

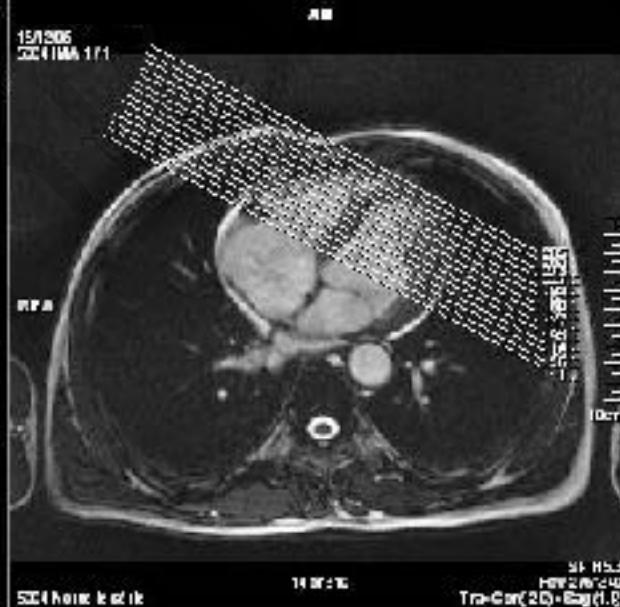


Patient Name:			
Patient ID: 1000001-66 Date: 15/2/05			
Patient Height: 162.00 cm. Patient Weight: 72.00 kg. HeartRate: 60/min			
Cardiac Function			Normal Range (N) (%)
Ejection Fraction			50 - 70
End Diastolic Volume			11.0 - 17.0
End Systolic Volume			7.0 - 12.0
Stroke Volume			5.0 - 10.0
Contractility			50 - 70
Myocardial Mass (g/kg)			78.00 - 92.00
Myocardial Mass (kg)			56.00 - 62.00
Filling and Ejection Data			
Peak Ejection Rate			1.2
Peak Ejection Time			1.4
Peak Filling Rate			1.2
Peak Filling Time (ms)			1.4

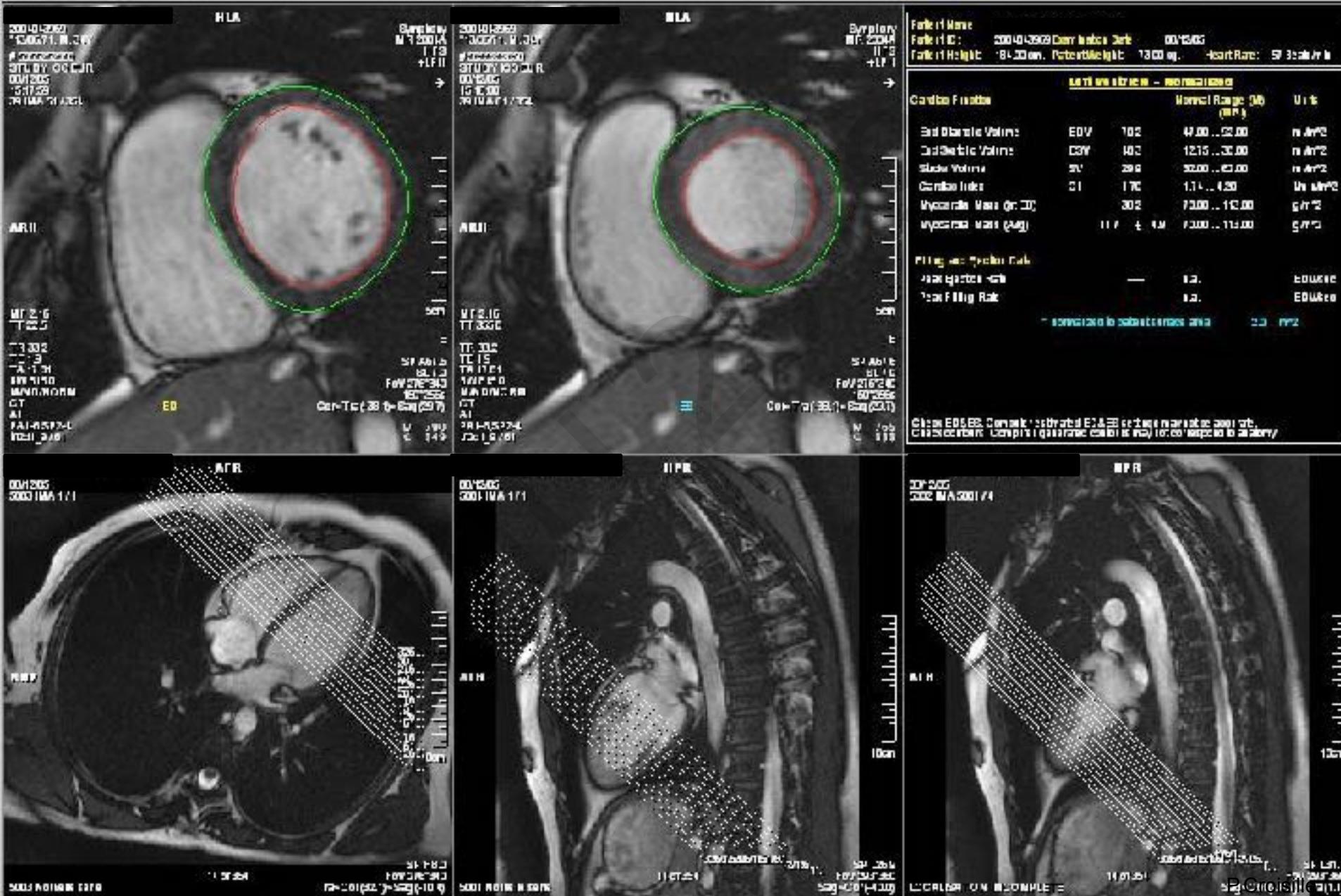
Click CBG/CDG/CPG/PRG/STG/STD/STG/STD/STG to change study type.

Click segment, complete generated contours and recompute to calculate.

Left Ventricle - Normalized				
Cardiac Function	Normal Range (N) (%)	Mean	SD	
End Diastolic Volume	EDV	45.0	10.00 - 32.00	40.0
End Systolic Volume	ESV	20.1	12.10 - 30.00	20.0
Stroke Volume	SV	24.9	32.00 - 62.00	30.0
Contractility	CI	—	—	60.00 - 70.00
Myocardial Mass (g/kg)	MM	78.0	70.00 - 86.00	80.0
Myocardial Mass (kg)	MM	56.0	42.00 - 62.00	52.0
Filling and Ejection Data				
Peak Ejection Rate	—	1.2	0.70 - 0.90	
Peak Filling Rate	—	1.2	0.80 - 0.90	
Peak Ejection Time (ms)	—	1.4	1.00 - 1.80	
Peak Filling Time (ms)	—	1.4	1.00 - 1.80	



Echbert Application | Enregistrer | Edition | Affichage | Image | Outils | Défillement | Analyse | Système | Options | Aide



## Quel choix d'épaisseur et distance intercoupe?

Yves Cottin, MD  
Claude Touzez, PhD  
Françoise Gay, MD  
Main Lalande, PhD  
Olivier Fessemeau, MD  
Sophie Ray, MD  
Paul M. Walker, PhD  
Pierre Louis, MD  
François Brunelle, MD  
Jean Eric Wolf, MD

INSTITUT  
Hôpital Saint-Louis, 58, 91  
Hoche, HB, 51, 21492, 51, 12142  
Hoche, 51, 12142  
Hoche, volume, 51, 52  
Magnetic resonance (MR), cineventricu-  
laires, 51, 12142  
Magnetic resonance (MR), volume  
measurements, 51, 12142  
51, 12142  
Synthesis, 51, 52  
*Radiology* 1998; 211:513-520

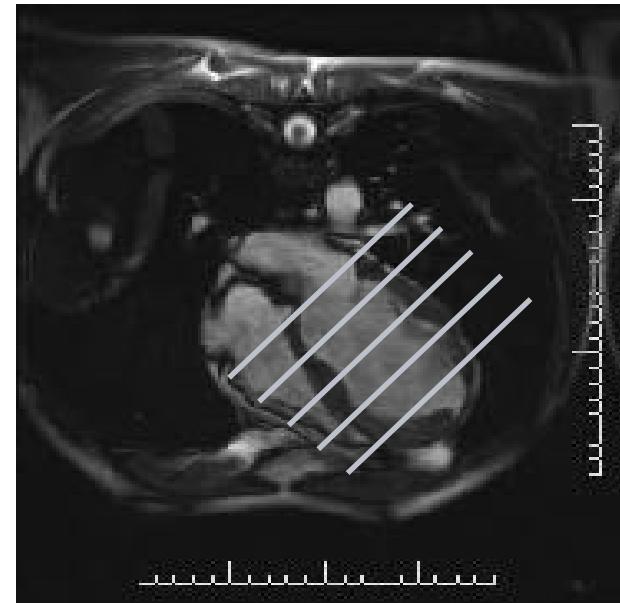
### MR Imaging of the Heart in Patients after Myocardial Infarction: Effect of Increasing Intersection Gap on Measurements of Left Ventricular Volume, Ejection Fraction, and Wall Thickness<sup>1</sup>

**PURPOSE:** To determine the extent to which the number of planes imaged at magnetic resonance (MR) imaging could be reduced without modifying the calculated volume and thickness of the left ventricle.

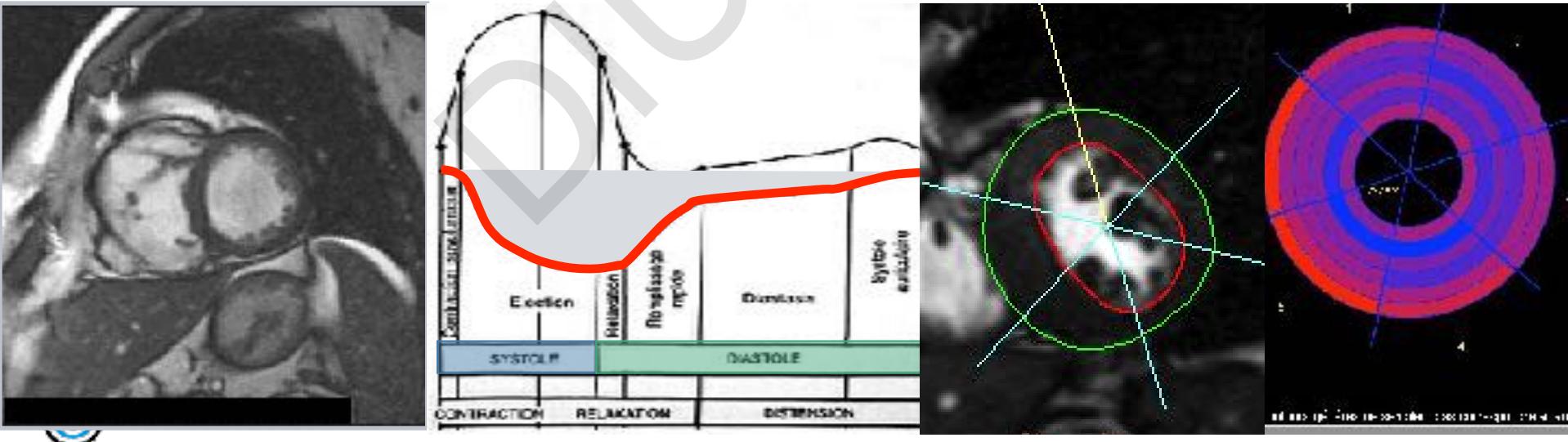
**MATERIALS AND METHODS:** Sixty-one patients were examined after myocardial infarction. The whole left ventricle was imaged by using 5-mm contiguous breath-hold cine MR slices (no intersection gap [SA]) from diastole to late systole.

### *En pratique:*

- 6 ou 7mm tous les 6/7mm (jointif)
- jointif base et apex (gap en médian)  
un bon compromis (économie de quelques coupes)

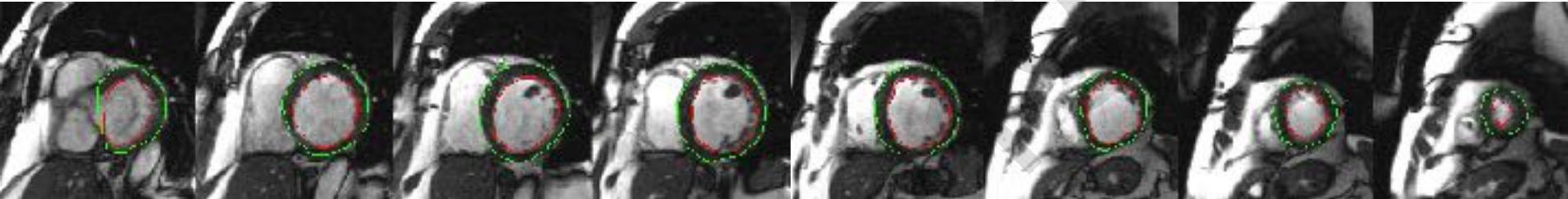


# Post-traitement fonction VG

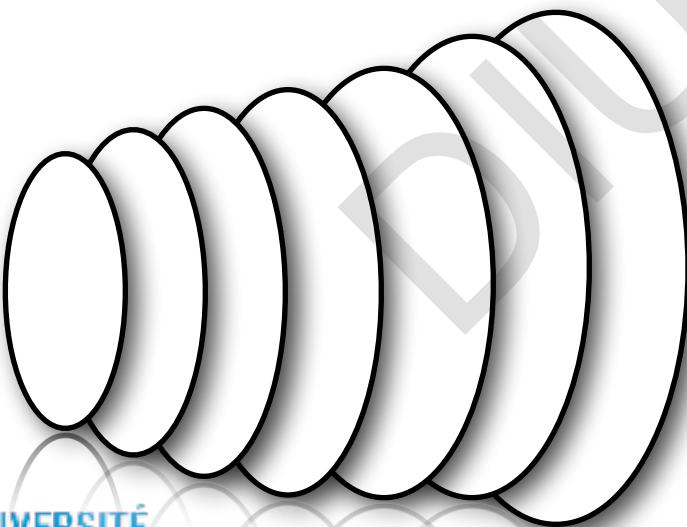


# Quantification de la fonction VG

## Méthode de Simpson



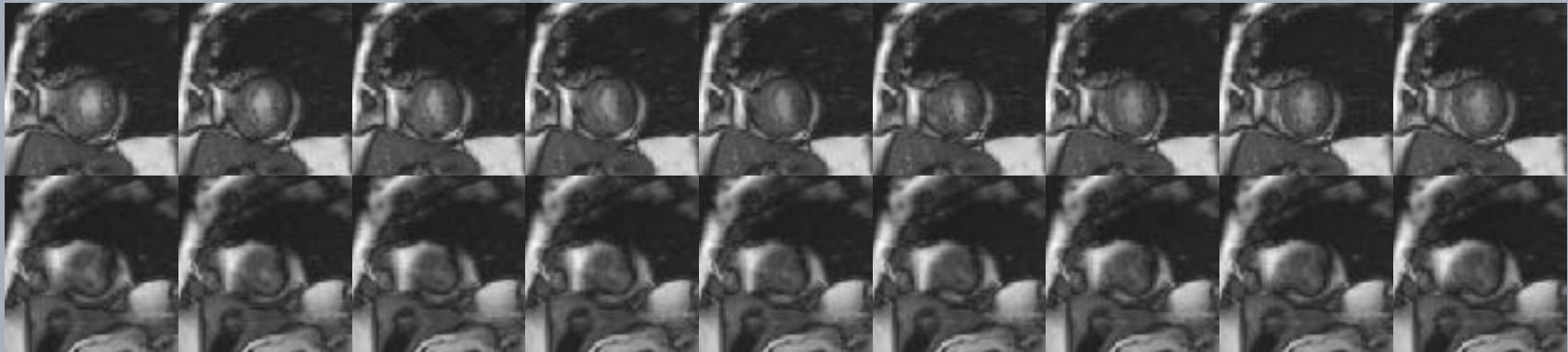
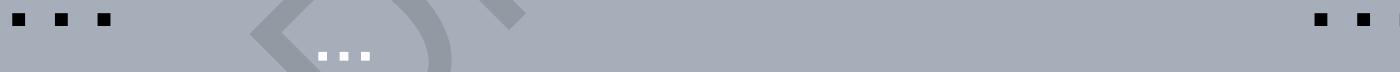
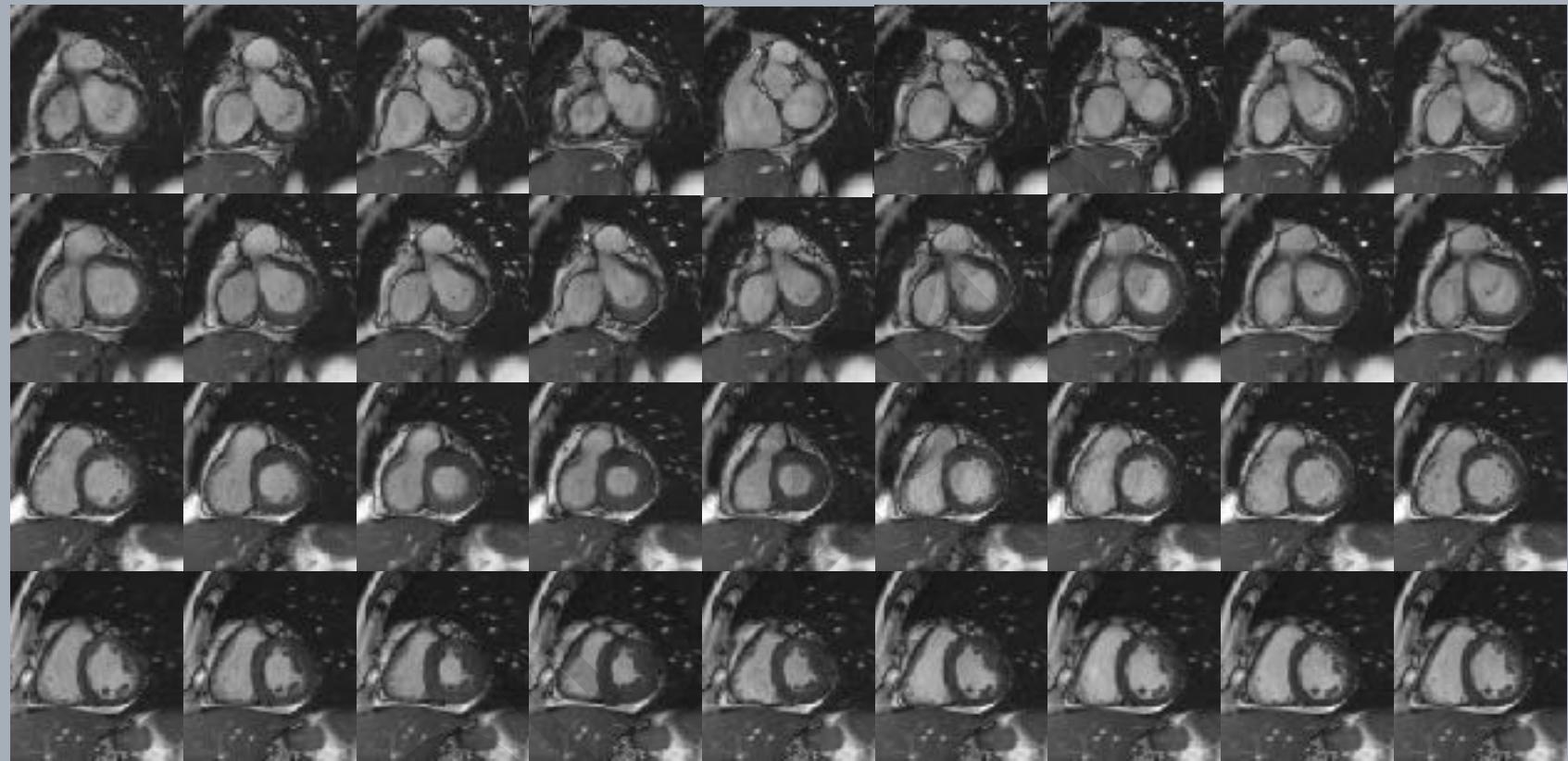
Volume Ventricule =  $\Sigma$  ( aire sous endocardique  
x distance facteur )



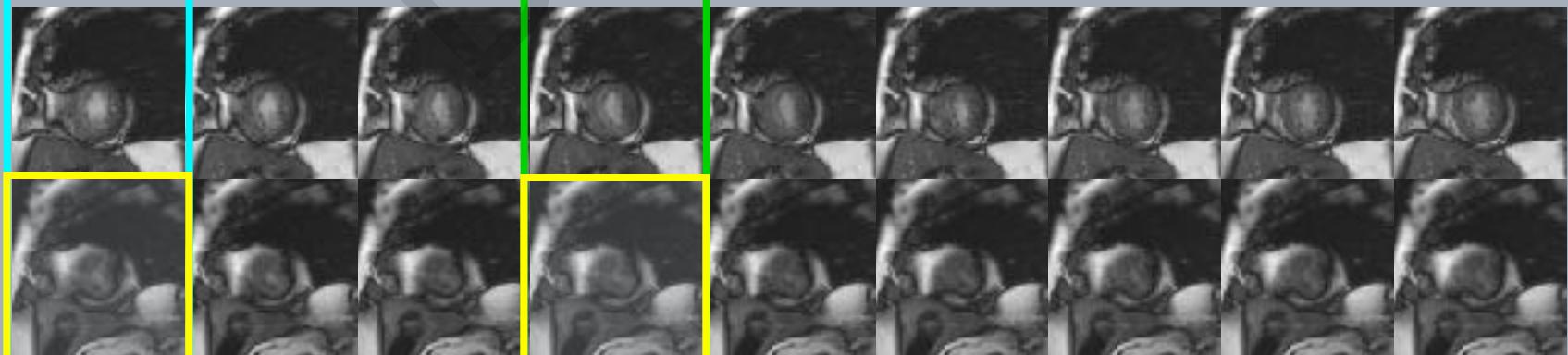
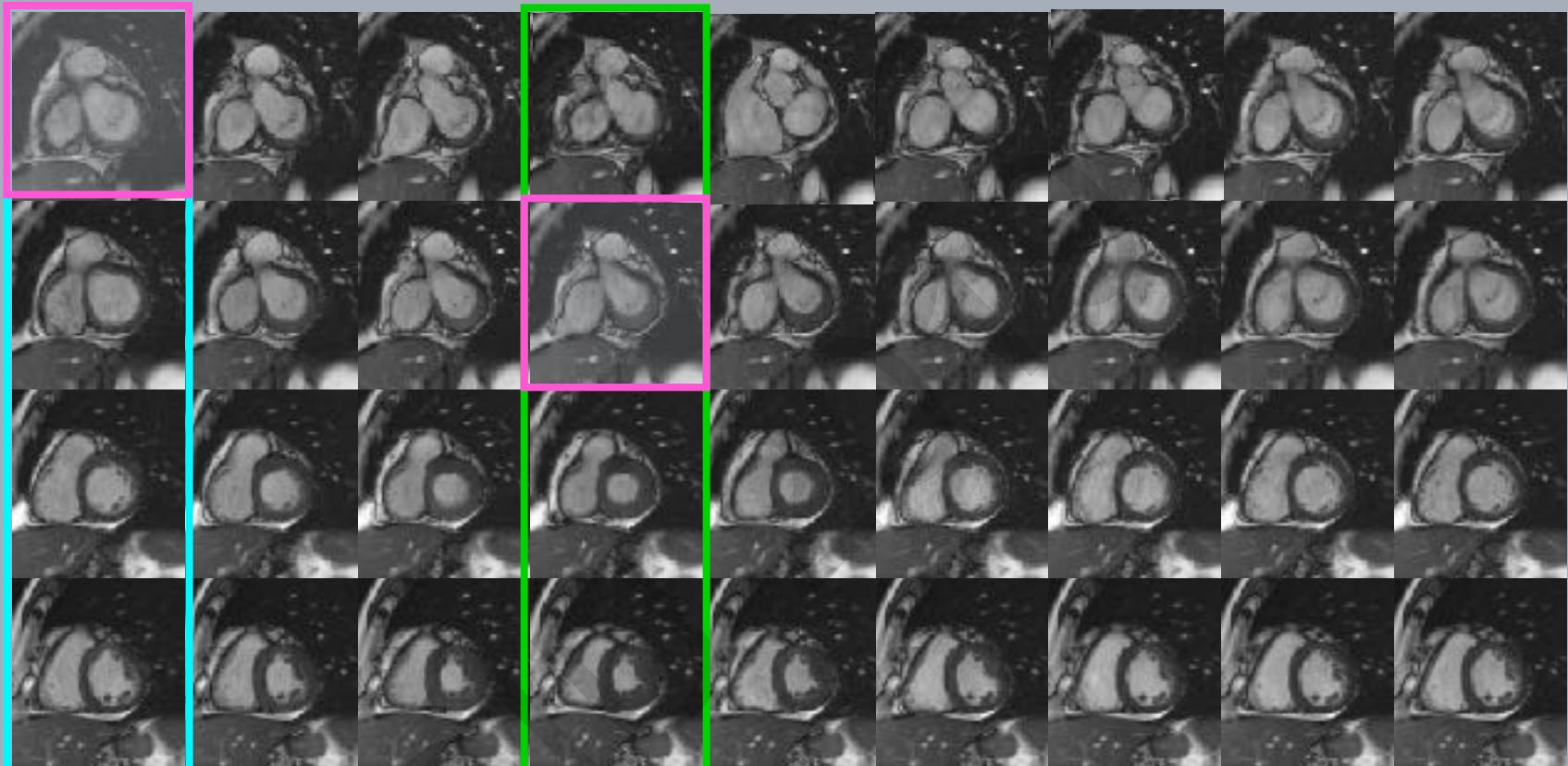
Pas d'hypothèses géométriques  
Méthode de référence (CMP  
ischémiques ou CMH)

