IMAGERIE SCINTIGRAPHIQUE CARDIAQUE POUR CARDIOLOGUES

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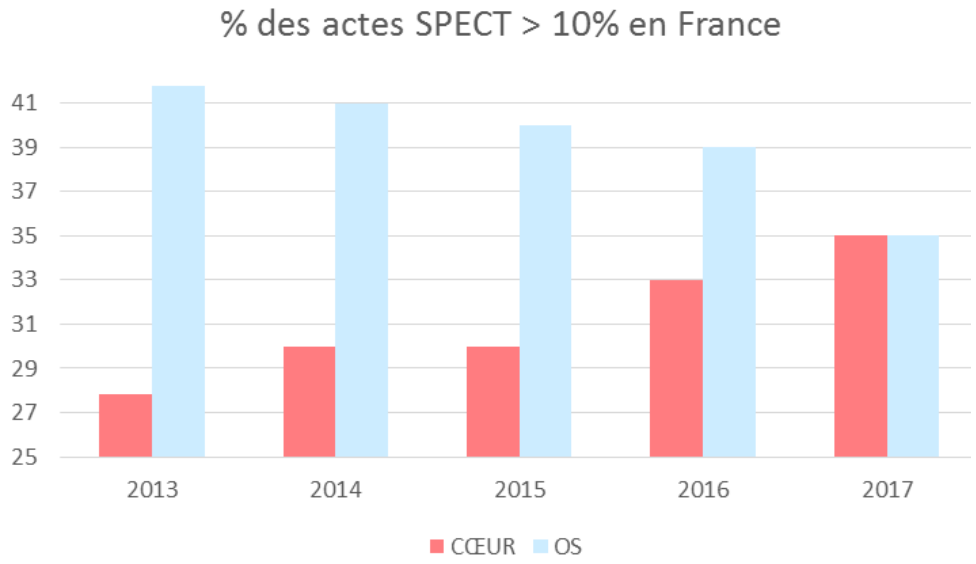
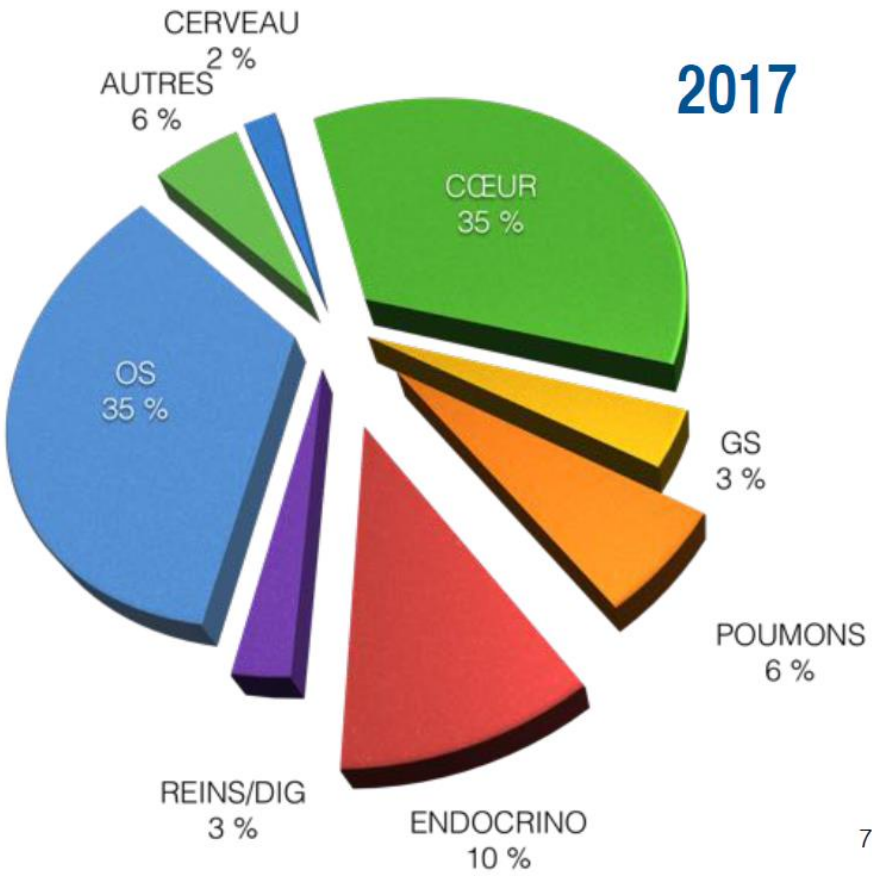
SCINTIGRAPHIES FREQUENTES