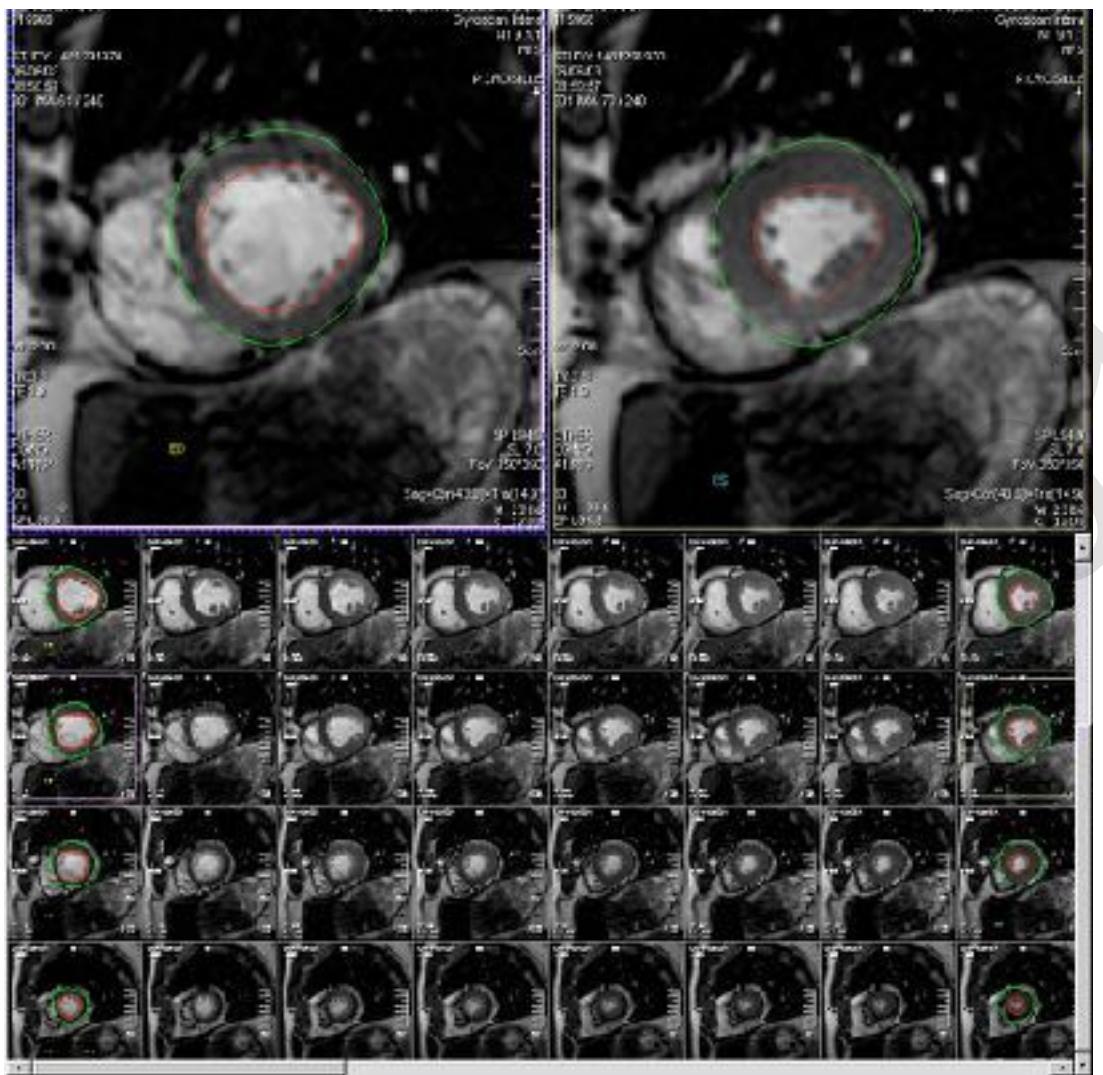
# Matrice d'image PA

Temps →



Définir la diastole Définir la systole Définir la Base Définir l'apex





New patient:  
 Patient: 0410-6 Date de location: 16/02/2014  
 Taille patient: 183.0 cm - Poids patient: 83.0 kg - Région: Estomac - Etat: Normal

Ventricule gauche - normalisé				
		Volume en ml (0-100)	Unité	
Volume d'excavation	EFG	9.2	17.00 .. 34.00	ml/ml
Volume d'excavation	IVS	1.0	17.00 .. 34.00	ml/ml
Volume basculement	EV	2.0	32.00 .. 62.00	ml/ml
Volume basculement	IC	—	—	ml/ml
Volume myocardique initial (MI)	MI	1.2	70.00 .. 113.00	ml/ml
Volume myocardique final (MF)	MF	0.2	0.00 .. 11.00	ml/ml

Durées remplissage et éjection

Temps d'éjection moy.	—	0.5	PRéciser
Temps remplissage moyen	—	0.5	PRéciser

Répartition: Moy. 1 patient: 1.7 - 100

Temps d'éjection moyen: 0.5 s - Temps remplissage moyen: 0.5 s - Temps total: 1 s - Temps de repos: 0.5 s - Temps de contraction: 0.5 s

Patient: 0410-6 Date de location: 16/02/2014  
 Taille patient: 183.0 cm - Poids patient: 83.0 kg - Région: Estomac - Etat: Normal

Ventricule gauche - sténose				
		Volume en ml (0-100)	Unité	
Pré éjection	EFG	40.7	56.00 .. 78.00	%
Volume d'excavation int.	IVS	10.5	11.0 .. 19.0	%
Volume d'excavation	EFG	9.2	17.00 .. 34.00	ml
Volume basculement	EV	2.0	32.00 .. 62.00	ml
Volume basculement	IC	—	—	ml/ml
Volume myocardique (MI)	MI	1.2	70.00 .. 113.00	ml
Volume myocardique final (MF)	MF	0.2	0.00 .. 11.00	ml

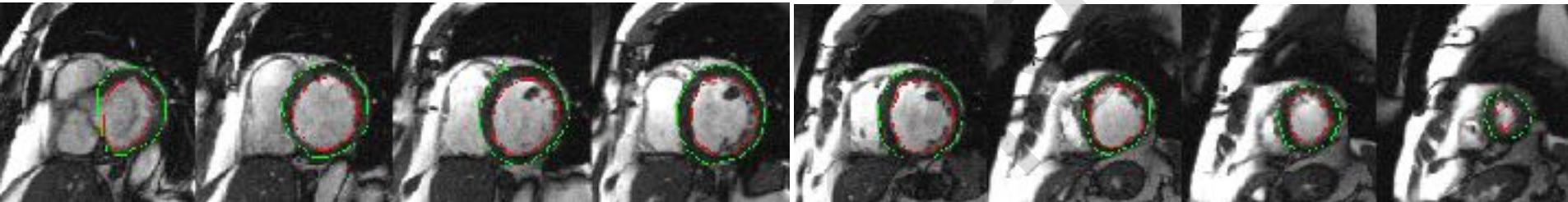
Durées remplissage et éjection

Contraction moy.	—	0.5	PRéciser
Temps d'éjection moy.	—	0.5	PRéciser
Temps remplissage moyen	—	0.5	PRéciser
Temps remplissage moyen (MI)	—	0.5	PRéciser

Temps d'éjection moyen: 0.5 s - Temps remplissage moyen: 0.5 s - Temps total: 1 s - Temps de repos: 0.5 s - Temps de contraction: 0.5 s

# Quantification de la fonction VG

## Méthode de Simpson



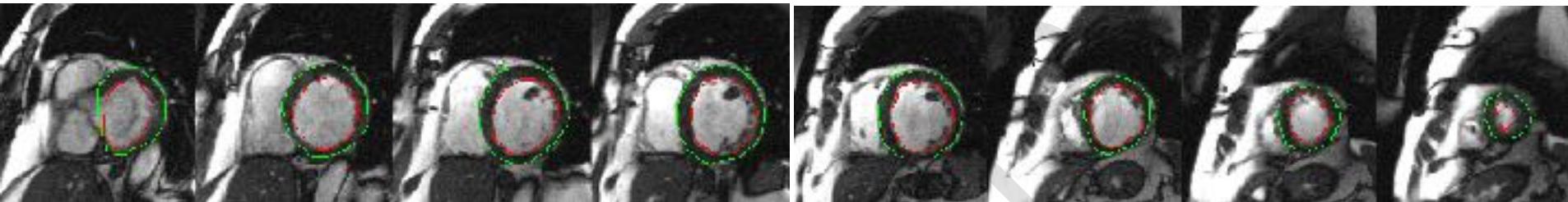
2 méthodes

Muscles  
papillaires exclus

CH Lorenz et al. Cardiovasc  
Magn Reson 1:7, 1999

Muscles  
papillaires inclus

Sandstede et al. Eur  
Radiol. 10, 438-442 (2000)



A partir des contours en téldia stole  
et en télésystole on peut extraire les paramètres:

- Volume diastolique VTD (ml)
- Volume systolique VTS (ml)
- Volume d'éjection systolique  $VES=VTD-VTS$  (ml)

-Fraction d'Ejection  $FE=(VTD-VTS)/VTD$  (%)

## Paramètres fonction VG

Valeurs indexées / surface corporelle en (m<sup>2</sup>)

Surface corporelle (BSA) = poids<sup>0.425</sup> x taille<sup>0.725</sup> x  
0.007184 (*poids en kg –taille en m*)

# Quantification de la fonction VG

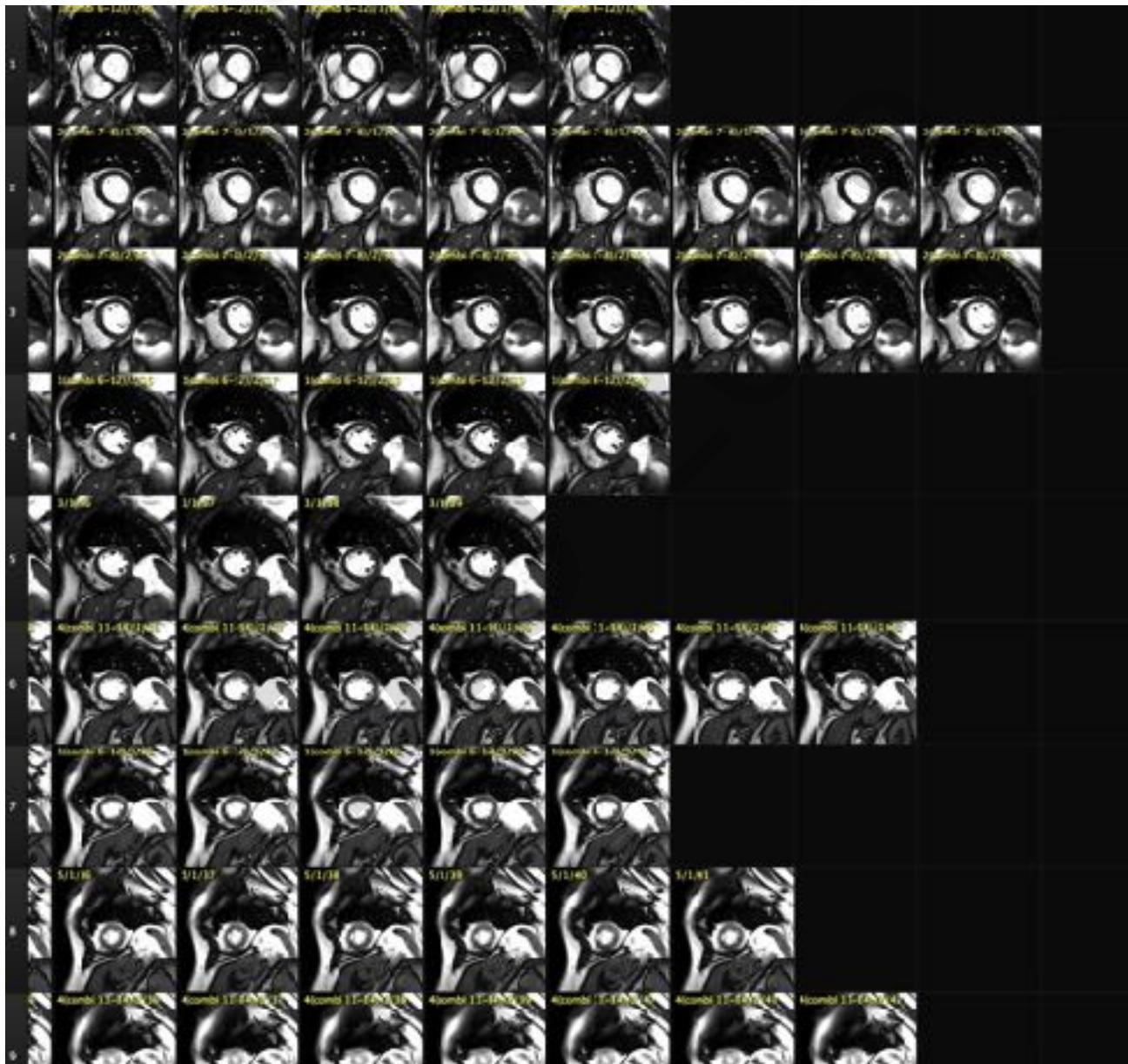
## Méthode de Simpson



	Hommes	femmes	Hommes/BSA	femmes/BSA
V Fin diastole	77-195 ml	52-141 ml	47-92 ml/m <sup>2</sup>	41-81 ml/m <sup>2</sup>
V Fin systole	19-72 ml	13-51 ml	13-33 ml/m <sup>2</sup>	11-31 ml/m <sup>2</sup>
VES	51-133 ml	33-97 ml	32-62 ml/m <sup>2</sup>	26-56 ml/m <sup>2</sup>
Fraction d'Ejection	56-78%	56-78%		
Masse	118-238 g	75-175g	70-113 g/m <sup>2</sup>	63-95 g/m <sup>2</sup>

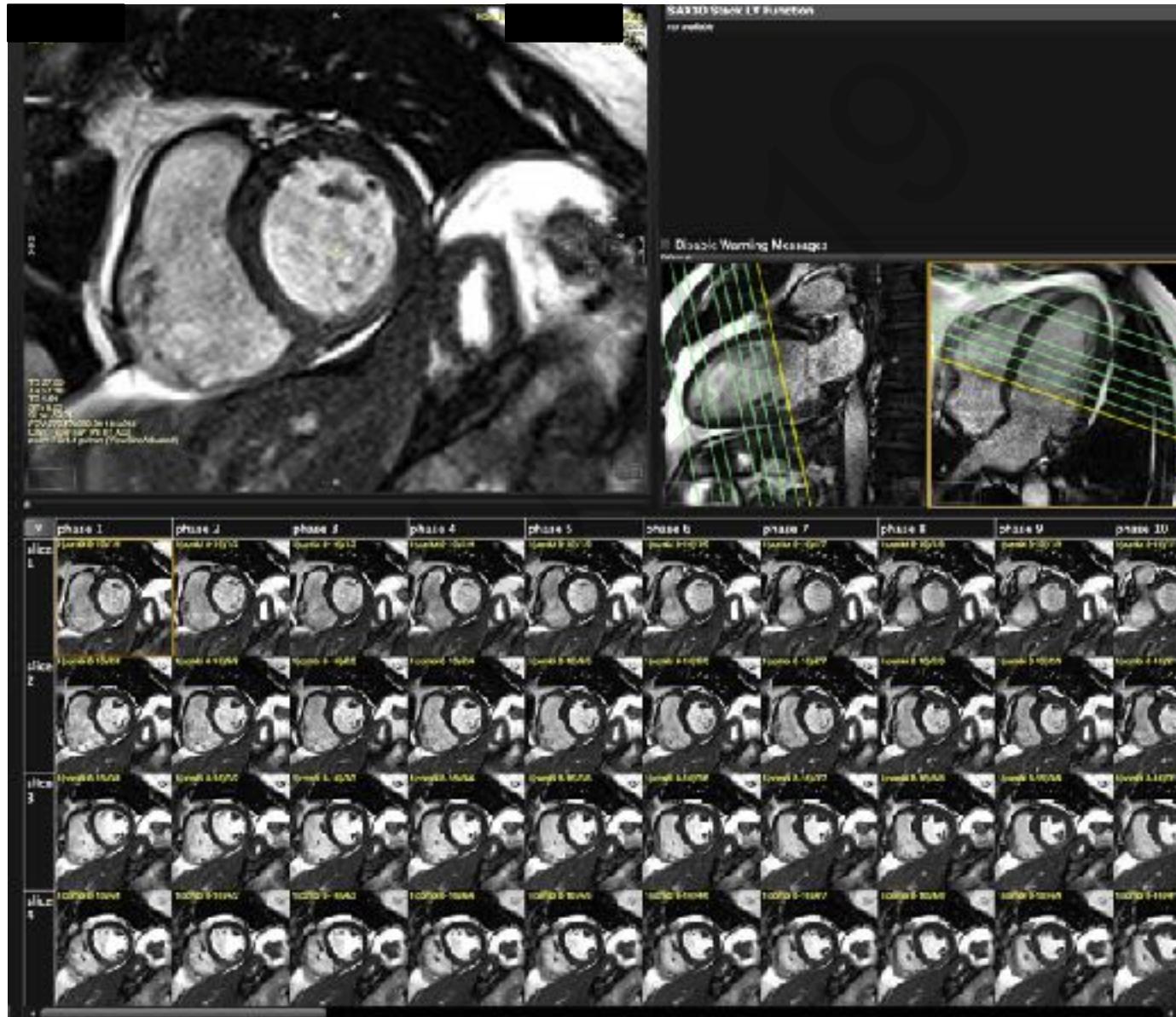
# Quelques erreurs classiques ...

N de phase variable selon le niveau



# Quelques erreurs classiques ...

Coupes Basales trop antérieures.... + coupes manquantes



# Les règles d'OR de la quantification de la Fonction VG globale

28



- pile de coupes jointives - 6-8mm ép.
- perpendiculaires axes L2 /L4
- couvrant l'ensemble du VG
- n phases >20

# Les tendances actuelles

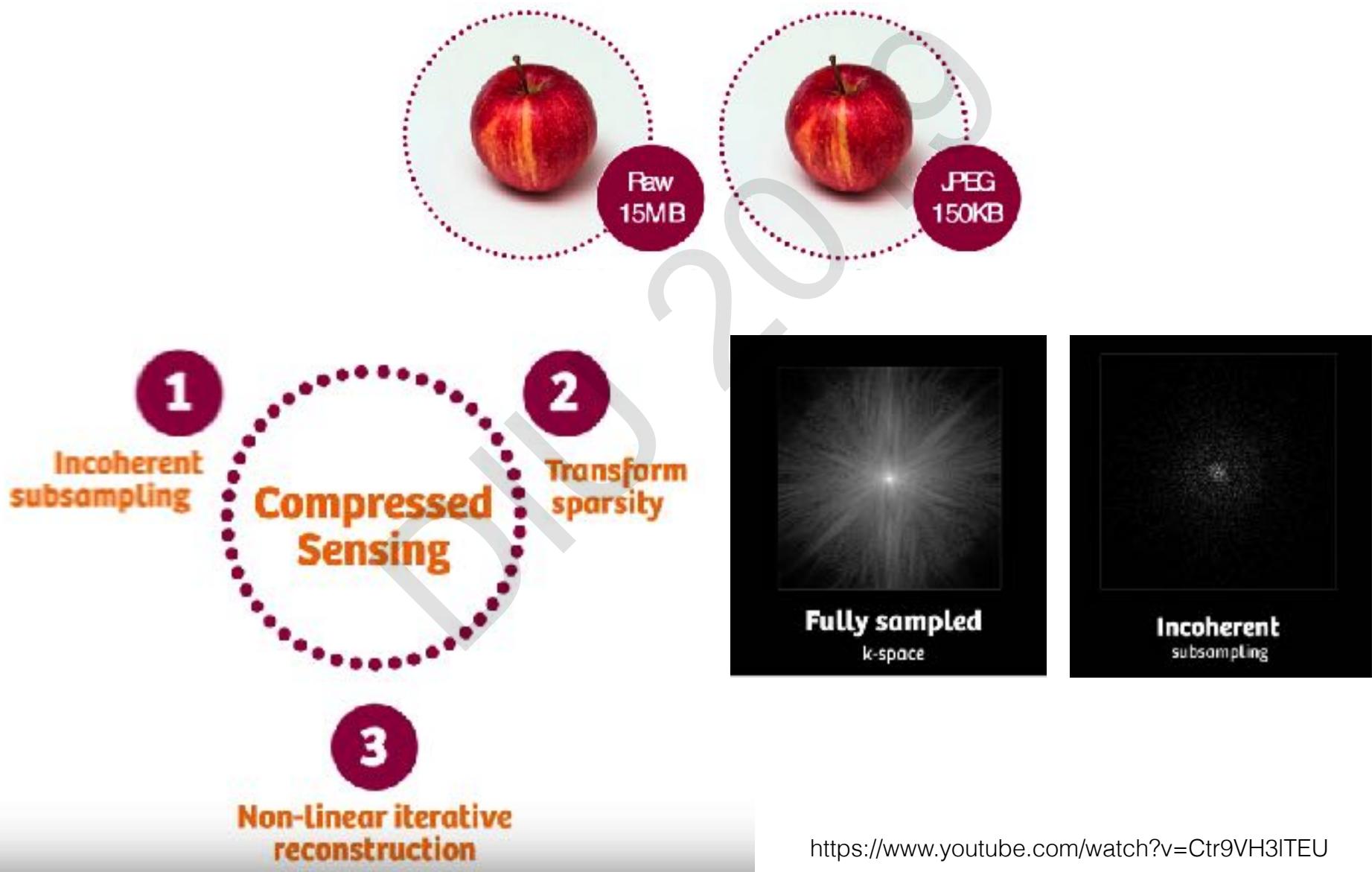
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# Compressing sensing

- Théorie de l'information/échantillonnage -formalisme mathématique (Candès,2005)
- un signal peut être reconstruit avec une bonne précision à partir d'un nombre réduit de mesures si on a recours à un système non-linéaire* (violation du théorème de Shannon  $f_e \geq 1/f_{\max}$ )
- Nombreuses applications dans le domaine de l'information /signal



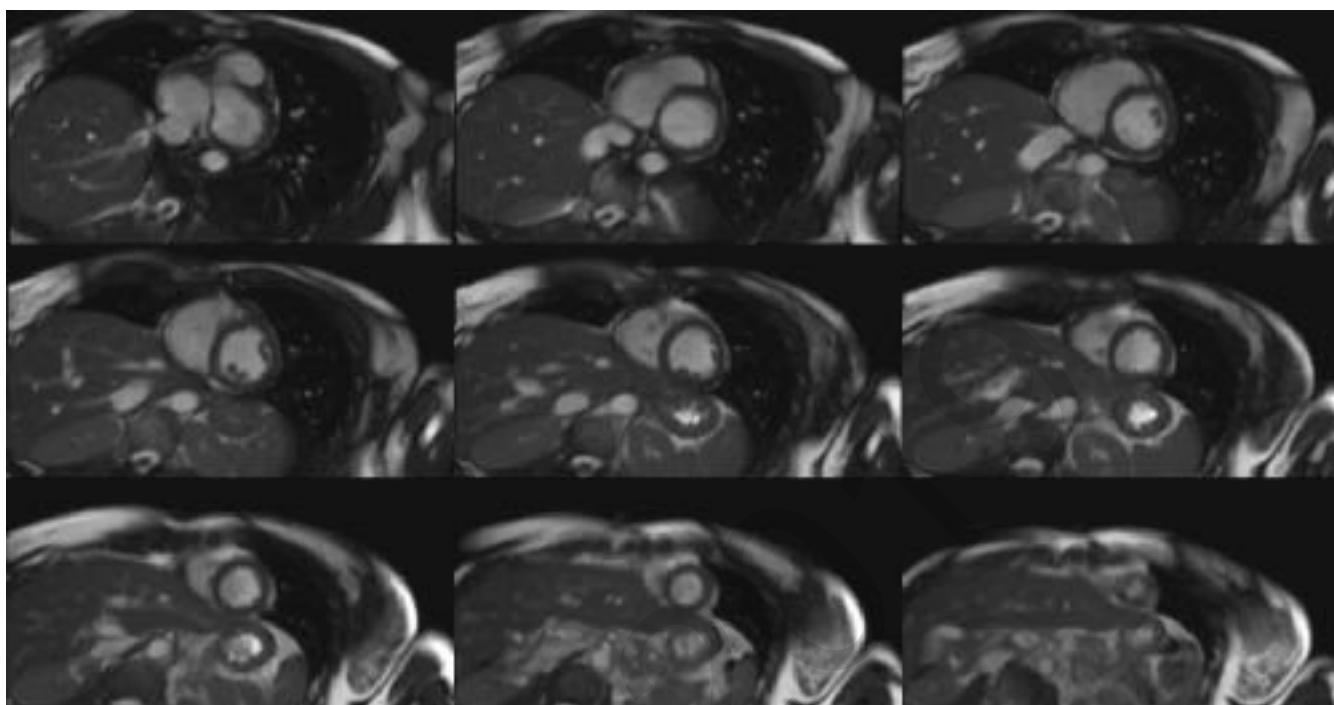
# Compressing sensing



CS realtime  
1beat x9.6

**Apnee**

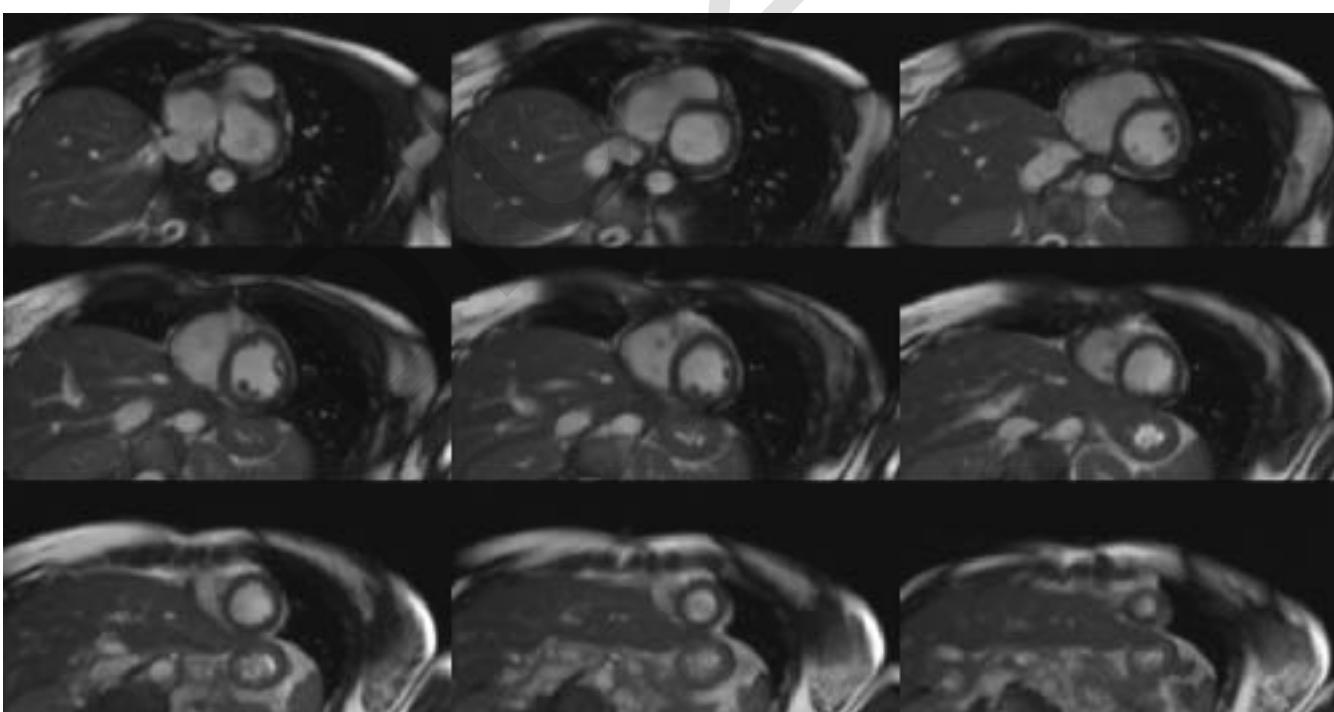
1.7mm  
35ms



CS realtime  
1beat x9.6

**Resp libre**

1.7mm  
35ms



CS realtime  
1beat x9.6  
FB  
1.7mm  
35ms



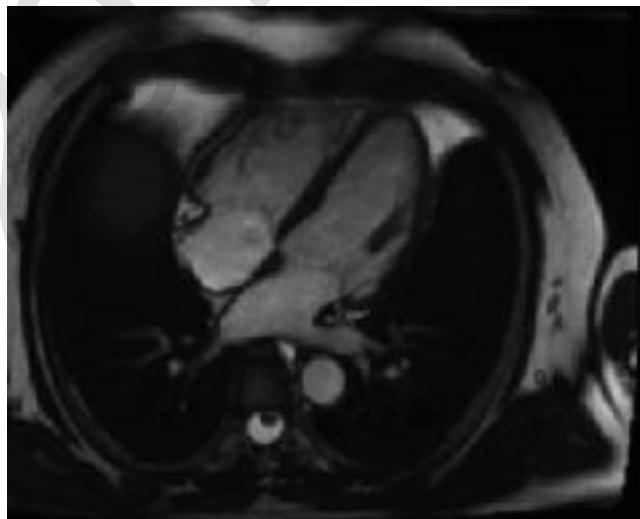
CS realtime  
1beat x9.6  
BH  
1.7mm  
35ms



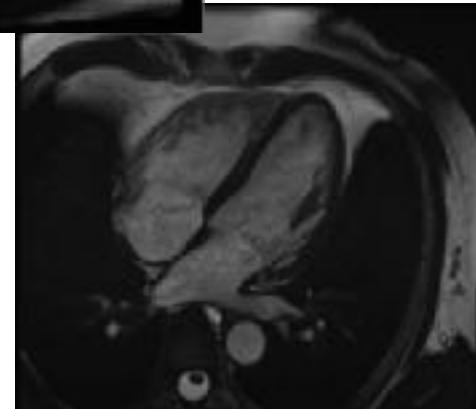
CS 8beats  
X4.8  
BH  
1.05mm  
25ms



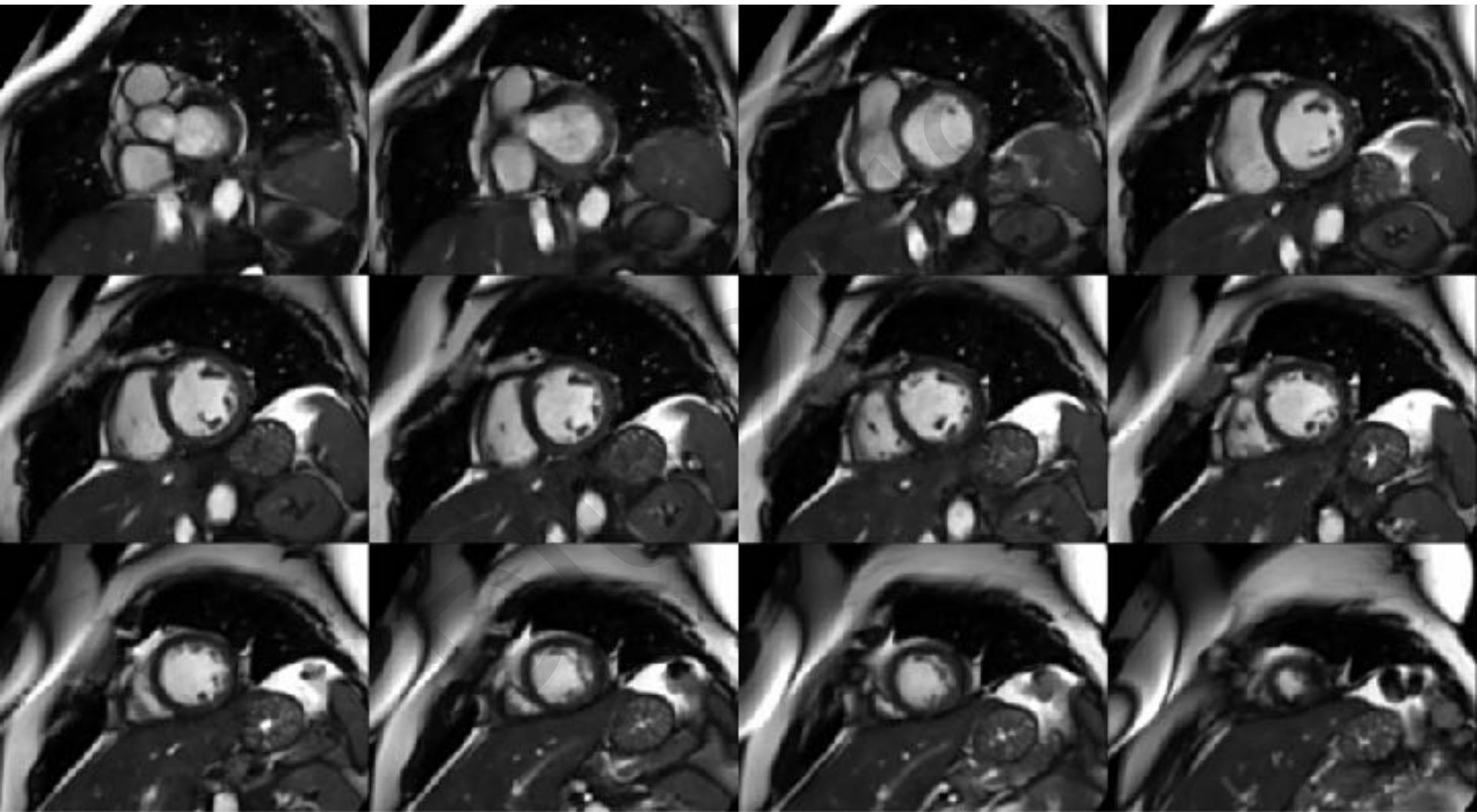
CS 8beats  
BH  
X6.2  
1.4mm  
**10ms**



Ref  
14beats  
iPAT2  
35ms



# CS 2BH/slice facteur x6.5 7mm 25phases - 14 slices en 2 apnées

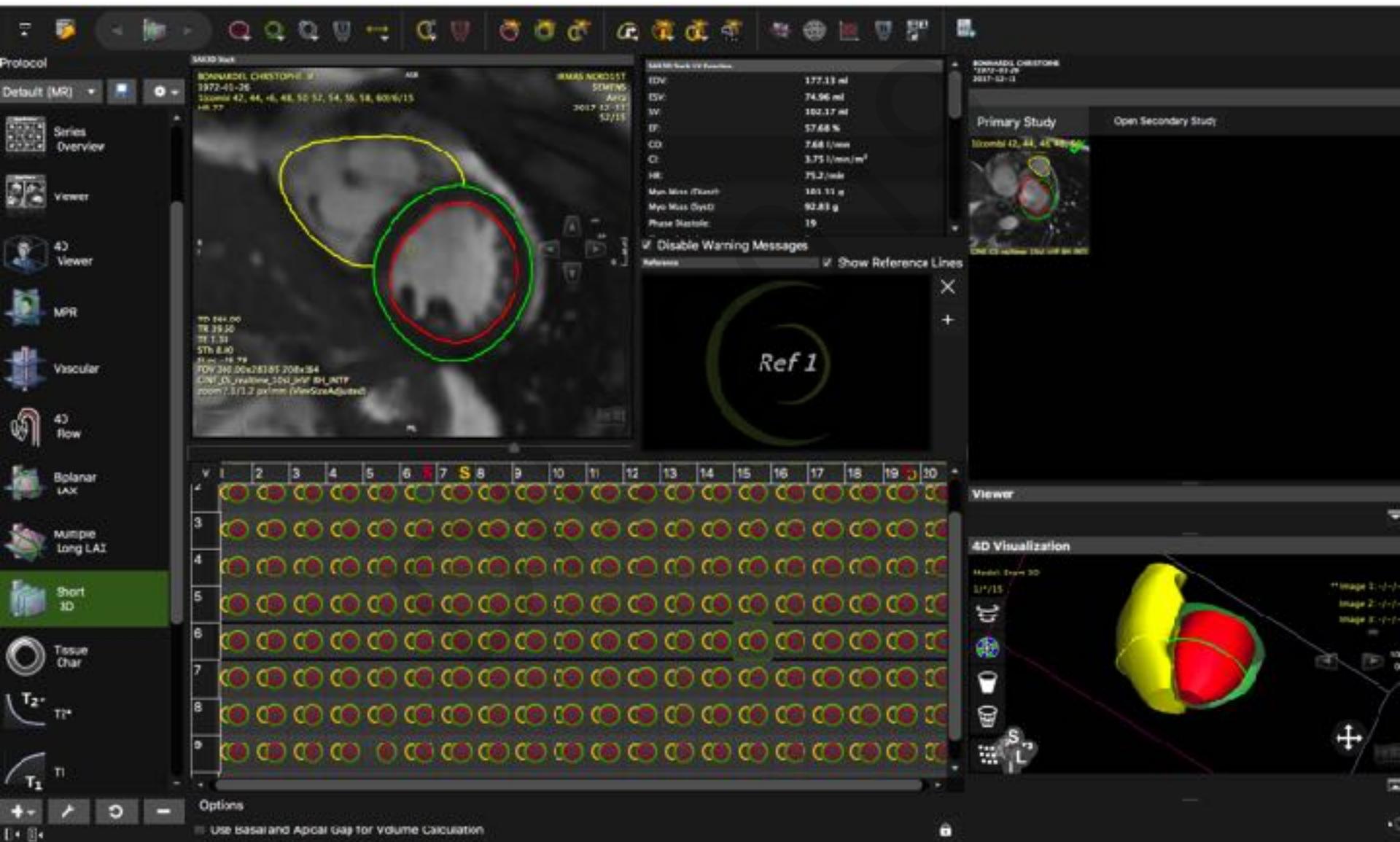


# Machine learning en imagerie cardiaque

DIU 2019

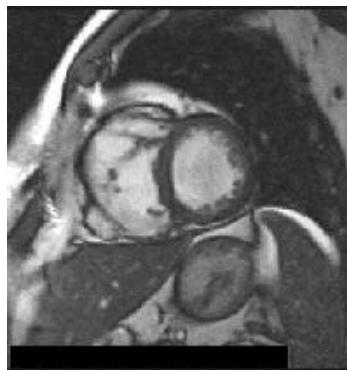
## Demo prototype Circle CVI42

Training 4000 datasets UK databank / testing 1000 datasets



# Protocole Cardiomyopathie Ischémiques

Ciné



2CAV,  
4CAV,  
8 SA

Fonction globale  
& régionale

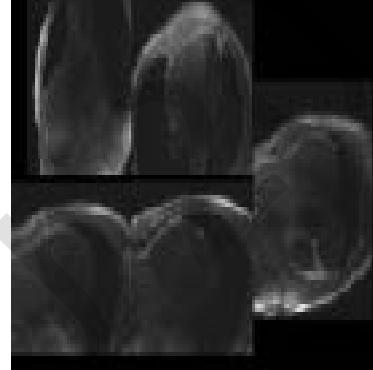
± Morpho T2



T2 TSE+ FS, IR  
T2map

Caractérisation eau  
interstitielle,  
œdème,  
inflammation

± Perfusion

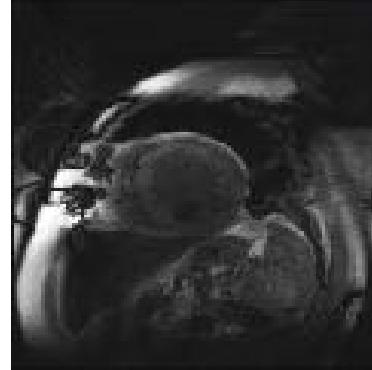


IR-TFLash

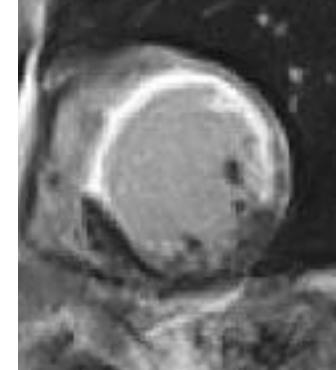
Caractérisation  
Ischémie, OMV

Gd-DTPA 0,2 mmol/kg

Rehaussement Tardif



TI Scout



IR-GRE 2D/3D

Caractérisation  
fibrose, nécrose

# Assessment of T2 relaxation times

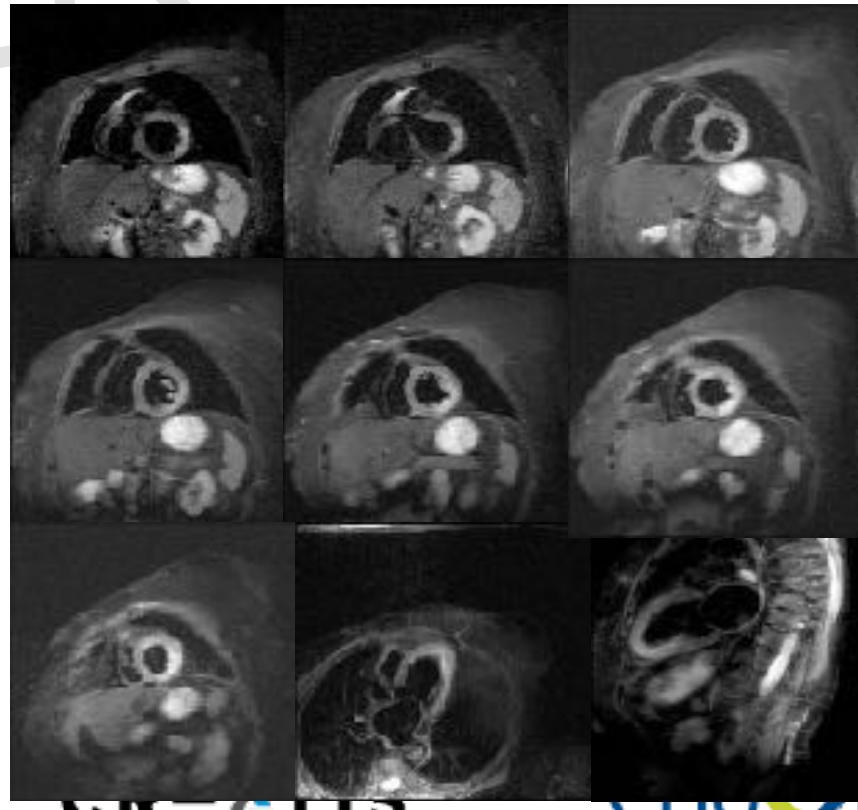
- T2 relaxation times sensitive to myocardial edema, inflammation and is elevated in particular in:

→Acute MI

→myocarditis

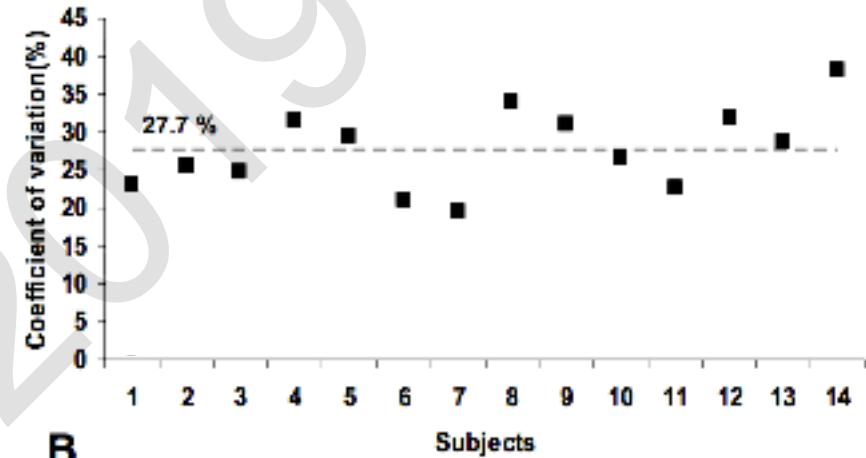
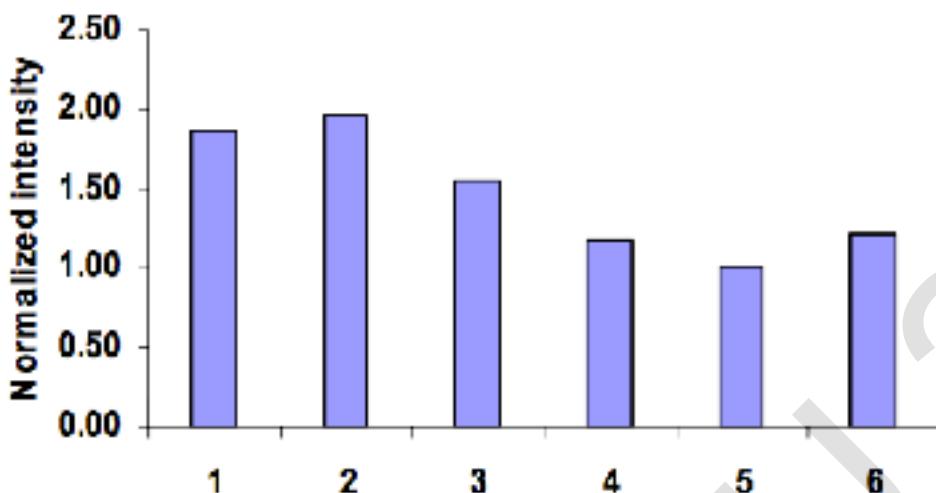
→sarcoidosis

→cardiac allograft rejection

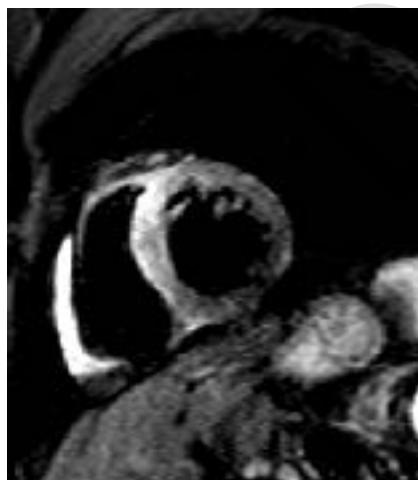


## Common artefacts with DB-TSE (STIR):

- 1) inhomogeneities due to surface coil sensitivity variations

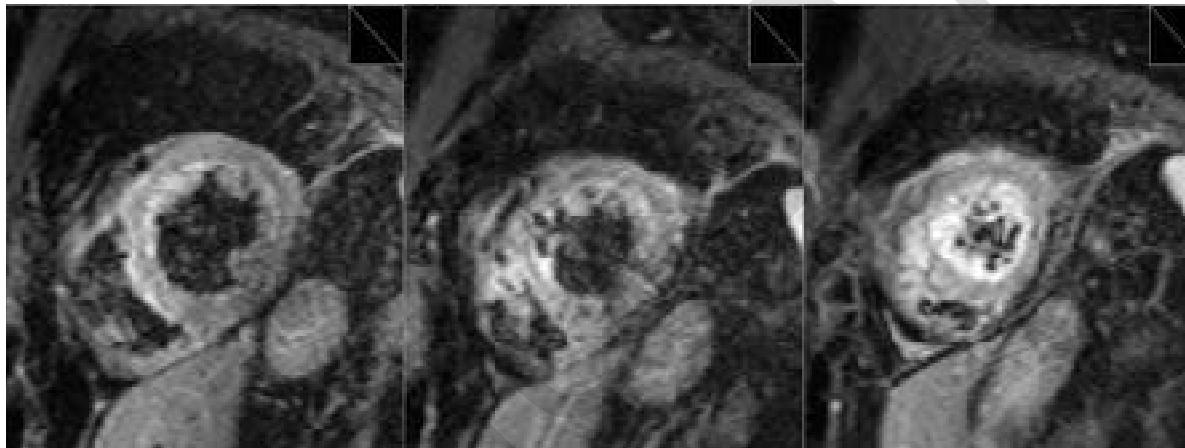


(Giri JCMR 2009)



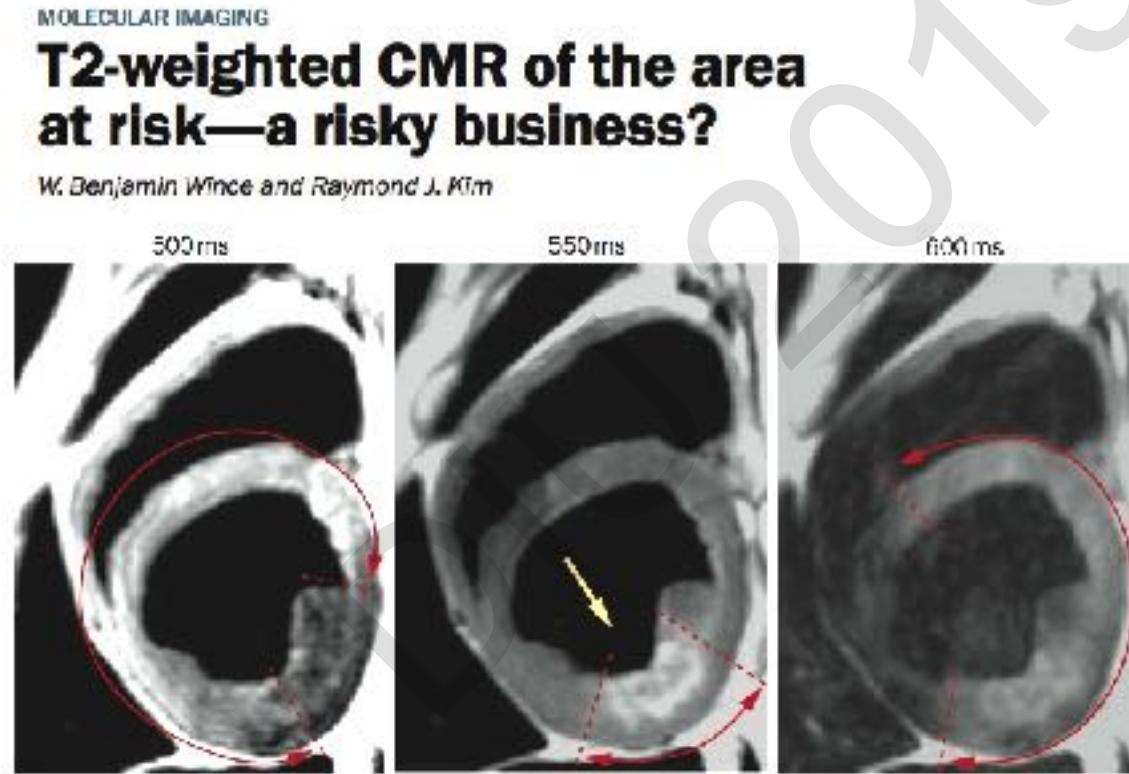
## Common artefacts with DB-TSE (STIR):

- 1) inhomogeneities due to surface coil sensitivity variations
- 2) stagnant sub-endocardial blood (apex)



## Common artefacts with DB-TSE (STIR):

- 1) inhomogeneities due to surface coil sensitivity variations
- 2) stagnant sub-endocardial blood (apex)
- 3) myocardial motion-related artefacts (signal drop or pseudo-hypersignal )