France, 2017: 1,5 10^6 Scinti = 71% SPECT + 29% TEP (94% FDG)

TEP cardiaque (CHU MTP 2018):
0,3% myocarde (25 examens)
+ infections et inflammations



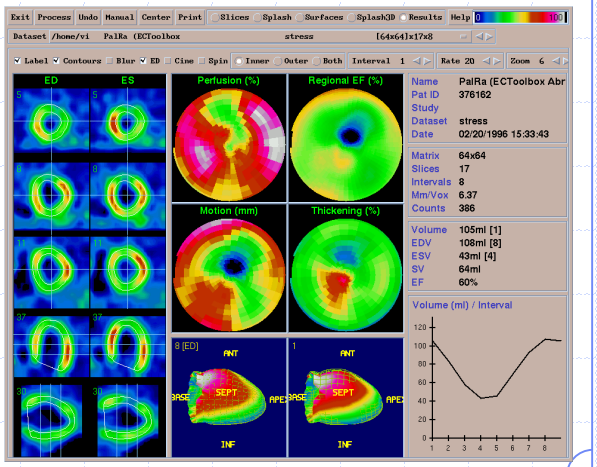


http://www.unscear.org/unscear/en/publications/2008_1.html
http:\\www.irsn.fr/FR/expertise/rapports_expertise/Documents:radioprotection/IRSN_INVS_Rapport_Expri_032010.pdf

PLAN DE LA PRESENTATION

- Perfusion myocardique
  - Tomoscintigraphie myocardique de perfusion, gated SPECT,
  - Tomoscintigraphie dynamique 4D
- Viabilité en TEP FDG
- Amyloses et Sarcoïdose
- Pathologies infectieuses
- Innervation sympathique
- Fonction ventriculaire