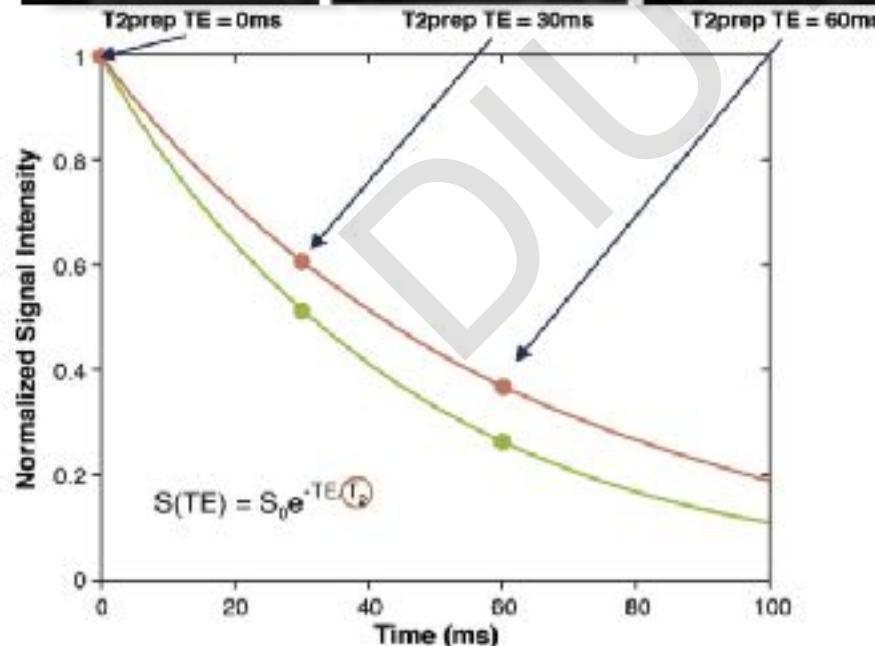
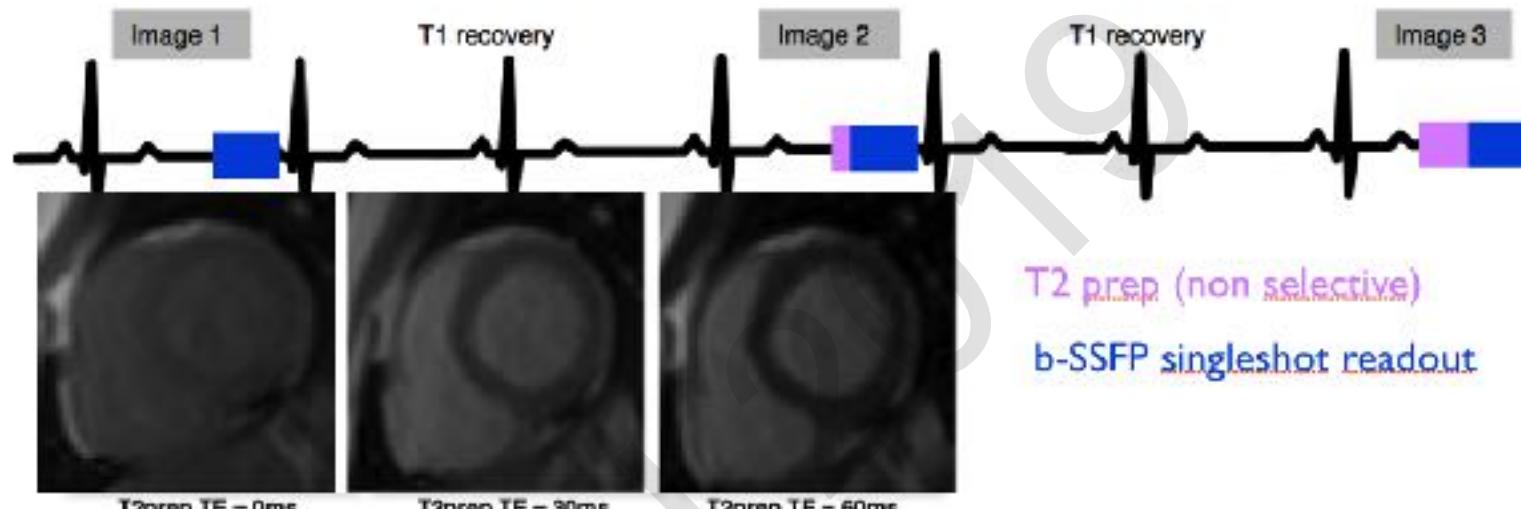


Wince et al *Nat Rev Cardiol* (2010) 7: 547-549

Incorrect results in up to 28% of the cases after MI

## T2 quantification for improved detection of myocardial edema

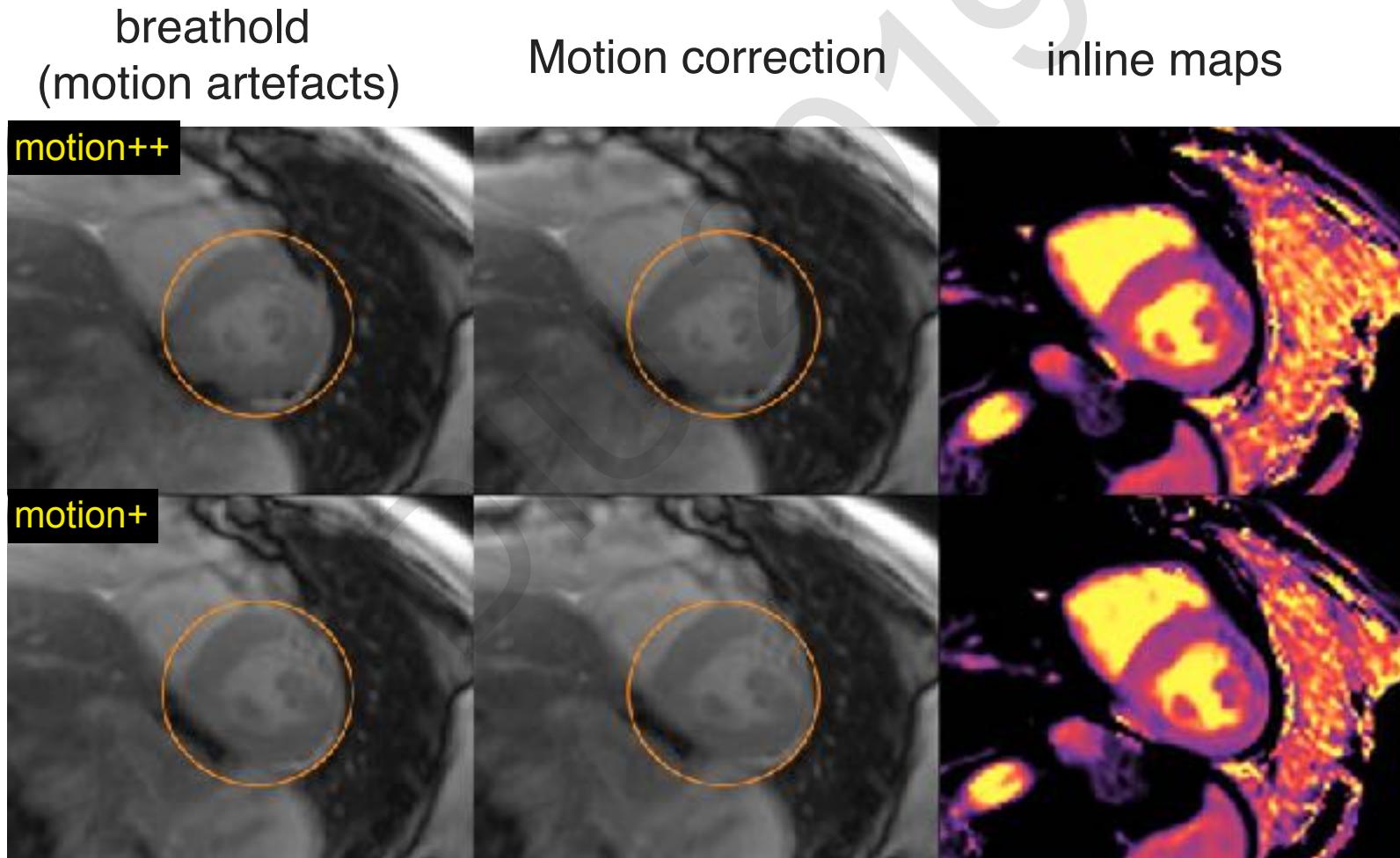
Shivraman Giri<sup>1,2</sup>, Yiu-Cho Chung<sup>4</sup>, Ali Merchant<sup>3</sup>, Georgeta Mihai<sup>2</sup>, Sanjay Rajagopalan<sup>2,3</sup>, Subha V Raman<sup>2,3</sup> and Orlando P Simonetti \*<sup>1,2,3,5</sup>



7 heart-beats  
Breathold  
non-rigid motion correction\*  
mono-exponential fit

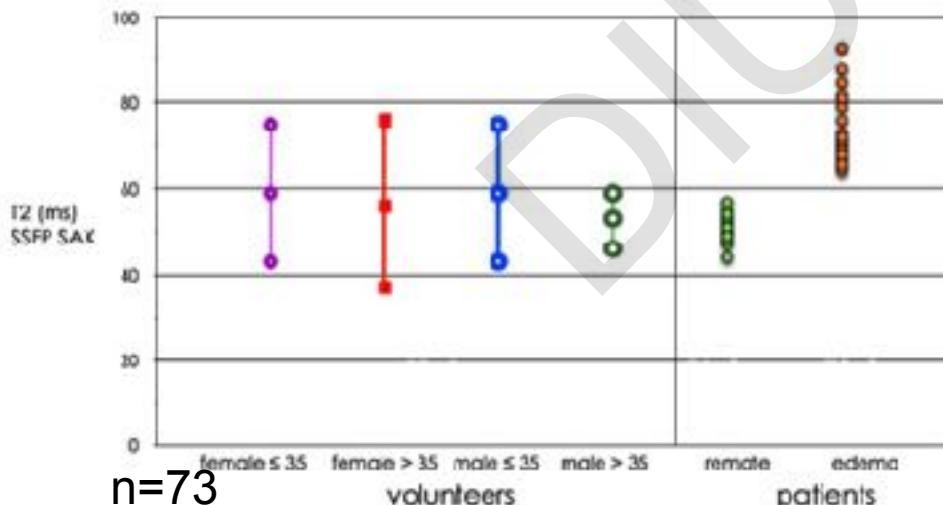
# improved T<sub>2</sub> mapping

- inline calculation
- with integrated specific motion correction



Year	T2 (ms)	Authors	Reference
1984	57 ± 16	Bottomley et al.	Med Phys. 1984 Jul-Aug;11(4):425-48.
1985	42.4 <sup>1</sup>	McNamara et al.	Circulation. 1985;71, No. 4, 717-724.
1993	50 ± 3	Walker et al.	Magn Reson Med. 1993 May;29(5):637-41.
1998	44.3 ± 3.5	Mavrogeni et al.	MAGMA. 1998 Aug;6(1):7-12
1998	48.3 ± 5.5	Mavrogeni et al.	Int J Card Imaging. 1998 Apr;14(2):117-22
2000	57.95 ± 4.9	Papanikolaou et al.	Acta Radiol. 2000 Jul;41(4):348-51.
2003	52 ± 4.3	Foltz et al.	Magn Reson Med. 2003 Jun;49(6):1089-97.
2005	58.1 ± 7.1	Mavrogeni et al.	Chest. 2005 Jan;127(1):143-8.
2006	56.9 ± 8.4	He et al.	J Magn Reson Imaging. 2006 Sep;24(3):580-5
2007	54 ± 4.3	Huang et al.	Magn Reson Med. 2007 May;57(5):960-6.
2009	50 ± 4	Blume et al.	J Magn Reson Imaging. 2009 Feb;29(2):480-7
2009	54 ± 6.8	Sparrow et al.	J Magn Reson Imaging. 2009 Nov;30(5):942-6.

**52± 3.4 ms**



Giri et al JCMR 2009

Wassmuth et al JCMR 2013

55±5 in SAX vs 59±6 in LA  
intra-observer variability 1.07ms  
inter-observer variability 1.6ms

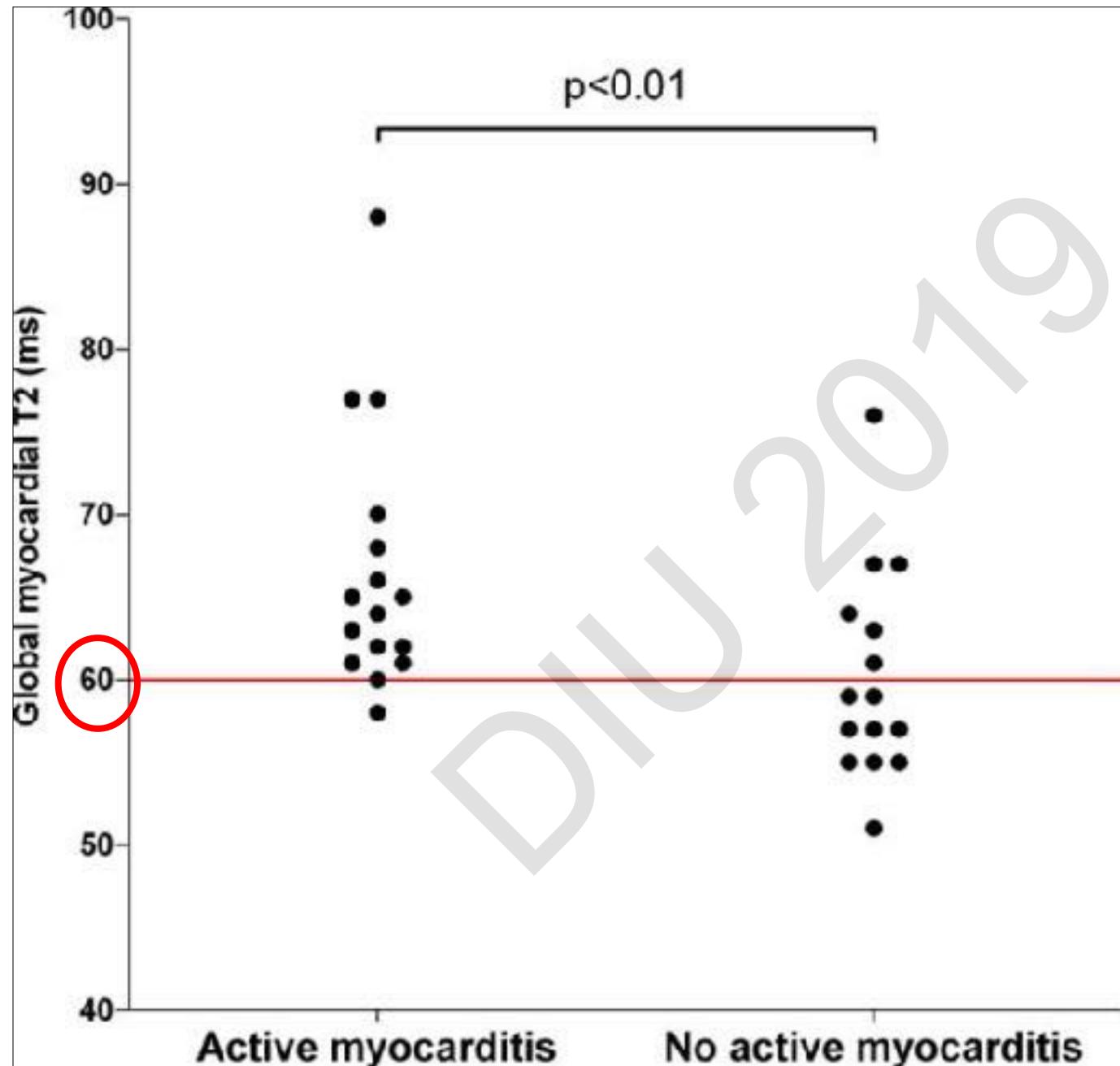
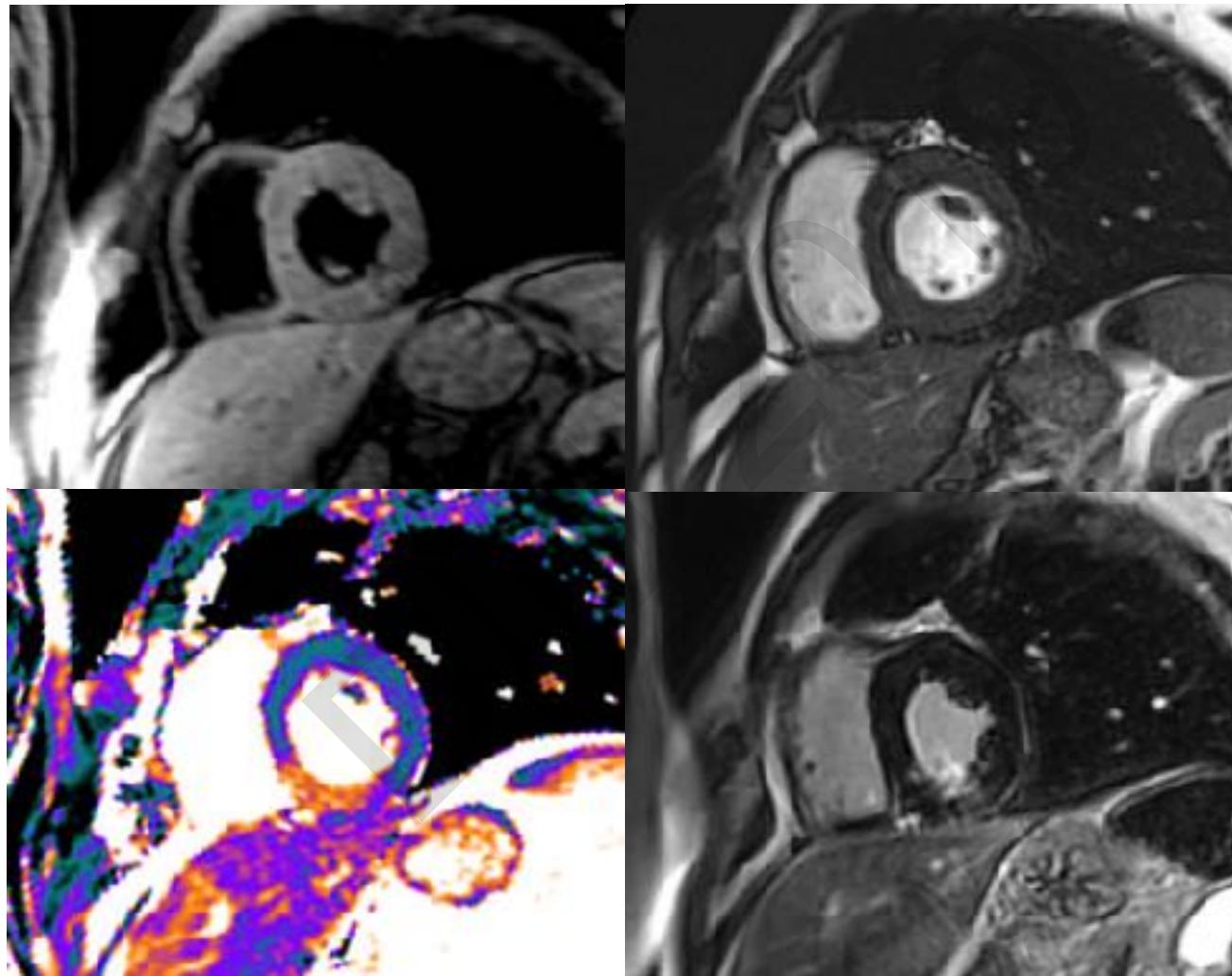
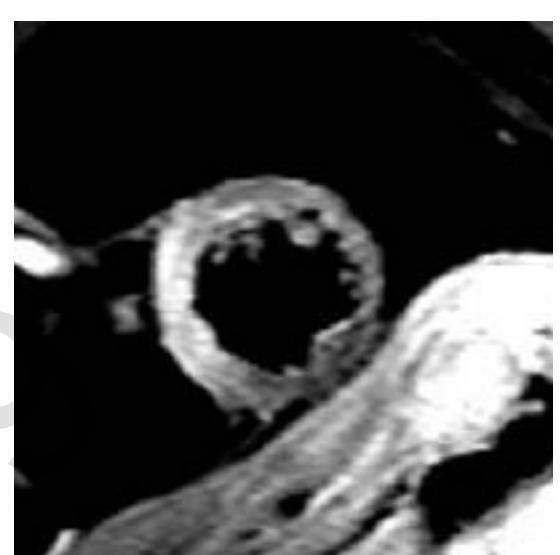
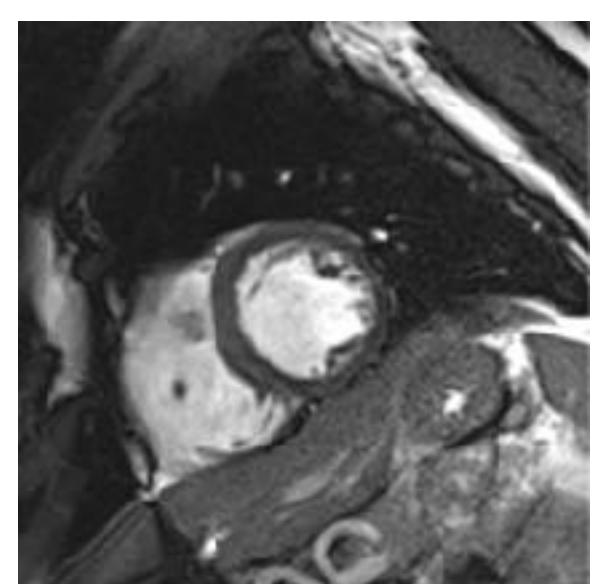


Figure 2 . Global myocardial T2 values in patients with and without active myocarditis. There were significantly higher median global myocardial T2 values in patients with active myocarditis (65 ms [61-70 ms]) than in patients without active myocarditis on endomyocardial biopsy (59 ms [55-64 ms]; Only 1 patient with active myocarditis had a global myocardial T2 of <60 ms in this study population.

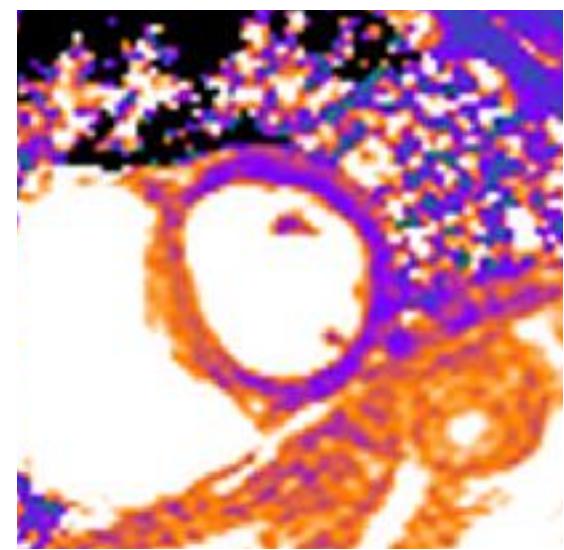
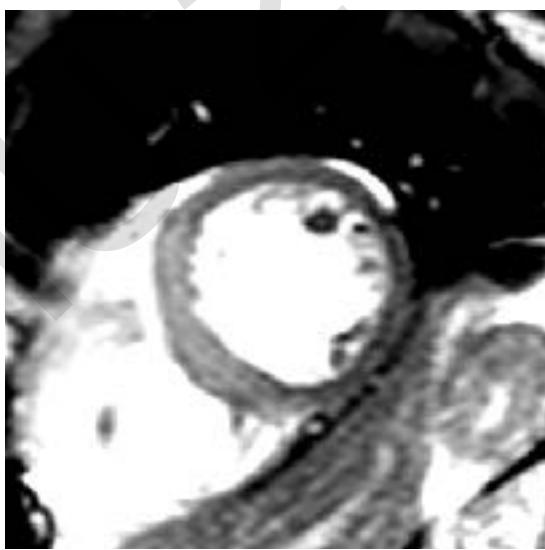
LAD occlusion H+2 (TIMI3); MRI @ 72 h





STIR td:700ms

STIR td:650ms

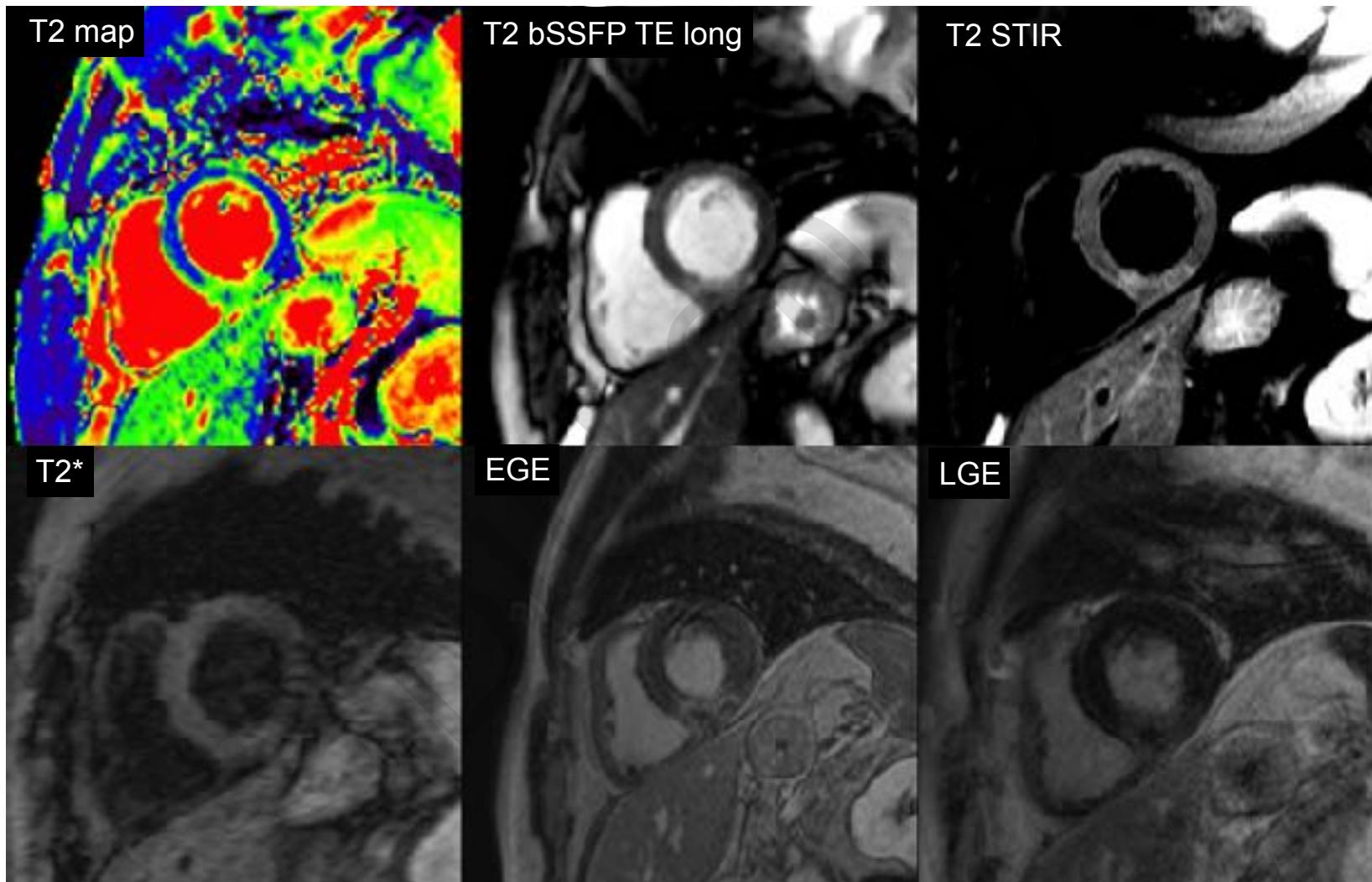


T2 SSFP

T2 mapping SSFP

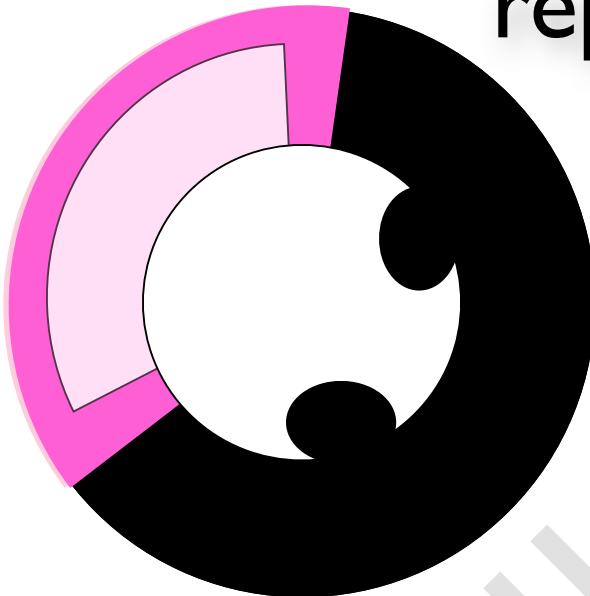
LAD AMI H+ 5:30; TIMI 1 >3; MRI @72h

## Imagerie quantitative: T2 sang blanc SSFP multi-echo / **T2 mapping**



Courtoisie MIMI investigateurs: L. Belle, P. Croisille, A. Marie, N. Ferrier etc..

# Can T2w imaging provide an accurate measurement of AAR in AMI after reperfusion ?

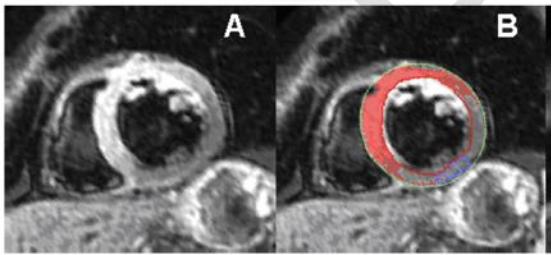


area at risk (AAR) - infarct size (IS)

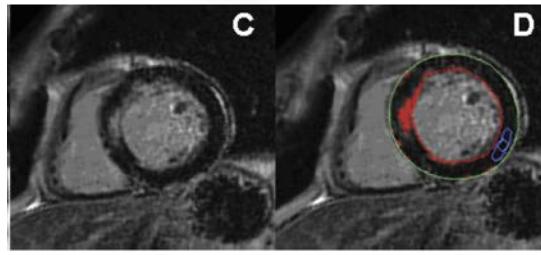
= myocardial salvage

Gibbons et al. *J Am Coll Cardiol* (1994) 24: 616-623

T2-w

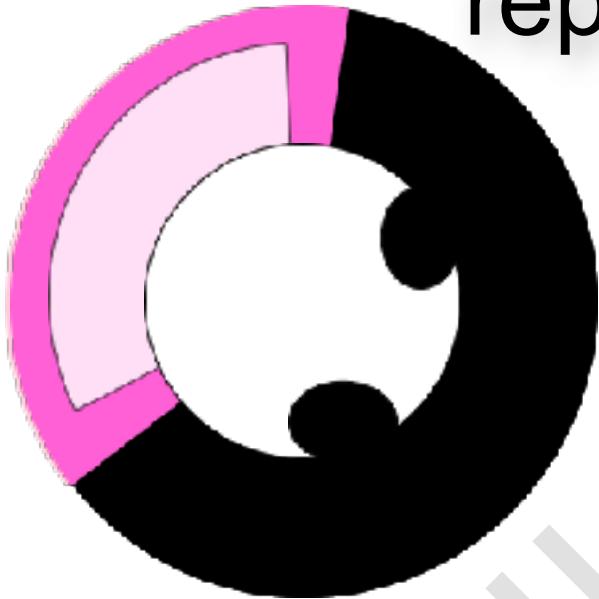


DE



= “Presumed”  
In-vivo CMR  
salvage

# Can T2 imaging provide an accurate measurement of AAR in AMI after reperfusion ?



area at risk (AAR) - infarct size (IS)

= myocardial salvage

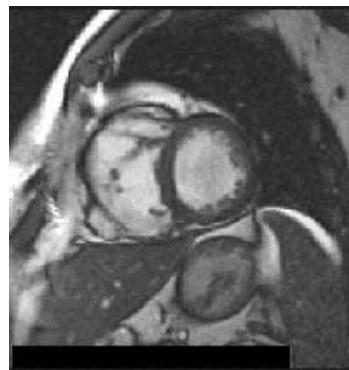
Gibbons et al. *J Am Coll Cardiol* (1994) 24: 616-623

***Answer is NO***

T2 in AMI patient (edema) a marker of reperfusion injury  
-varies with coronary status (collaterals)  
-varies with treatments  
A marker of inflammation = a current target for treatment

# Protocole Cardiomyopathie Ischémiques

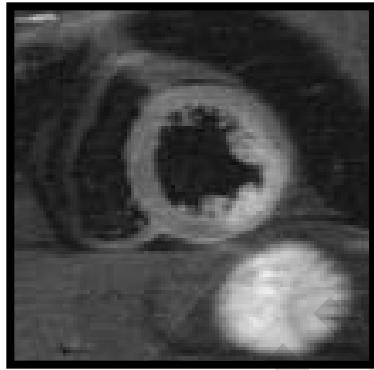
Ciné



2CAV,  
4CAV,  
8 SA

Fonction globale  
& régionale

± Morpho T2



T2 TSE+ FS, IR  
T2map

Caractérisation eau  
interstitielle,  
œdème,  
inflammation

± Perfusion



IR-TFLash

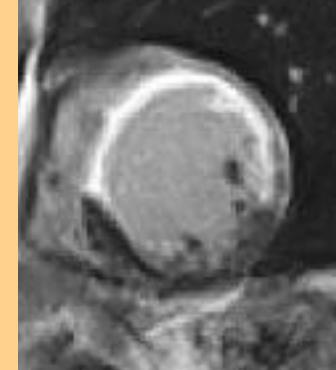
Caractérisation  
Ischémie, OMV

Gd-DTPA 0.5 mmol/kg

Rehaussement Tardif



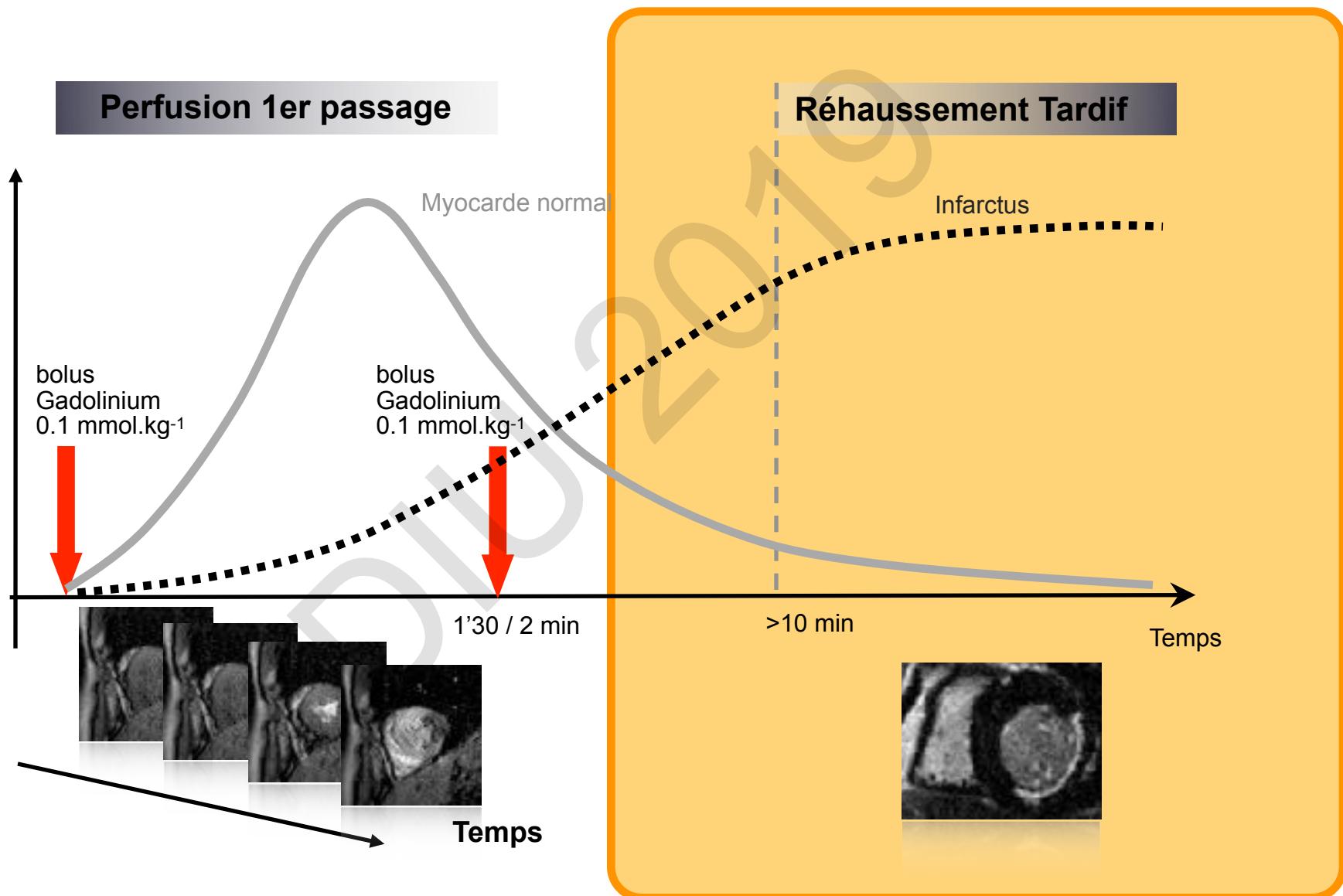
TI Scout



IR-GRE 2D/3D

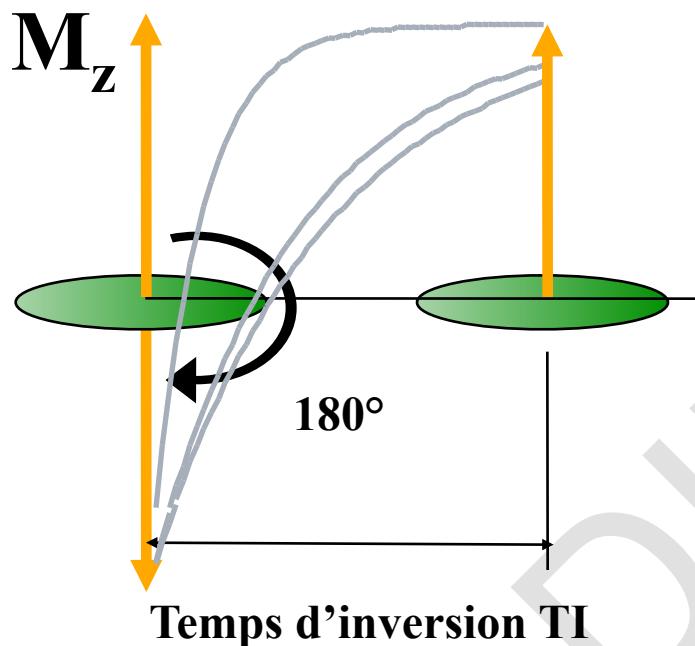
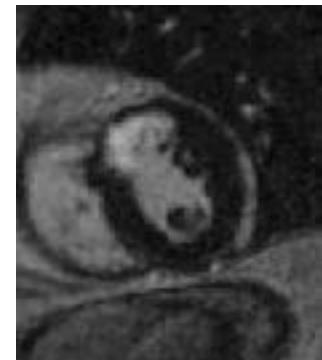
Caractérisation  
fibrose, nécrose

# Imagerie de premier passage et tardive (image pondérée T1)



# Imagerie de la rétention tardive du Gadolinium

## Méthodologie

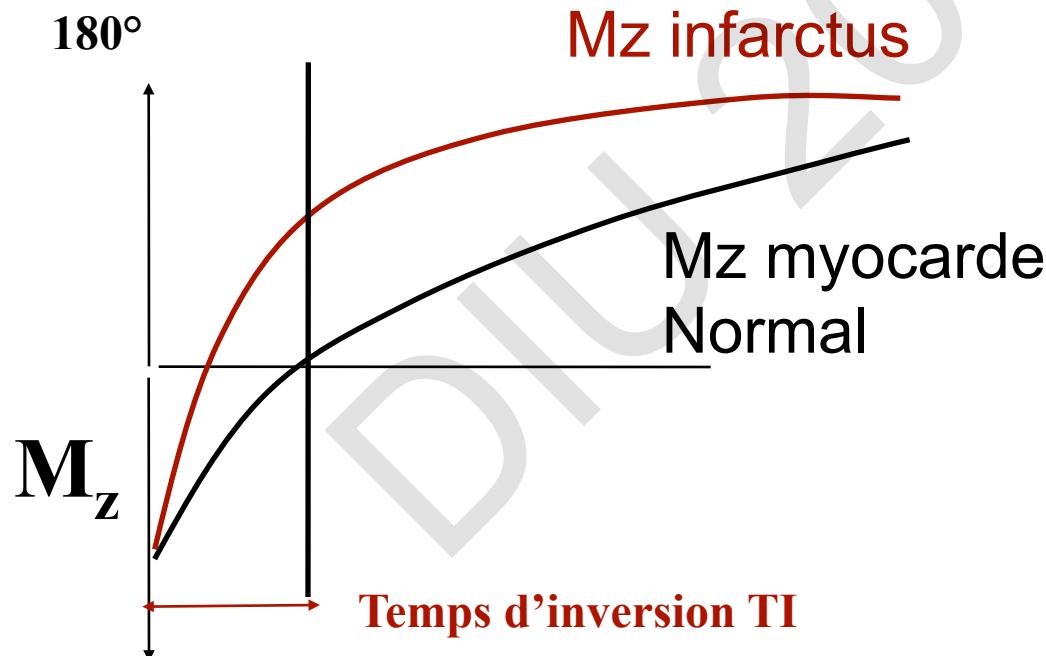


- Séquences pondérées T1 (Flash/Truefisp/2D/3D...)
- Préparation d'aimantation par **Inversion-Récupération (IR)**
- Acquisition haute résolution spatiale morphologique, segmentée

# Imagerie de la rétention tardive du Gadolinium

## Méthodologie

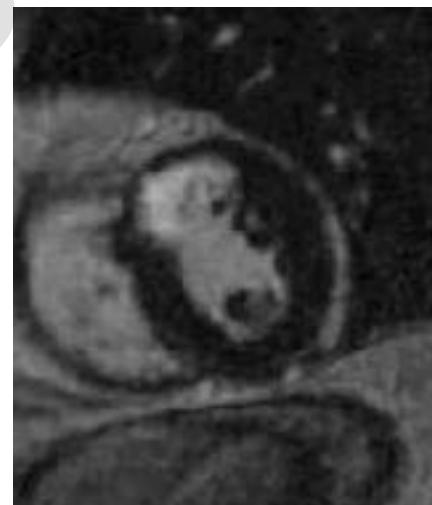
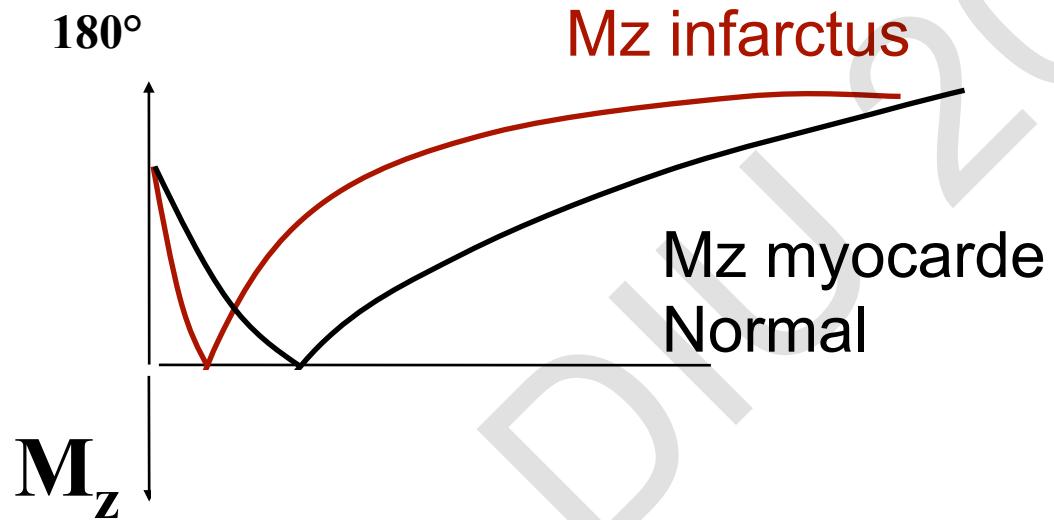
Séquences pondérées T1 par préparation d'aimantation via Inversion-Récupération (IR): avec quel TI?



# Imagerie de la rétention tardive du Gadolinium

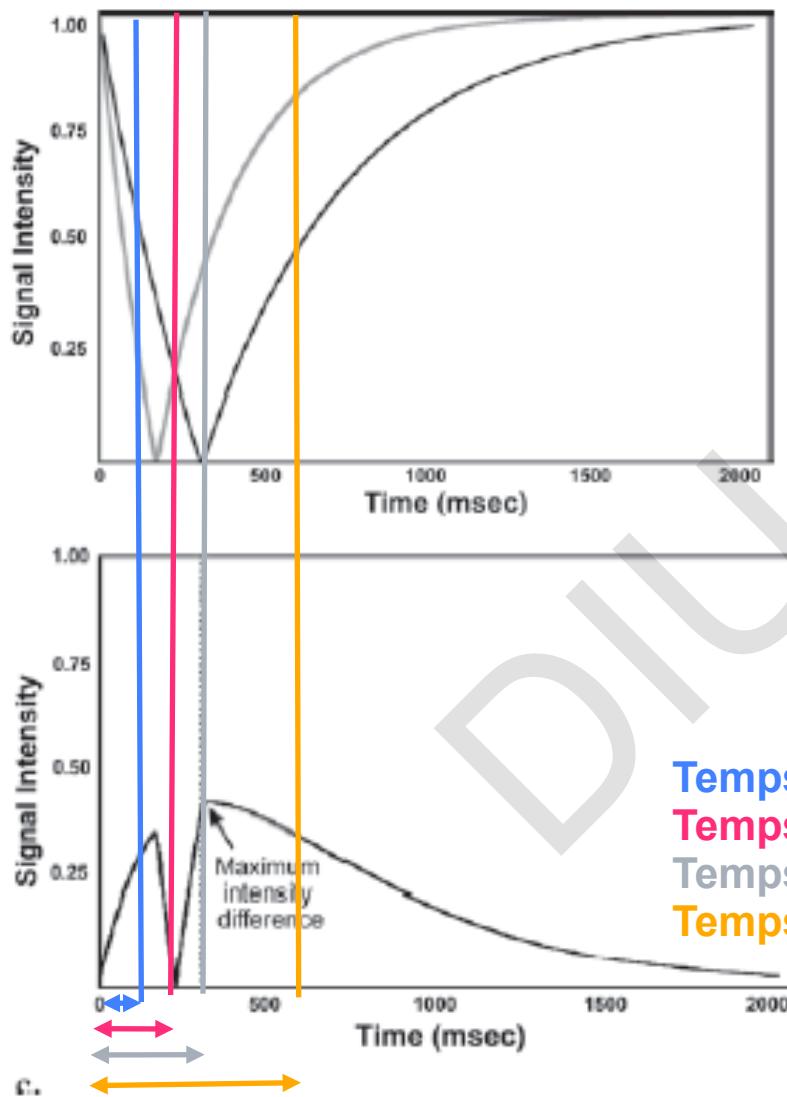
## Méthodologie

*Image IRM de magnitude signal*

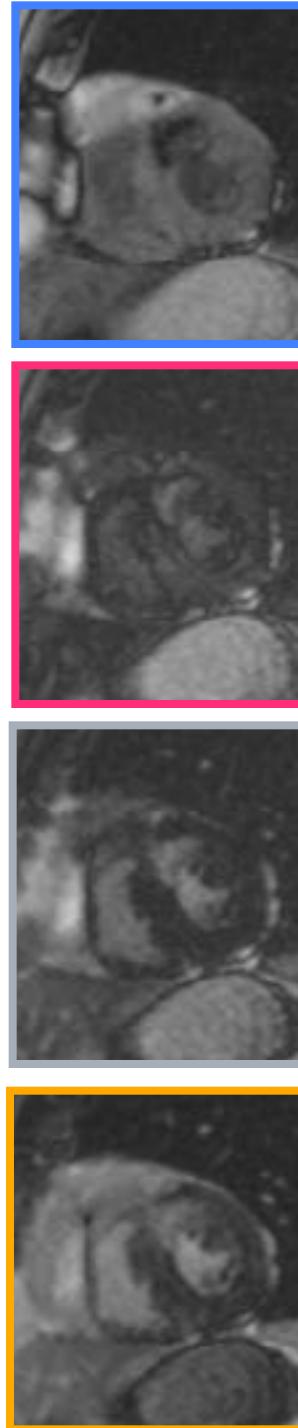


# Imagerie de la rétention tardive du Gadolinium

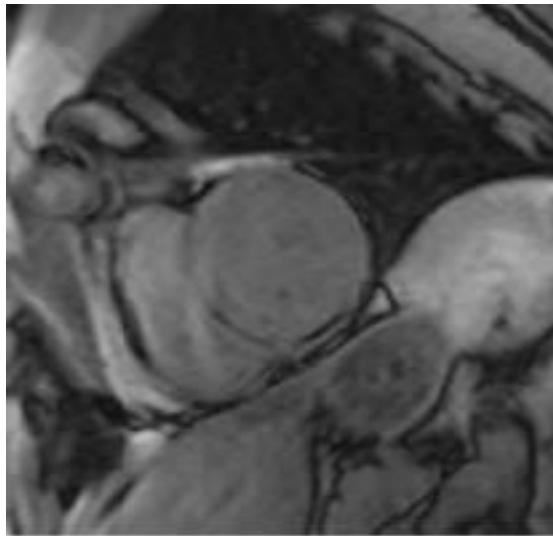
## Méthodologie



Temps d'inversion TI  
Temps d'inversion TI  
Temps d'inversion TI  
Temps d'inversion TI