TOMOSCINTIGRAPHIE DE PERFUSION MYOCARDIQUE

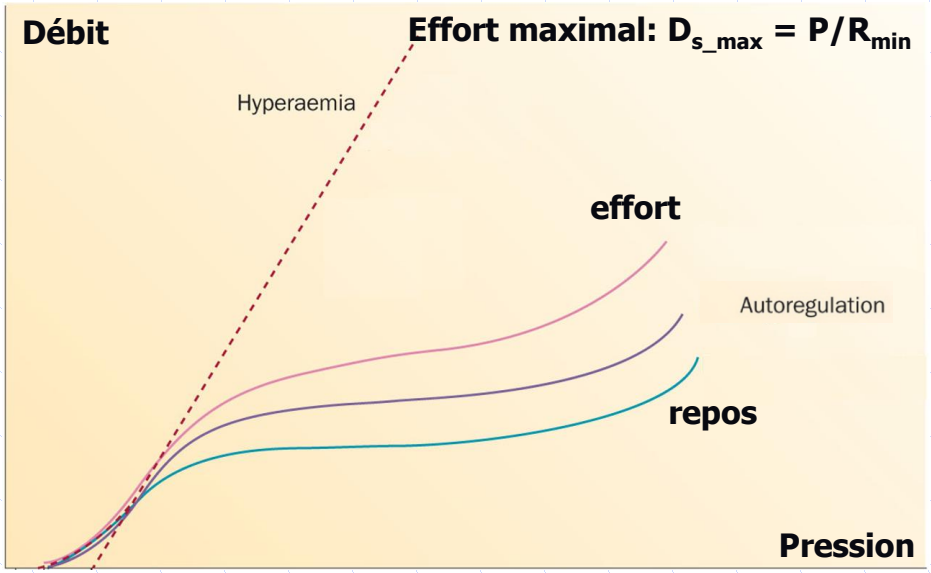


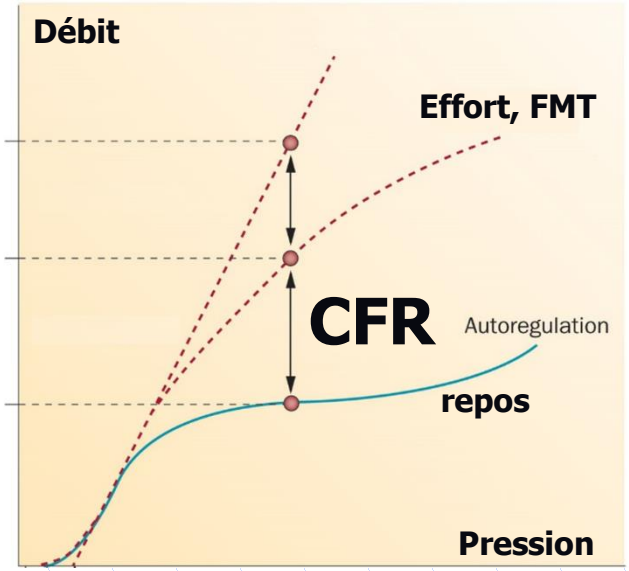
INDICATIONS

- **DIAGNOSTIC & SUIVI DES CORONAROPATHIES**
  - **Pendant, après un angor, suivi douteux.**
  - **ATTENTION : sténose $\not\Rightarrow$ ischémie $\Rightarrow$ traitement**
- **DEPISTAGE DES CORONAROPATHIES**
  - **Pré-Op, cardiopathie,**
  - **FRCV, ischémie silencieuse (DNID,VIH)**
- **RECHERCHE DE VIABILITE MYOCARDIQUE**
- **EVALUATION DE LA FONCTION SYSTOLIQUE VG**
  - **À des fins pronostiques seulement**
- **RECHERCHE DE MALADIE DE SURCHARGE CARDIAQUE**
  - **Sarcoïdose cardiaque…**

Am Heart J 1999;137(5):949-57 – Am J Cardiol 2002;90:827-832 – Eur Heart J 2004;25:543-550 - Diabetes Care 2004;27:1954-61 - Circulation 2005;112:I311-6 -Diabetes Métab 2004;30 – Circulation 2002;106:1883-1892 - Eur Heart J 2006;27:713-21 – JACC 2009;53(23):2201-2229

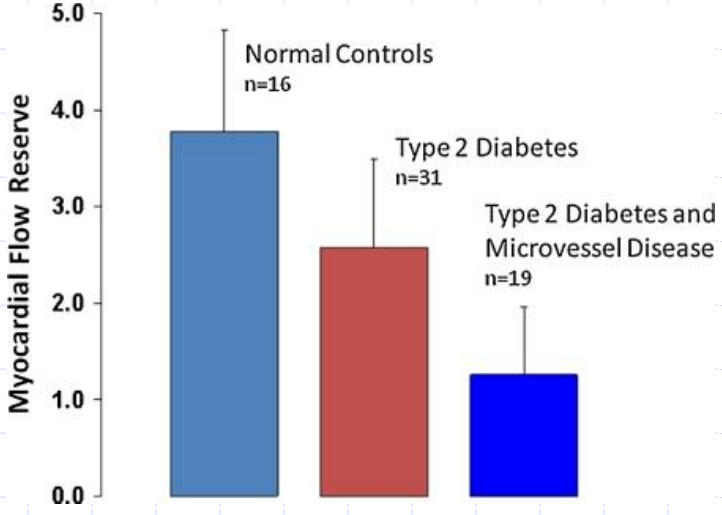
Physiopathologie





Débit de repos ~ 1 mL/g/min

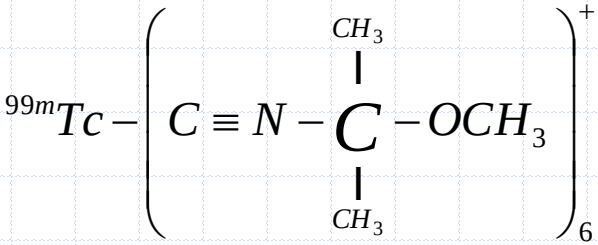
Réserve de perfusion = débit d'effort / débit de repos