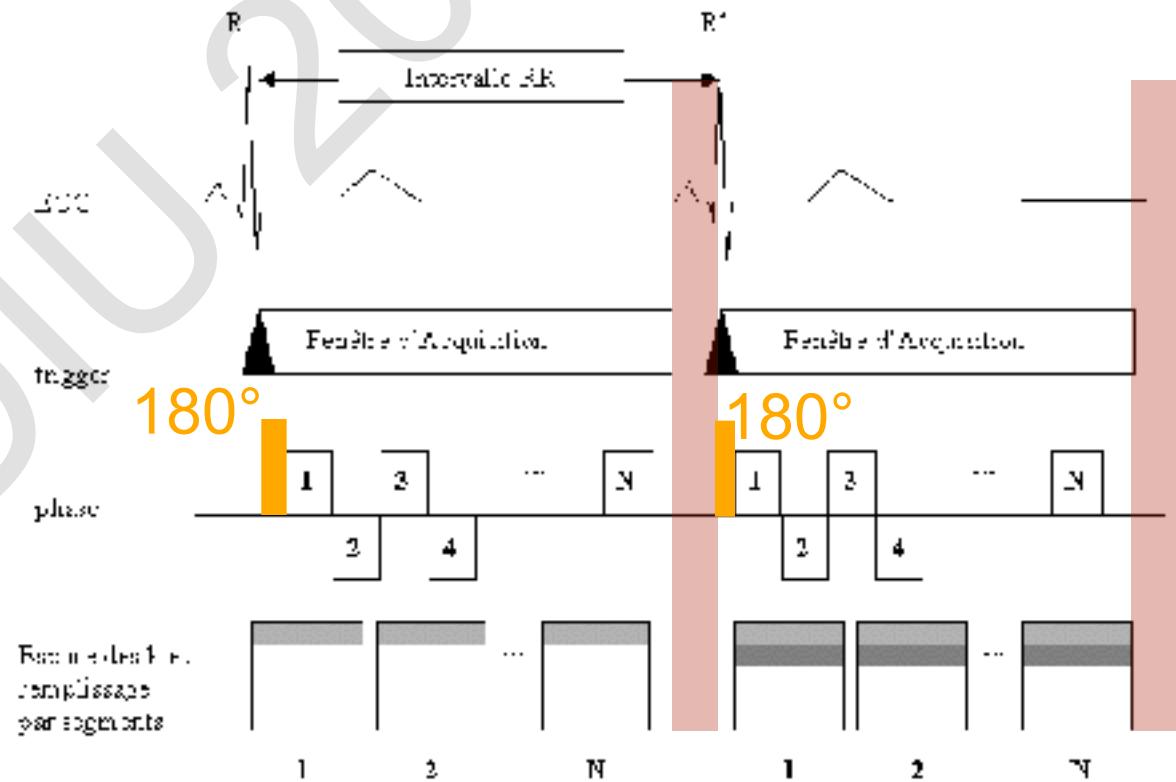


# Séquence de TI scout



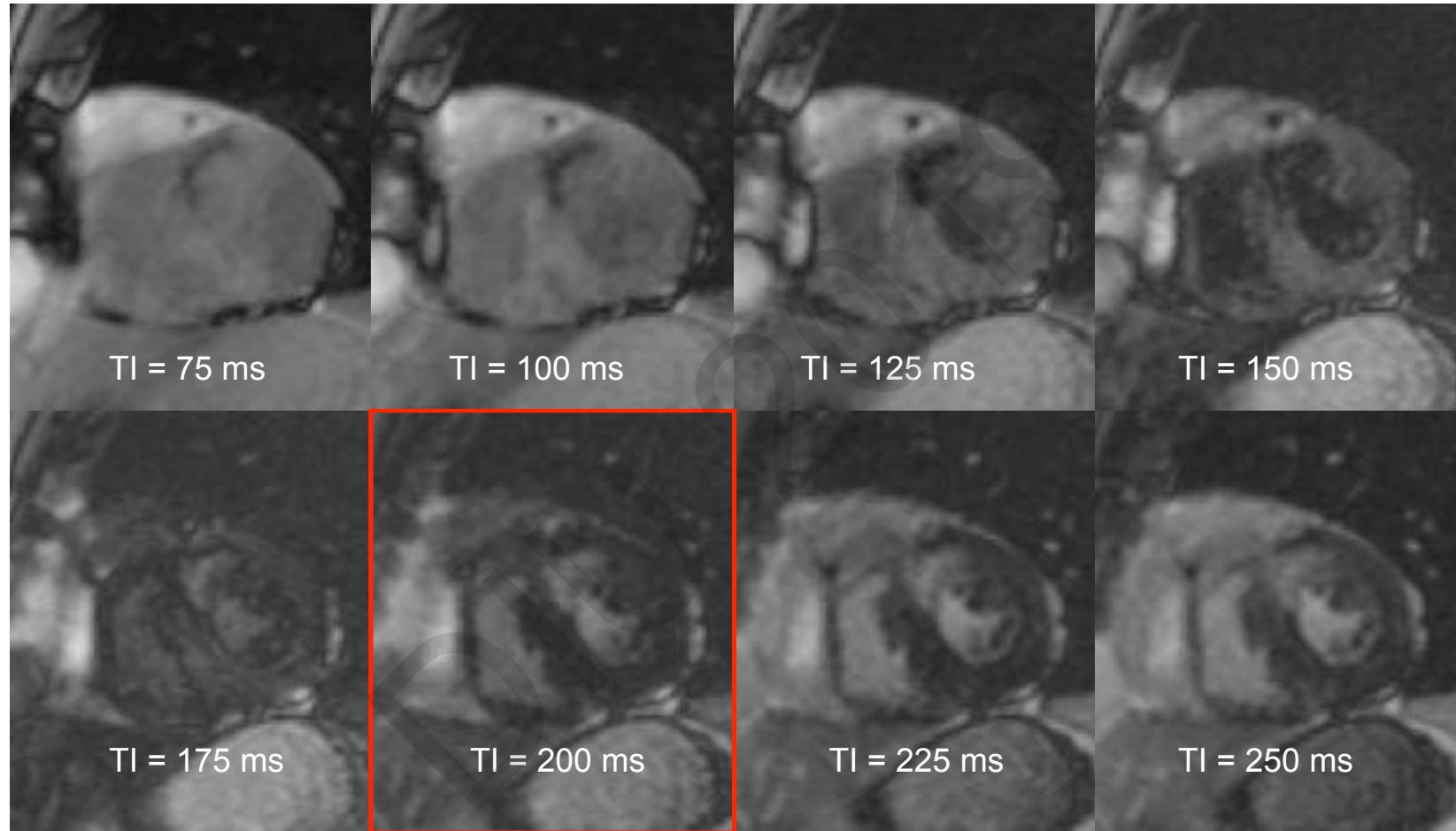
Séquence cine multi-phasés  
avec 1 valeur de TI par phase  
(Séquence de TI-Scout)

***Synchronisation prospective.***



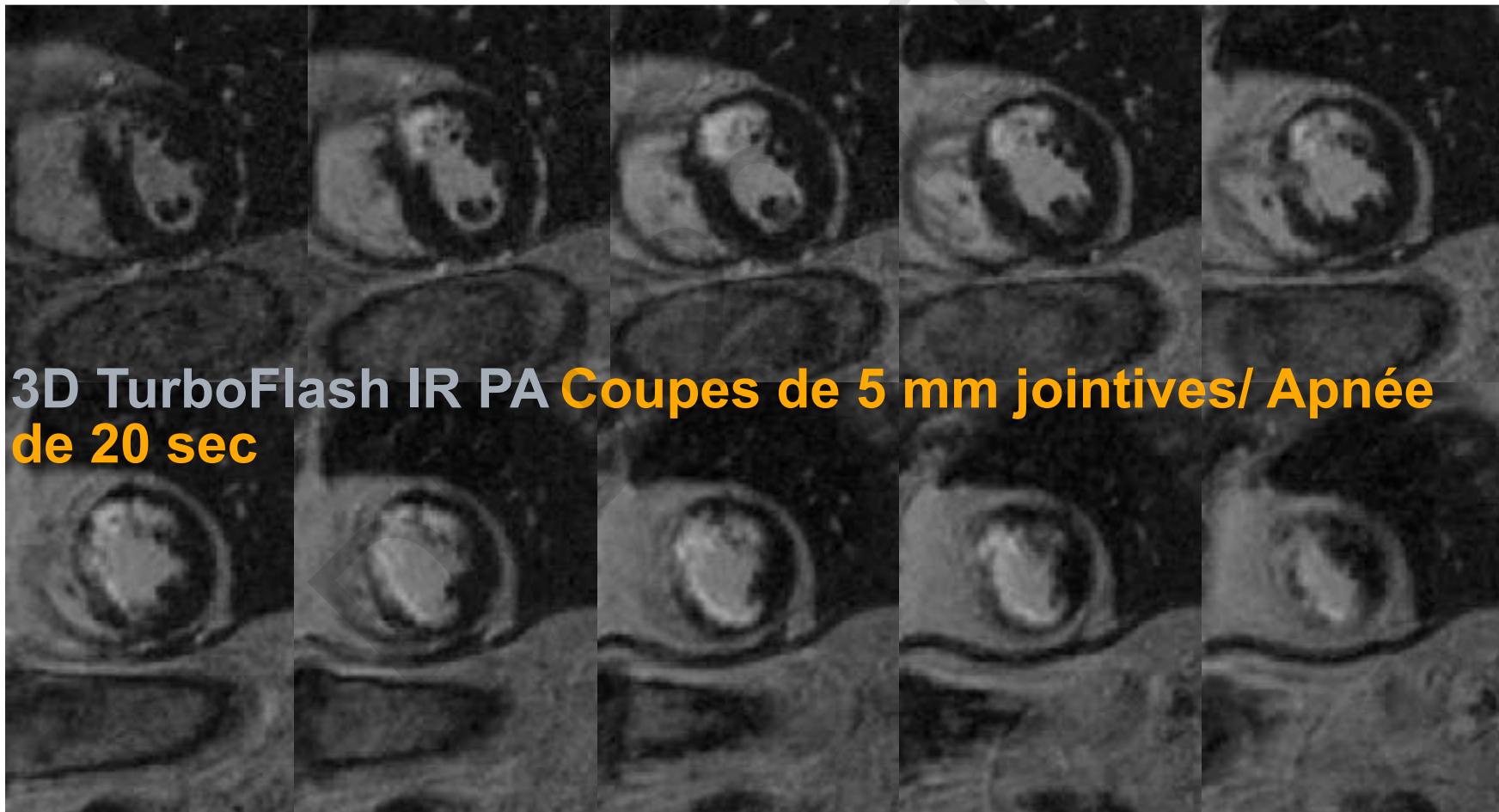
- RR  
-> F.Acq=RR- $\Delta R$   
-> RT=5% (RR)  
-> # phases

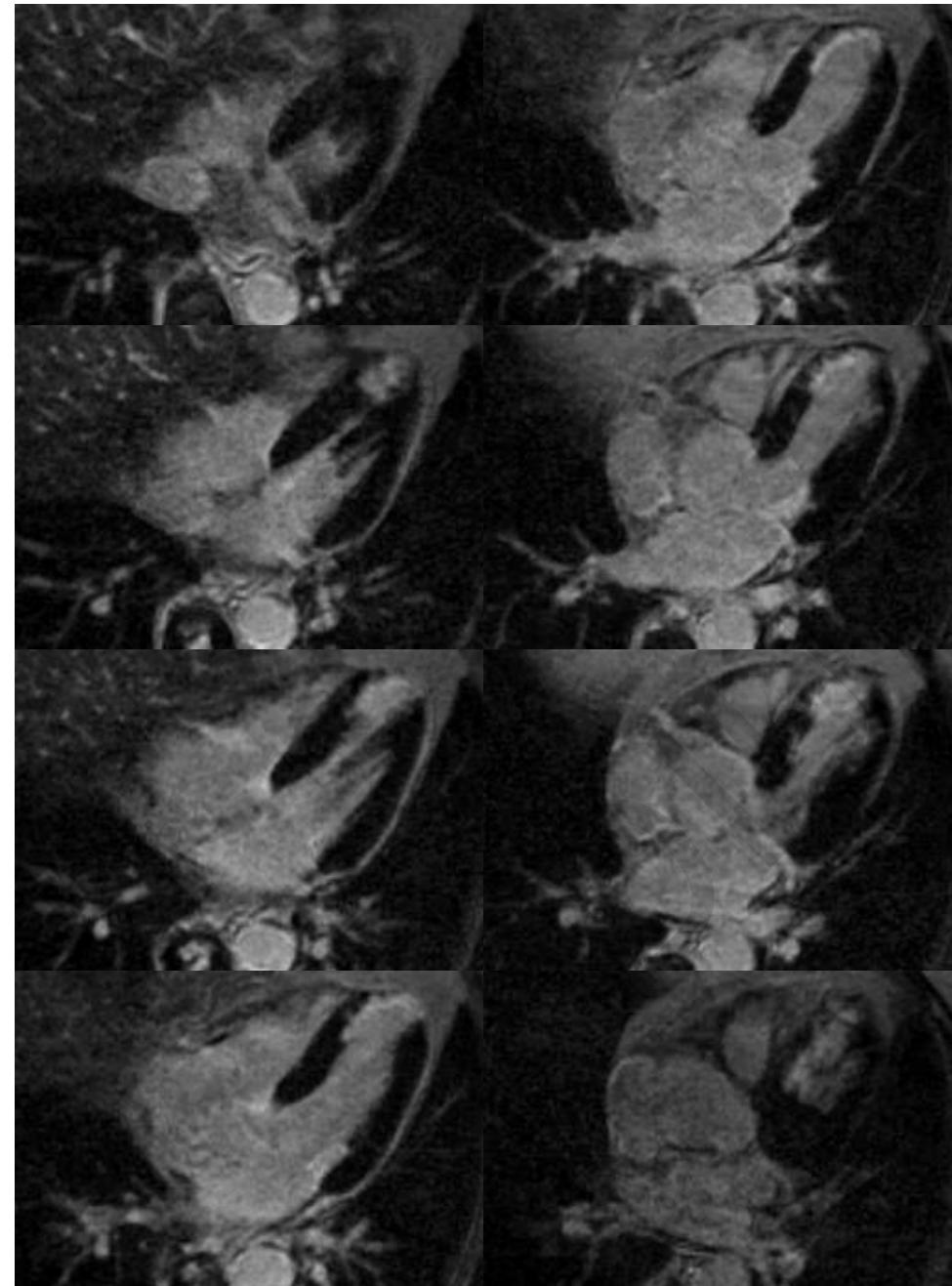
## Séquences de TI Scout (cine en 1 apnée)



10 min env. après injection - immédiatement avant la réalisation  
de la séquence IR

# **Rehaussement Tardif : Sequence 3D IR-Echo de Gradient**



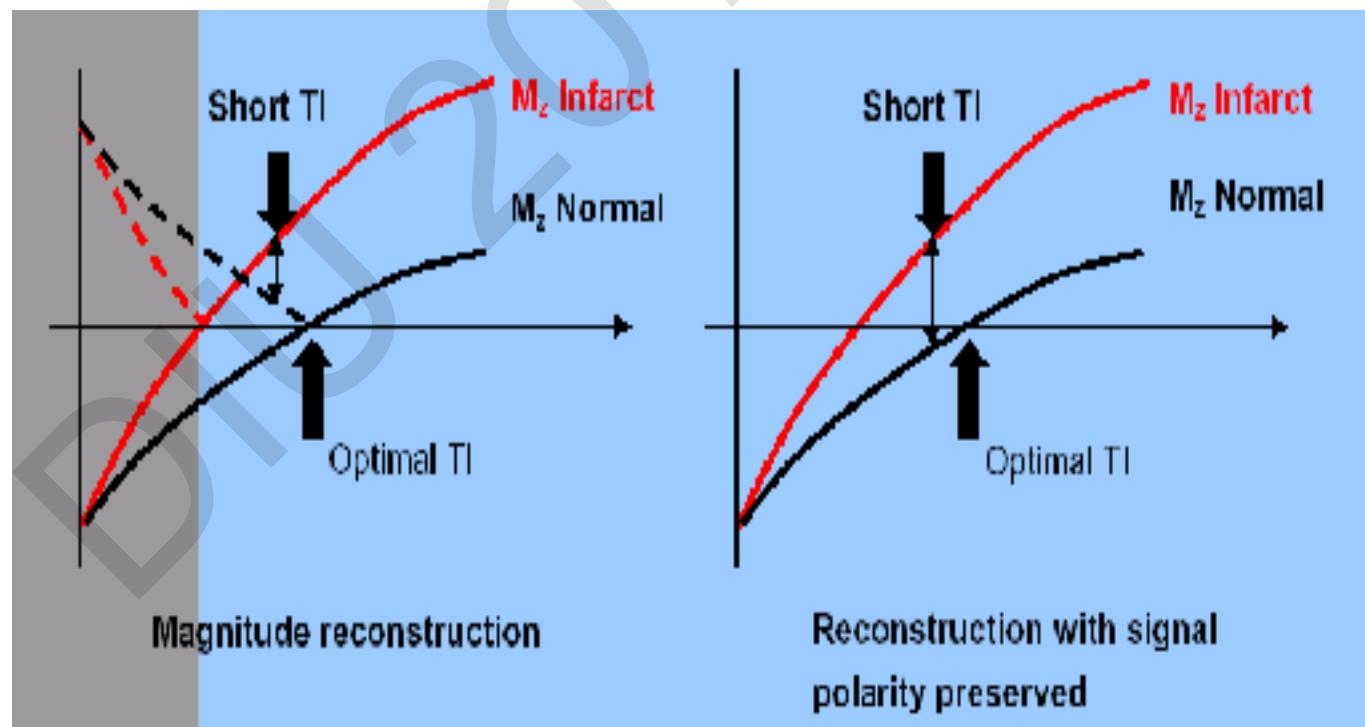
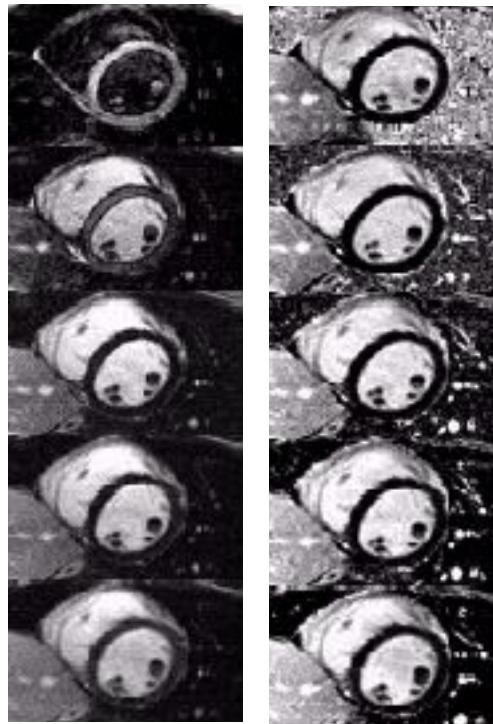


## **Rehaussement Tardif 3D IR-TurboFLASH**

**Coupes de 5 mm  
jointives  
TA = 20 sec**

# Principe des séquences IR/PSIR

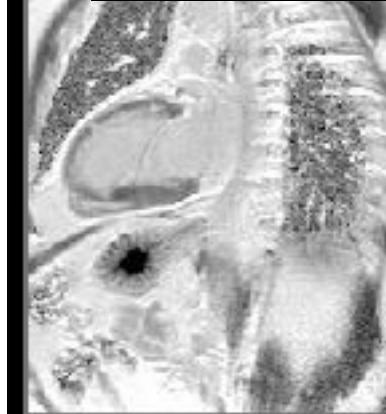
Conservation de la polarité du signal et maintien du contraste à  $TI < TI$  null



Magnitude

Phase  
Sensitive

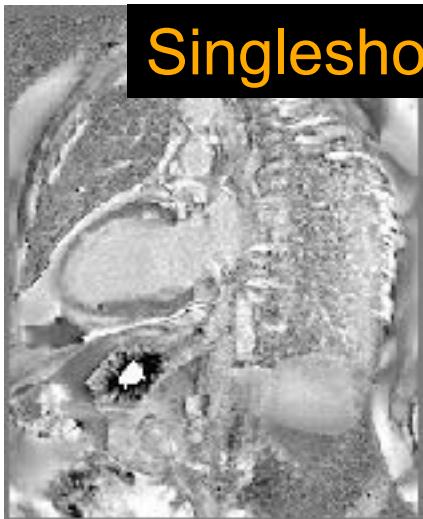
TurboFlash2D (TA=8sec.)



PSIR                    IR

TrueFISP 2D

Singleshot (TA=2HB)



Multishot (TA=5sec.)



PSIR

IR

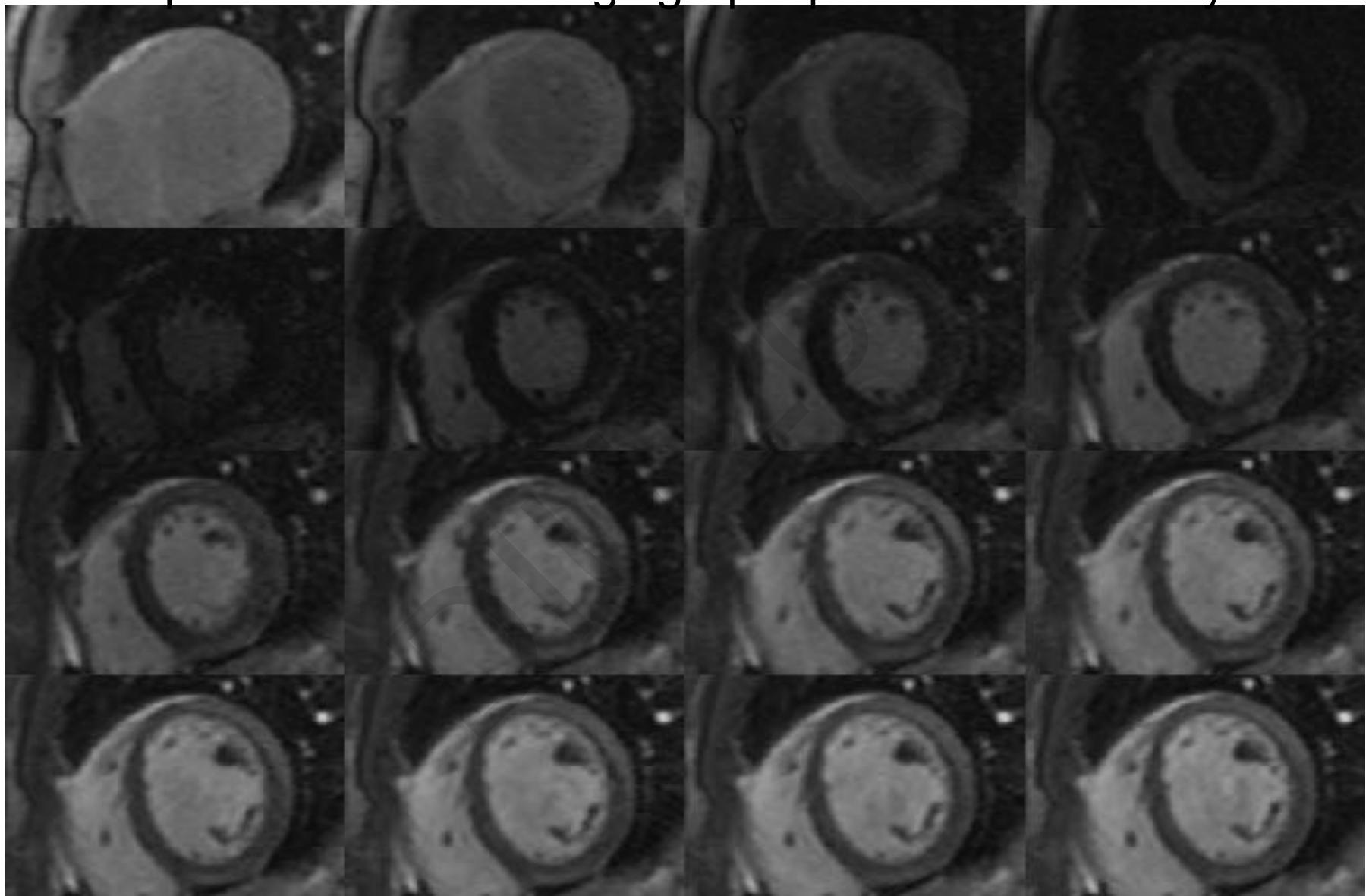
PSIR

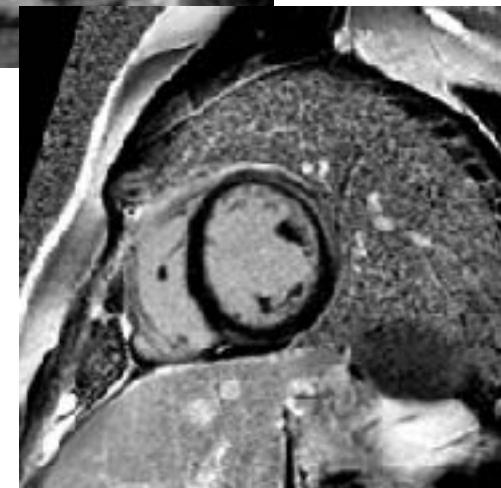
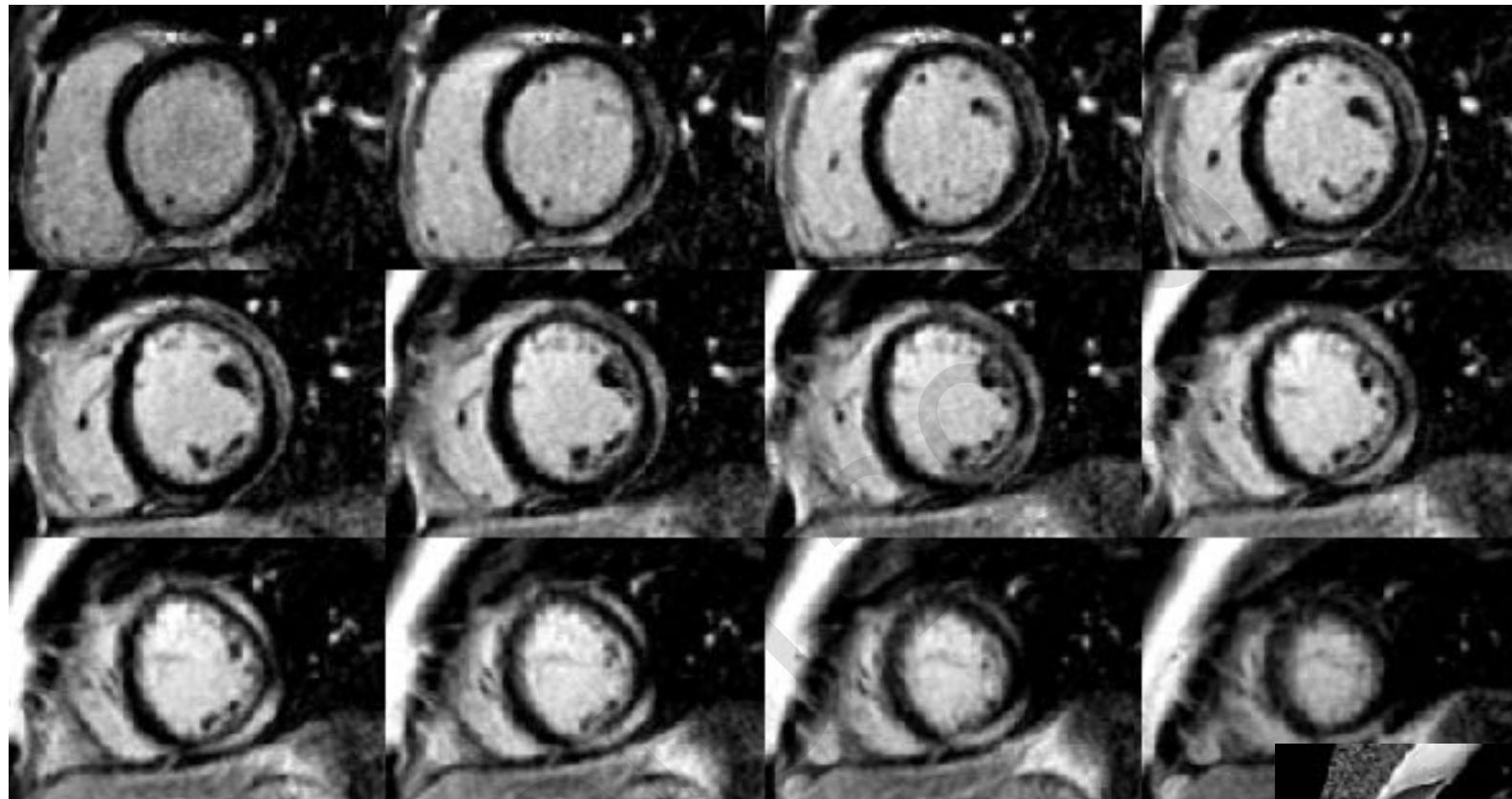
IR