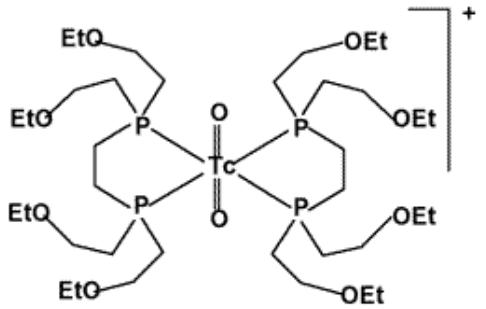


Van de Hoef et al. Nat Rev Cardiol 2013 – Heinrich et al J Nucl Cardiol 2010

RADIOTRACEURS

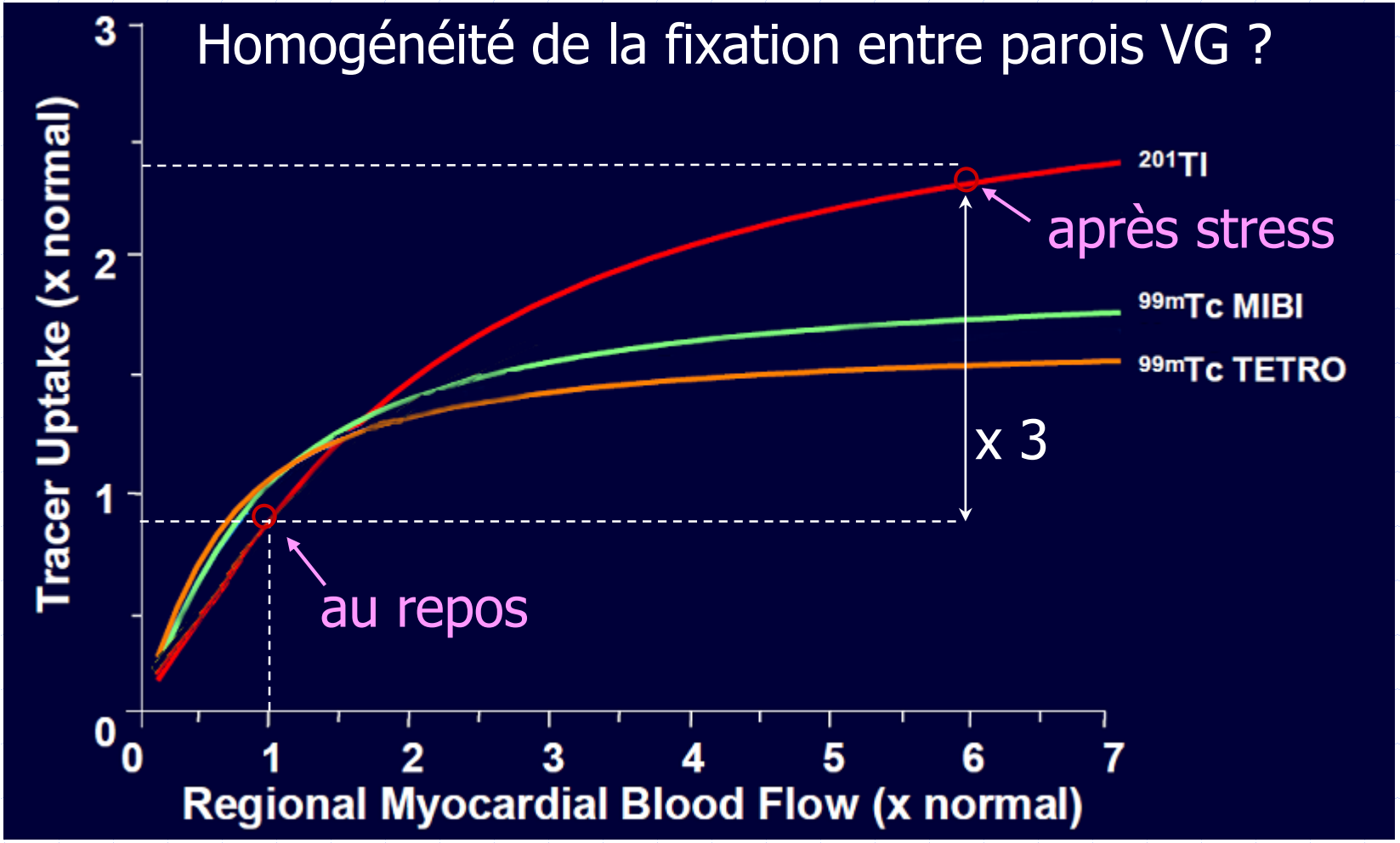
- CATIONS LIPOPHILES
  - MIBI, TETROFOSMINE
  - Diffusion passive
  - $\propto$ ddp transmembranaire
  - 95% $\in$ mitochondries
    - Muscle, Gld. Exocrines, cancers