## Protocole Rétention tardive (à 1,5T)

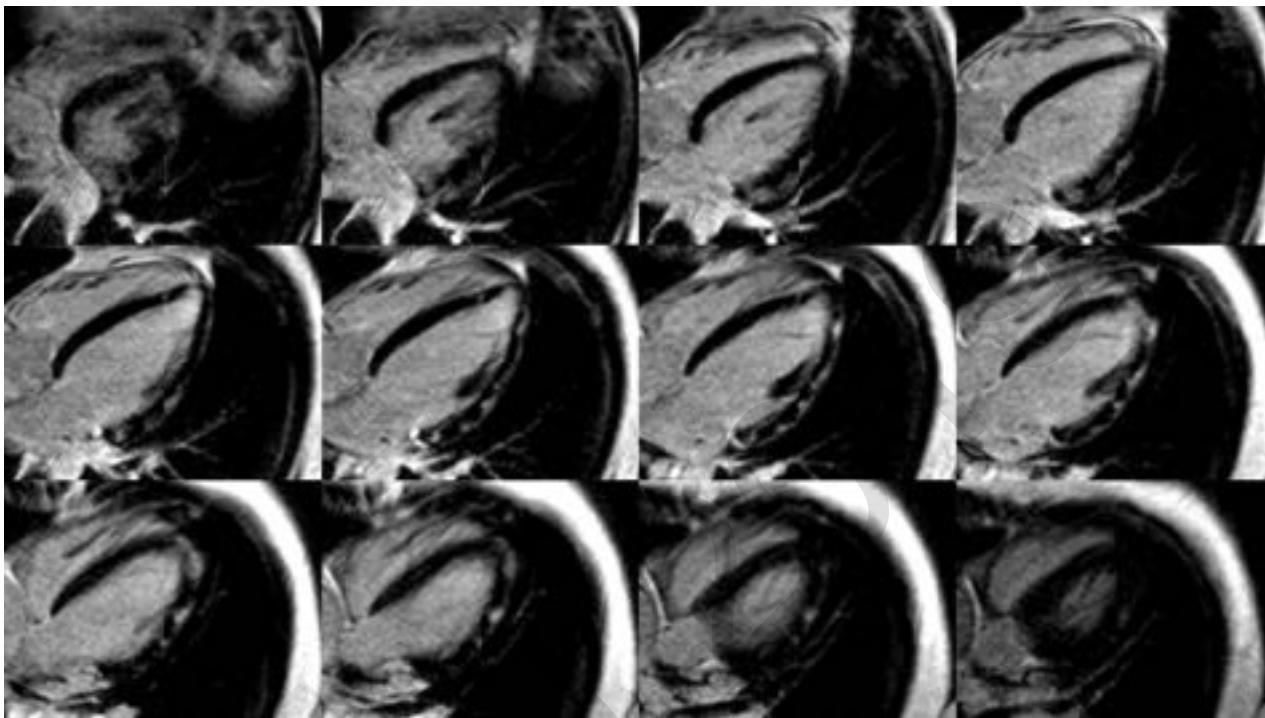
- Importance du TI scout
- **IR Flash 3D** (Intérêt des séquences 3D : SNR++, volume partiel , couverture spatiale ++, caractérisation transurmale et circonférentielle ++)
- Si TA> apnée possible alors **IR-Flash2D**
- Si pas d'apnée possible alors **single-shot IR-Truefisp 2D**

SCA tropo +. Coronaires angiographiquement saines: myocardite

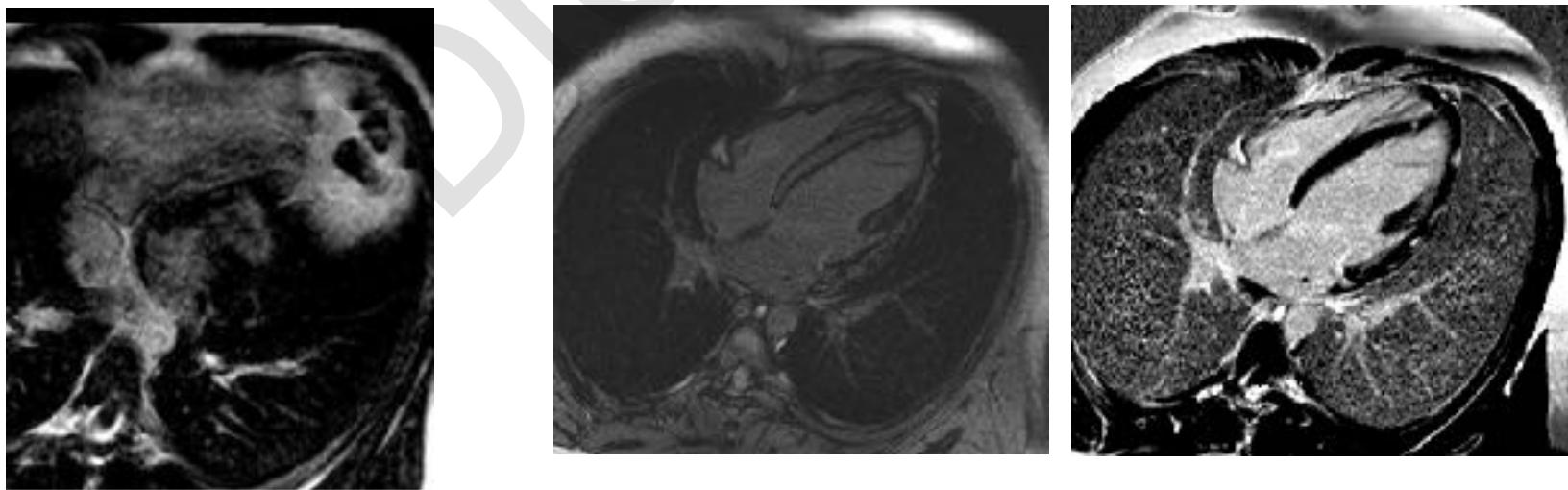




TFL 3D



PSIR TFI 2D BH

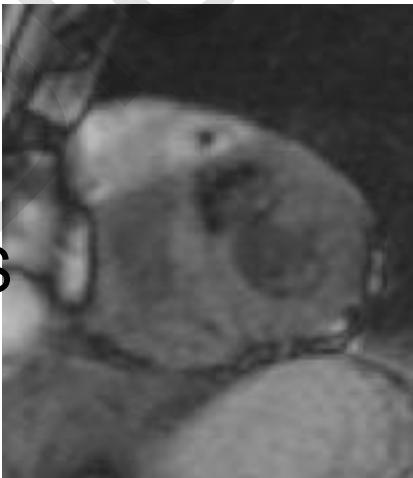


# Imagerie de Rehaussement Tardif: Problématique du réglage de TI

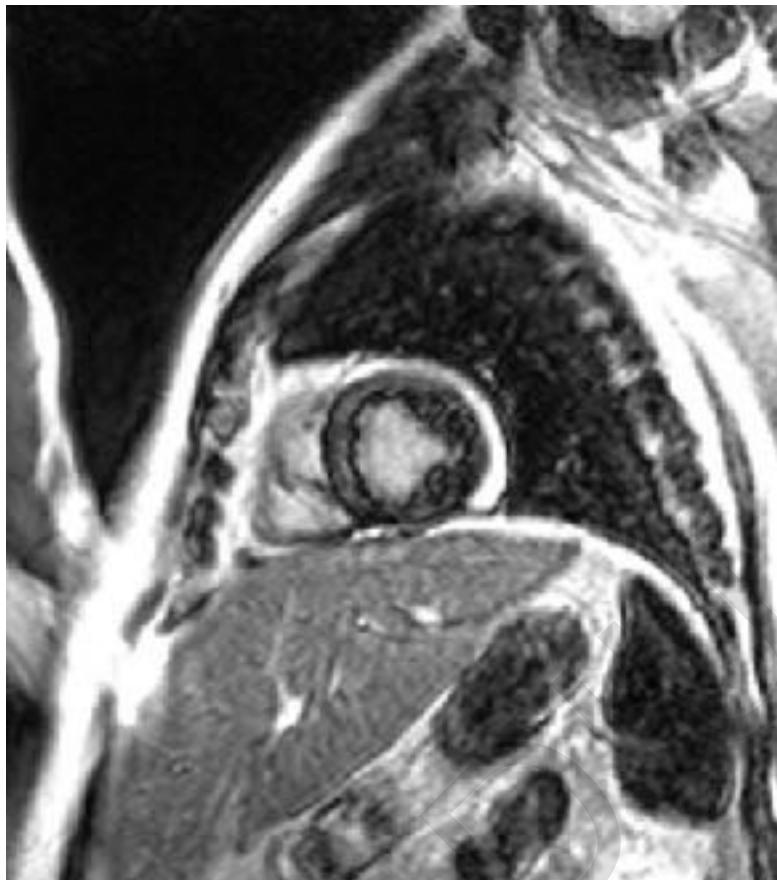
RESULTAT  
attendu:



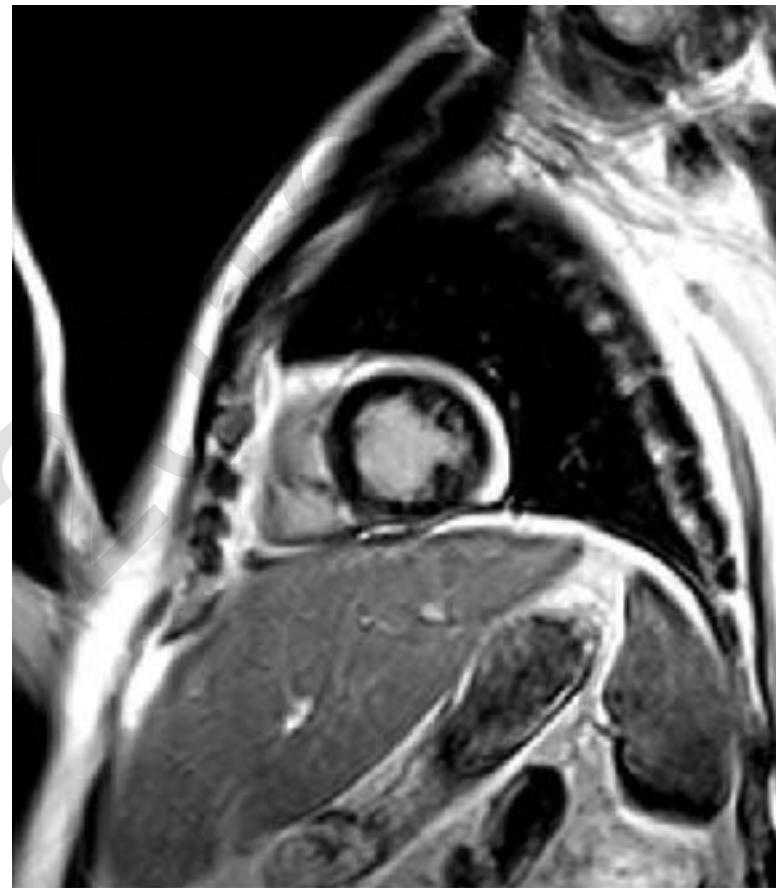
RESULTATS  
possible:



# LGE artifacts

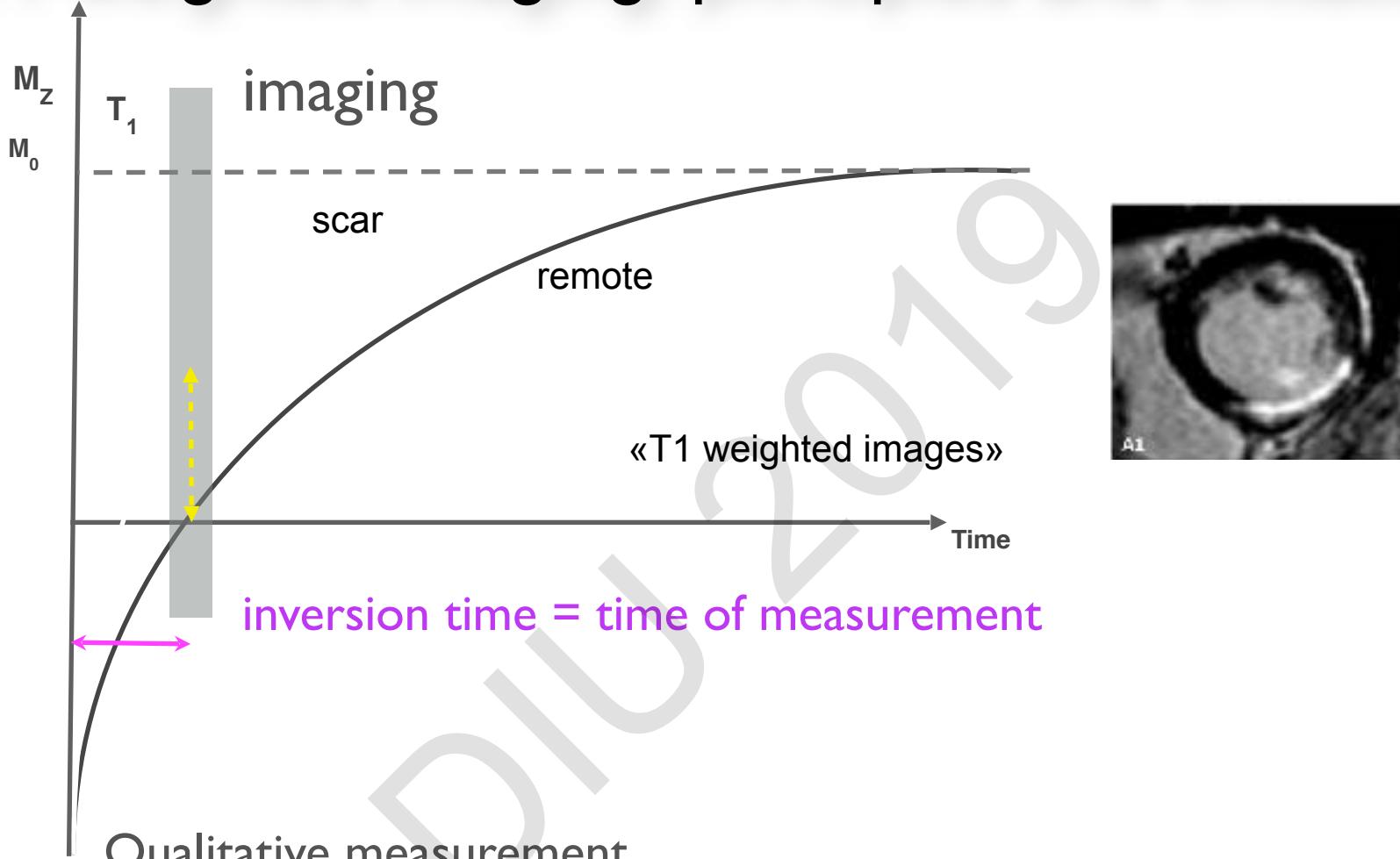


TI=240ms



TI=270ms

# T1-weighted imaging: principles and limitations



Qualitative measurement

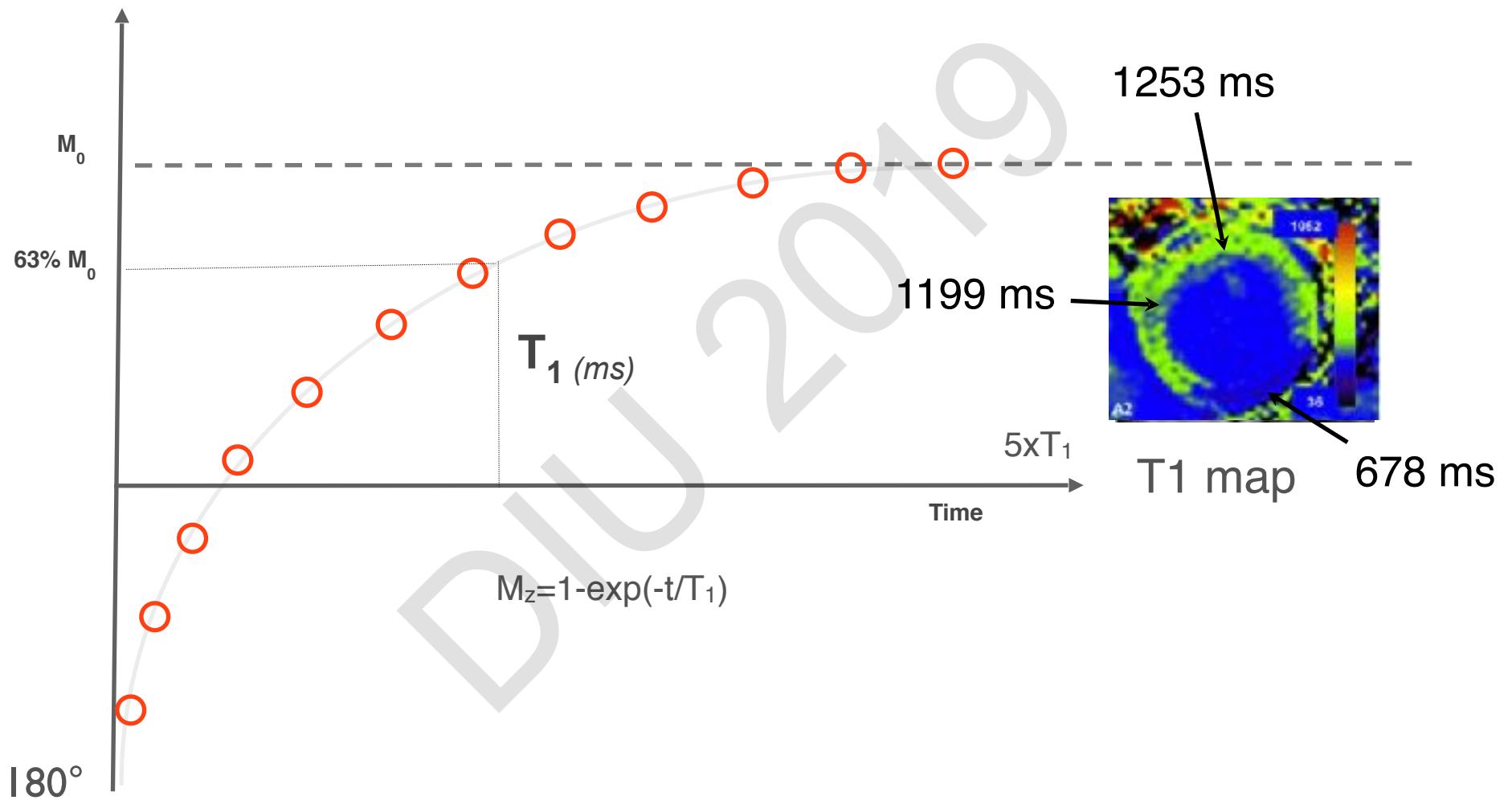
Arbitrary choice of inversion time (contrast optimization)

Relative comparison between regions

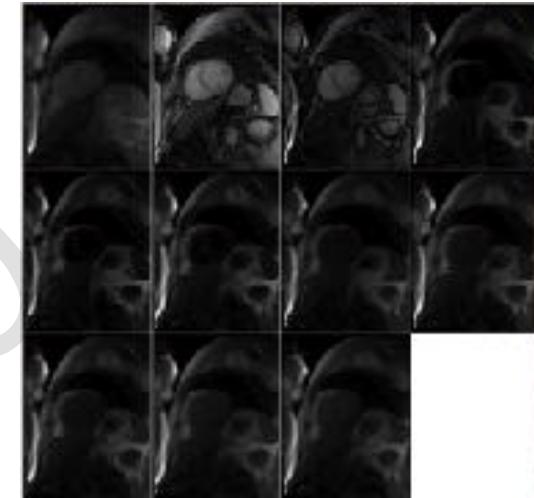
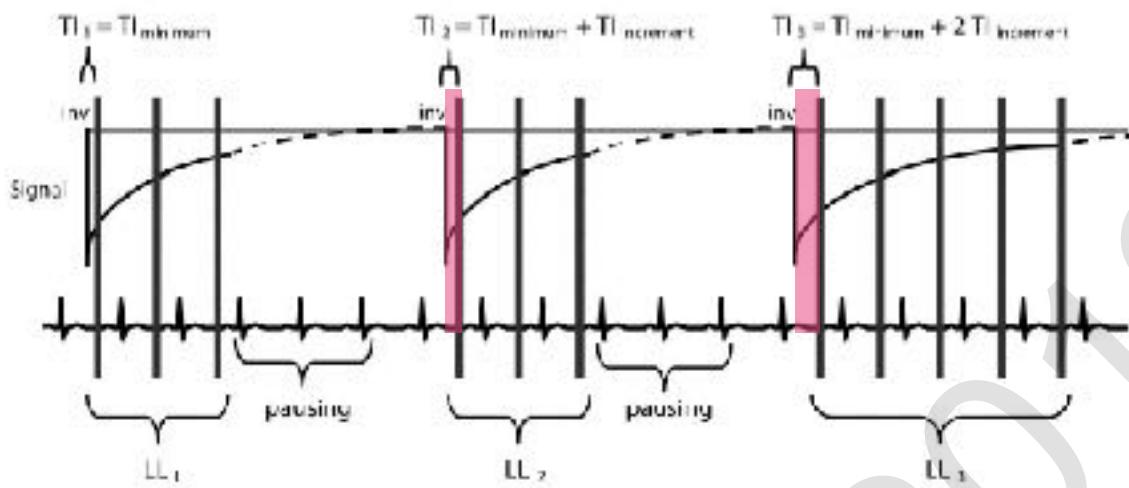
No comparison between individuals

Loss of information ~ « not the full picture »

# what is $T_1$ mapping ?



# MOLLI (Modified Look Locker Inversion Recovery)



Mode 3-3-5

11 images / 17 HB in breathhold

Messroghli DR, MRM 2004

## Variants: ShMOLLI (shortened MOLLI)

Mode 5-1-1

7 images / 9 HB in breathhold

- faster
- less heart rate variability dependency
- less breathhold motion artifacts (31% of artifacts!!)

Piechnick SK, JCMR 2010

Alternatives: SASHA, SAPPHIRE etc....

# T1 (native) Normal Values – 1.5T



# Native values – clinical utility

INCREASED ↑

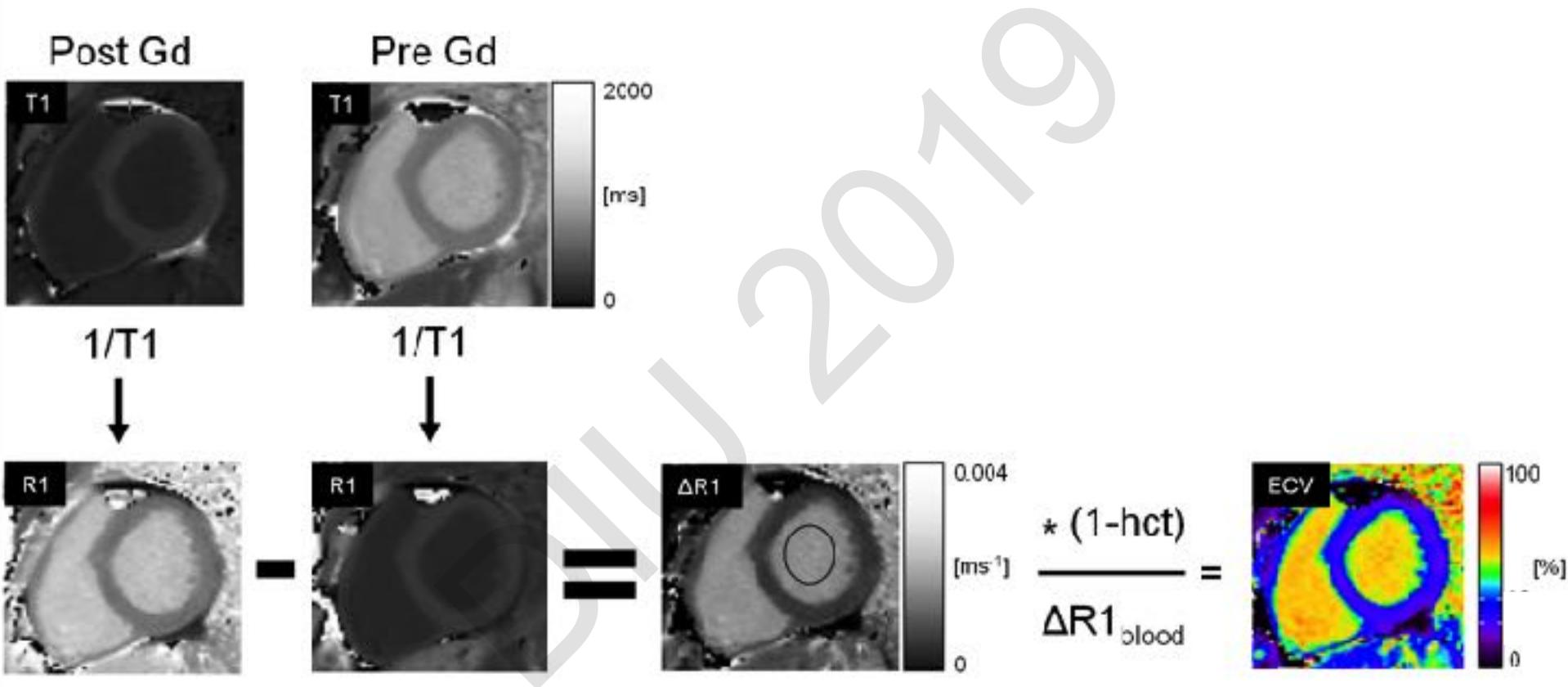
DECREASED ↓

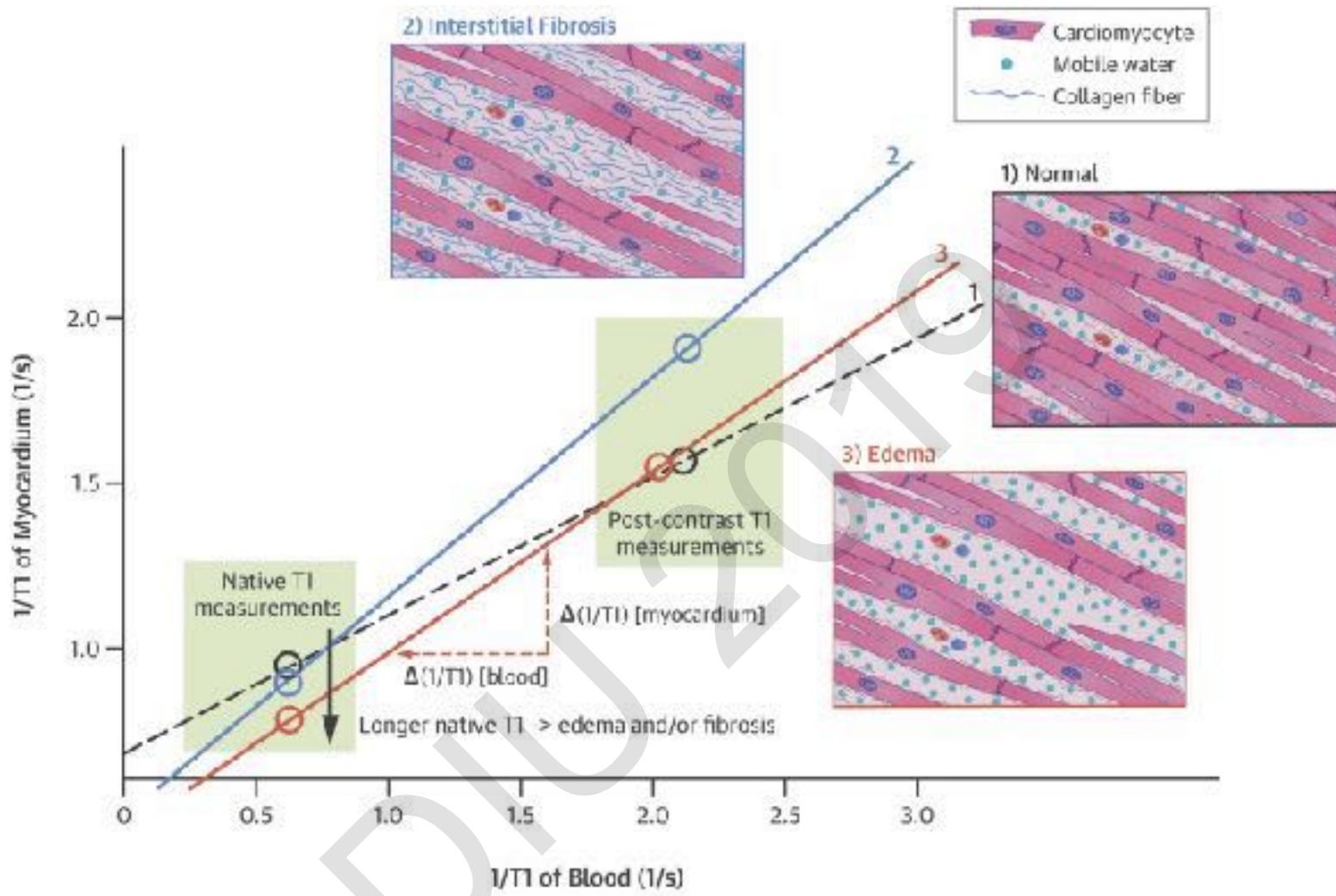
T1

- Fibrosis
- Amyloidosis
- Edema

- Anderson-Fabry Disease
- Iron overload CM
- Fat e.g. fatty metaplasia (MI)

# ECV imaging





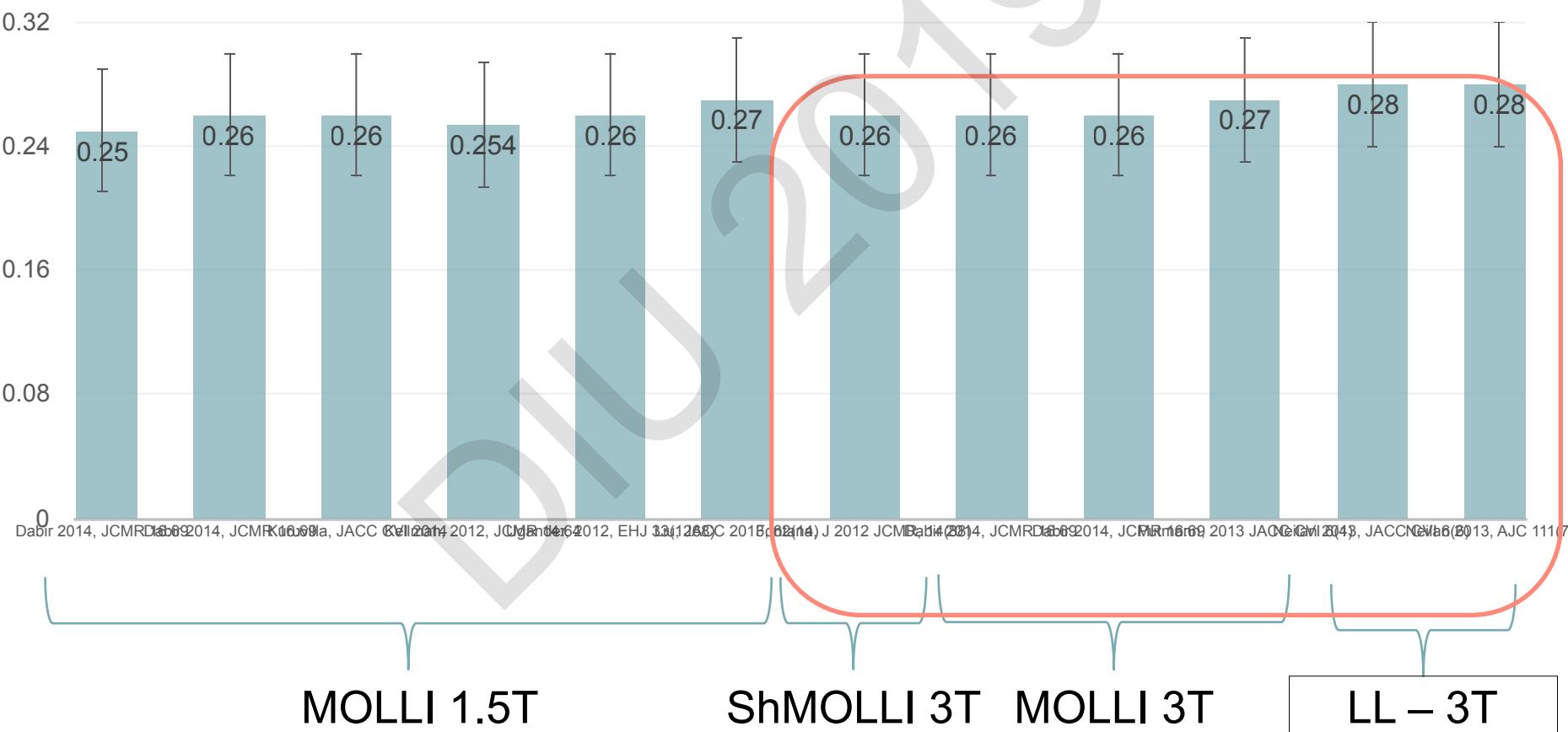
Taylor, A.J. et al. J Am Coll Cardiol Imaging. 2016; 9(1):57-61.

## Pre and Post Contrast Myocardial $T_1$ Mapping

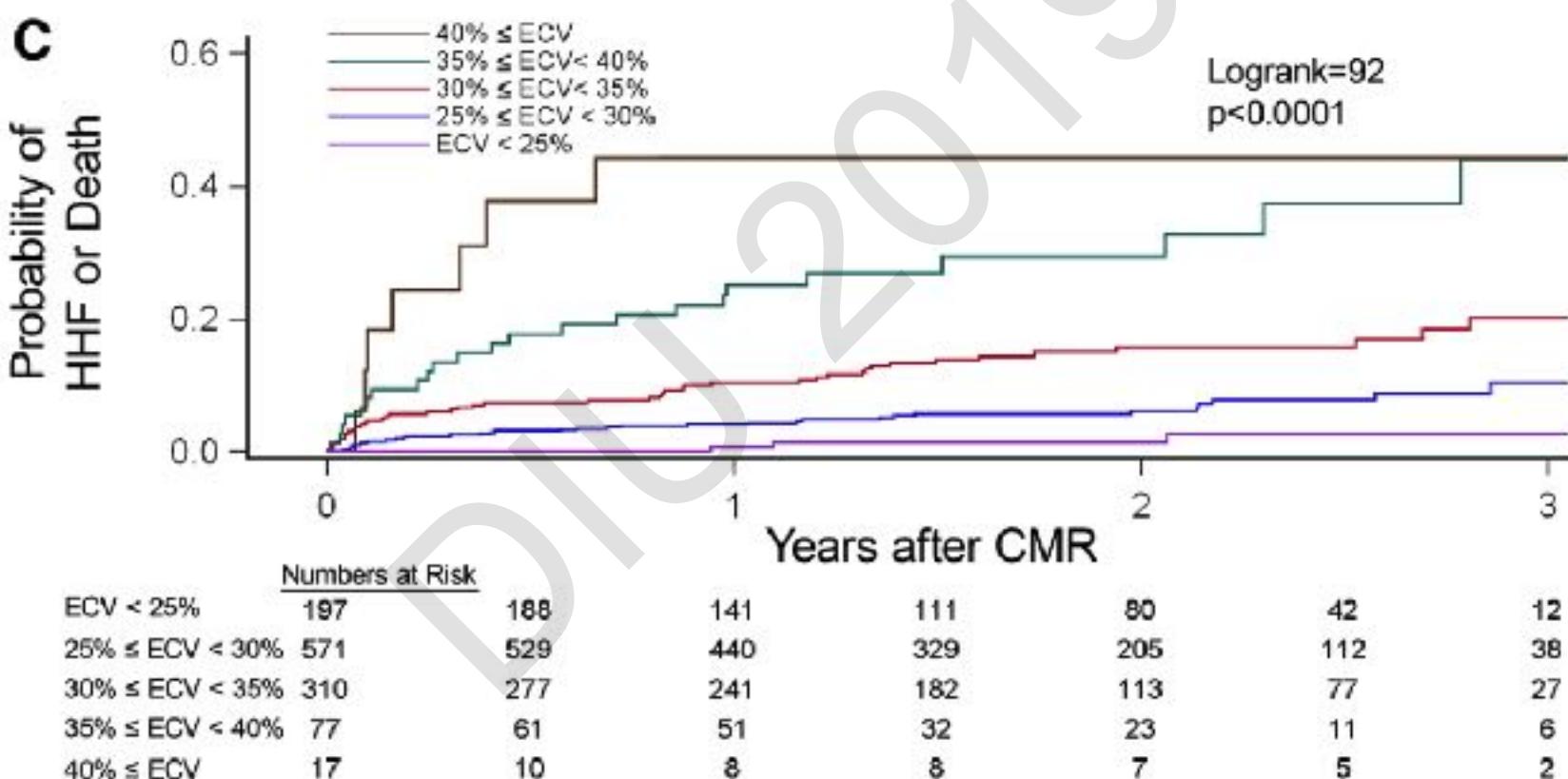
Andrew J. Taylor, Michael Salerno, Rohan Dharmakumar, Michael Jerosch-Herold

JACC: Cardiovascular Imaging, Volume 9, Issue 1, 2016, 67–81

# ECV Normal Values 1.5 & 3T



## Myocardial Fibrosis Quantified by Extracellular Volume Is Associated With Subsequent Hospitalization for Heart Failure, Death, or Both



**Figure 3.** Among 1172 participants, increasing degrees of extracellular matrix expansion in noninfarcted myocardium quantified by the myocardial ECV was significantly associated with increased risks of adverse

# *Strengths of T1 mapping techniques*

- From contrast (T1w) to absolute scale (ms)
- Native T1 (no Gd) reflects the myocardial disease involving myocyte + interstitium *together*
- T1 post-Gd becomes sensitized to extracellular space
- ECV % reflects “interstitial disease” alone
- ECV can detect early fibrosis changes not always detectable by LGE imaging
- Can be performed with multi-slices
- Allow inter-subjects (diagnosis) and follow-up studies

# Sequences MOLLI avec reconstructions synthétiques

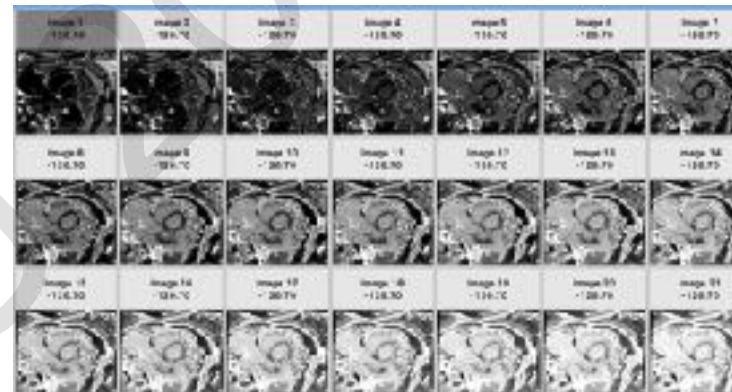
1 acquisition de 8 seconde par coupe (9 mesures)



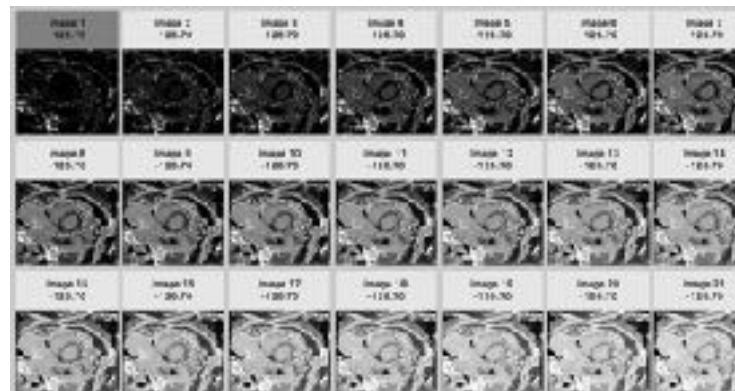
1 cartographie T1



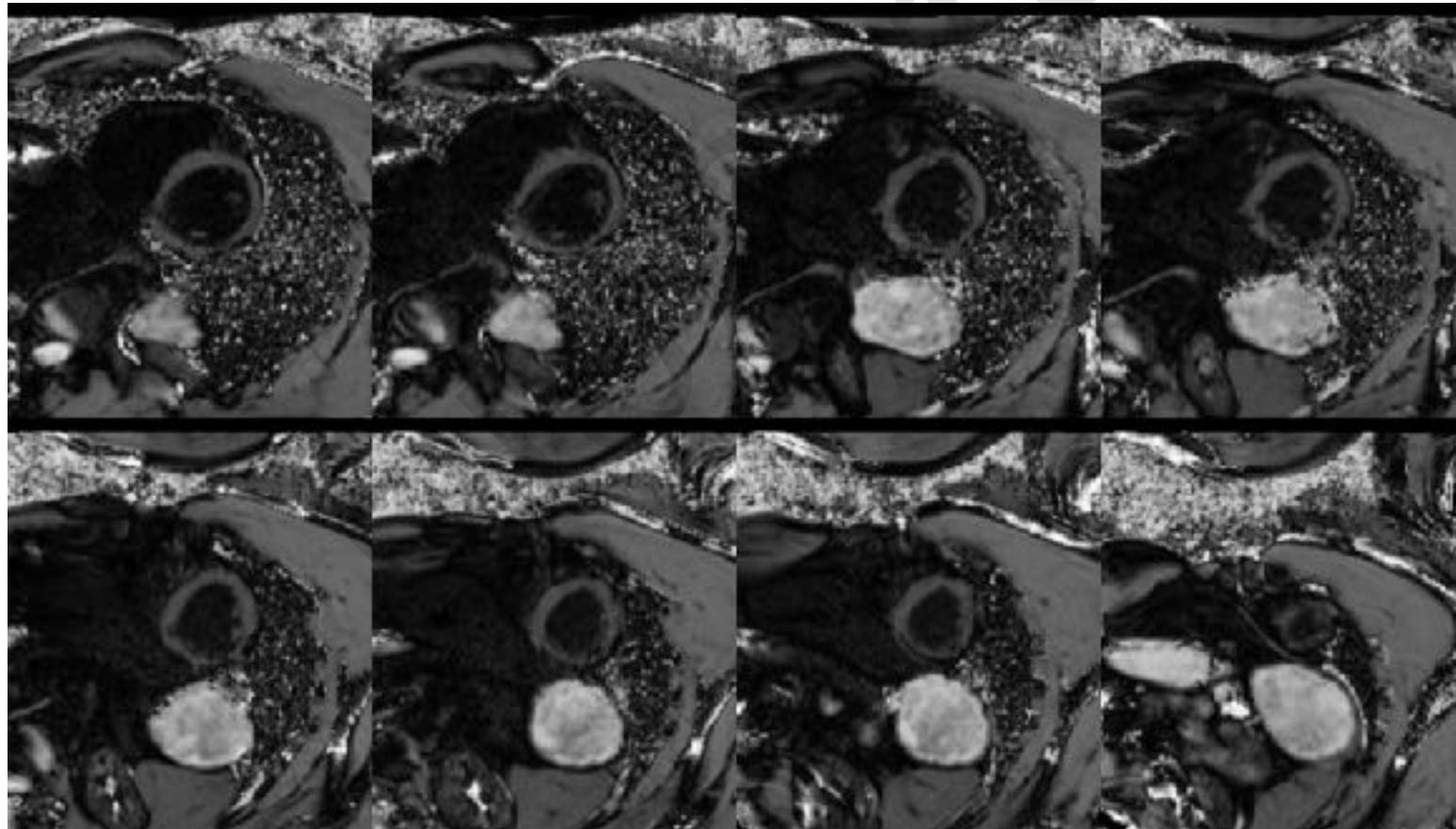
+1 séquence MagIR synthétique



+1 séquence PSIR synthétique

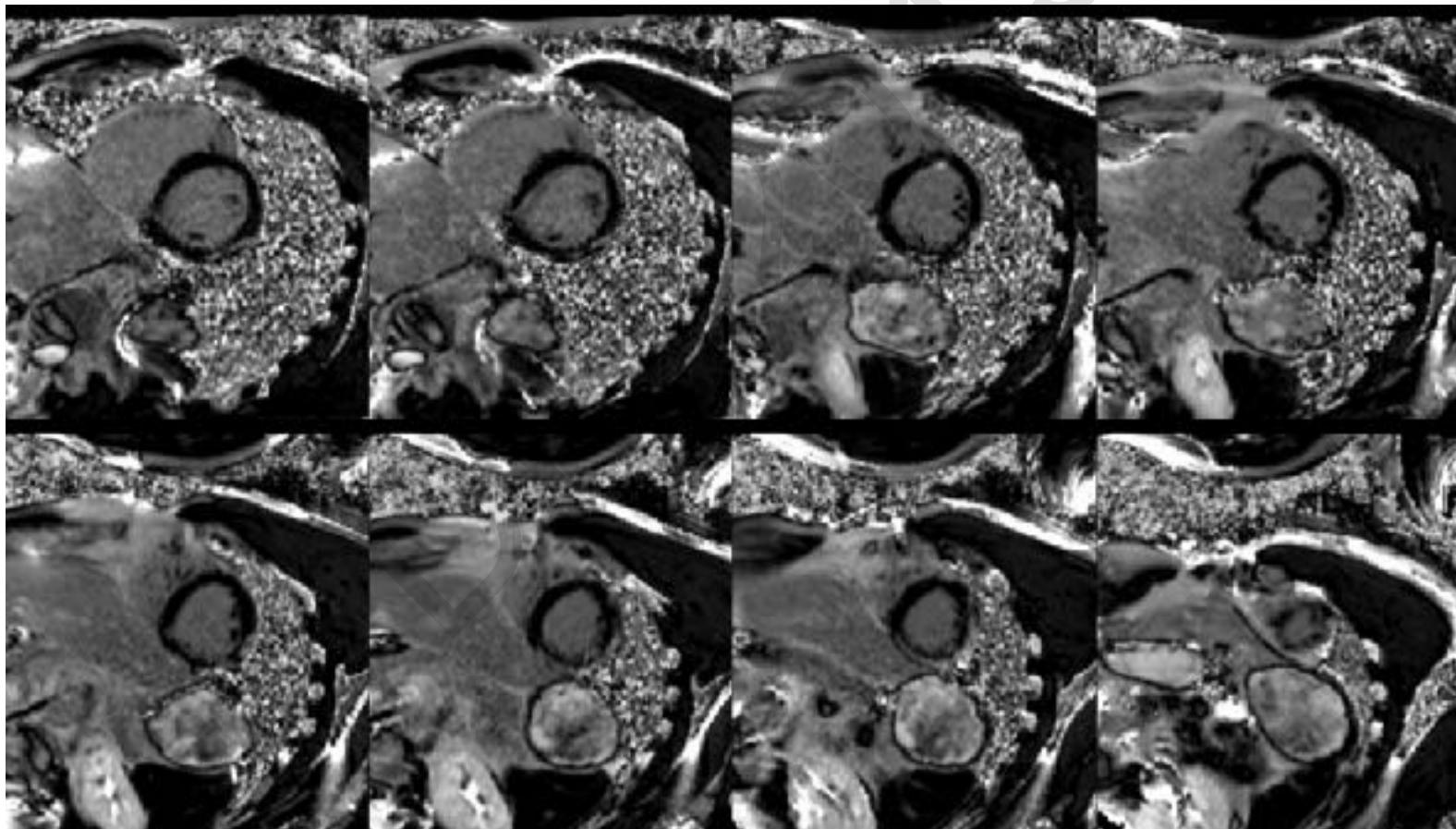


# Sequences MOLLI avec reconstructions synthétiques

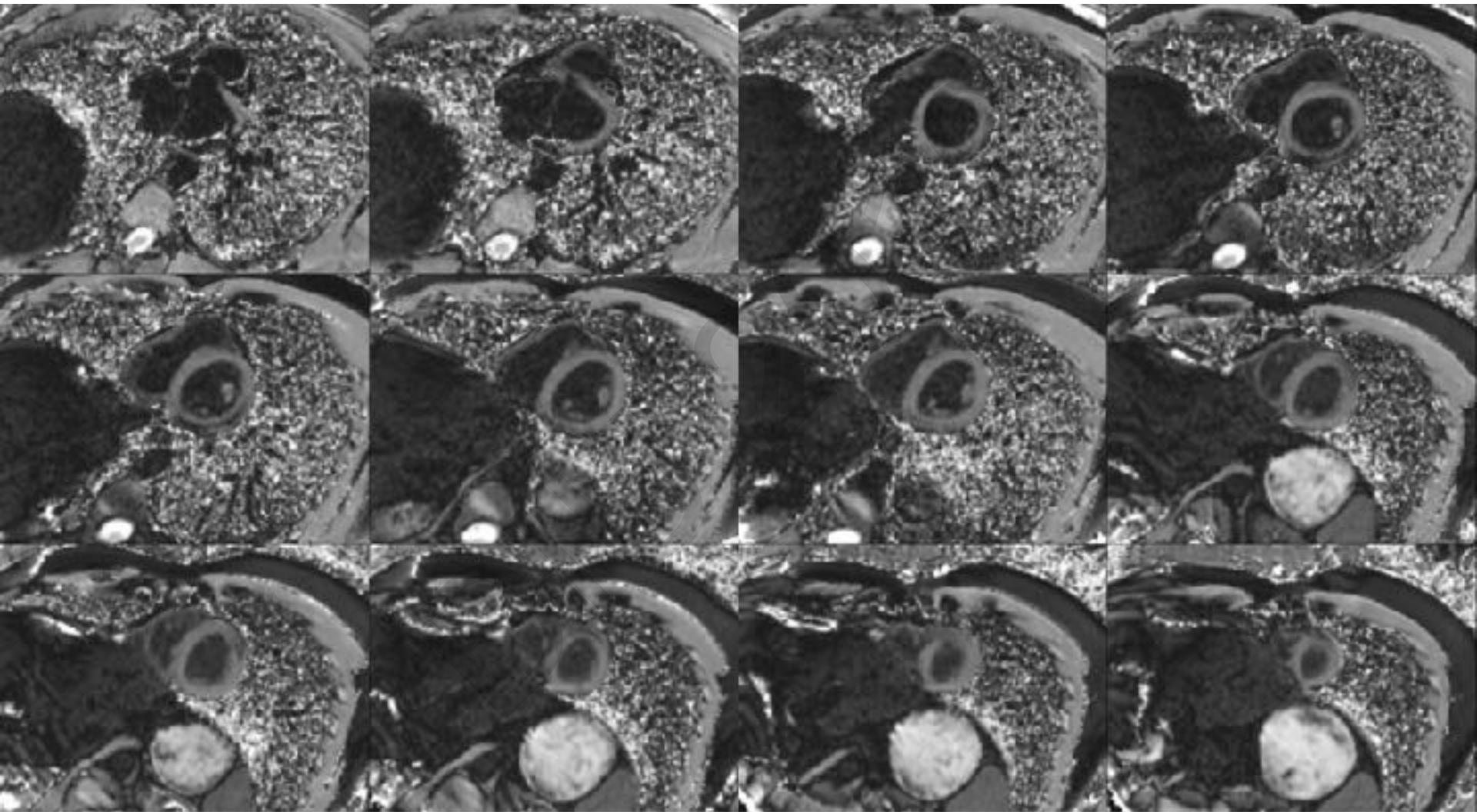


# Sequences MOLLI avec reconstructions synthétiques

= choix rétrospectif du contraste optimal sans TI scout sur l'ensemble du volume



## Case 5 – acute myocarditis – synth MAGIR reconstruction



## Case 5 – acute myocarditis