- THALLIUM 201 (^{201}Tl)
  - Analogue du K (Na/K ATPase, cotransport Na/K/2Cl)
- RUBIDIUM 82 (^{82}Rb)
  - Analogue du K (Na/K ATPase, cotransport Na/K/2Cl)
  - En cours de développement clinique (quantification ++)
- ^{18}F-FDG : traceur d'ischémie myocardique

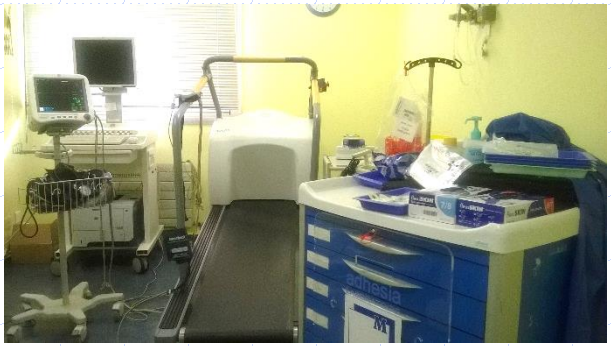
RADIOTRACEURS SPECT



Glover et al. Circulation 1995 et 1997, ACC 2003. Vanzetto et al. Circulation 1999.

PROTOCOLE 1 (ANGER) en 4h

± TNT SL ou 3x20 mg Vastarel
(Dichlorhydrate de trimétazidine)



3 h

Stress mixte :
fc > 85% (220-âge)
dipyridamole 0,56-0,75 mg/kg
Sur 4 minutes
si CI: Regadenoson 0,4 mg
ou dobutamine

A L'acmé du stress
3,7 MBq/kg MIBI/TF acmé stress
(7 mCi pour 70 kg)
ou 1,5 MBq/kg Tl201

20' (30 x 40")
synchro ECG
procubitus/decubitus

RPF/OSEM BTW 0,25/5

Au repos
11 MBq/kg
21 mCi pour 70 kg
ou 0,5 MBq/kg Tl201

20' (30 x 40")
synchro ECG
procubitus/decubitus

RPF/OSEM BTW 0,4/10

Dosimétrie: 7 mSv = 1 an d'exposition naturelle à Clermont Ferrand (260 mSv/an à Ramsar)

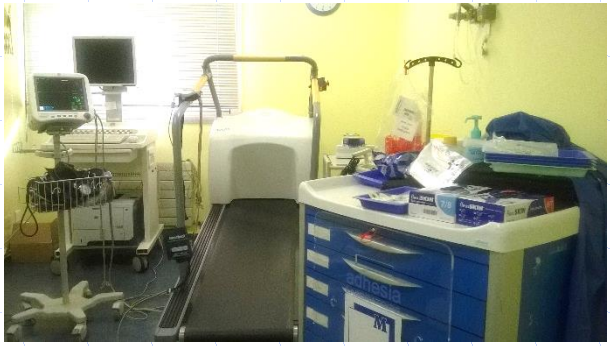
PROTOCOLE 2 (CZT) en 30’

Repos
± TNT/Vastarel

3,7 MBq/kg
MIBI/TF
7 mCi pour 70 kg
au repos

3’-5’ repos
synchro ECG
procubitus/decubitus

RPF/OSEM BTW 0,4/5



Stress mixte :
fc > 85% (220-âge)
dipyridamole 0,56-0,75 mg/kg
Sur 4 minutes
si CI: Regadenoson 0,4 mg
ou dobutamine

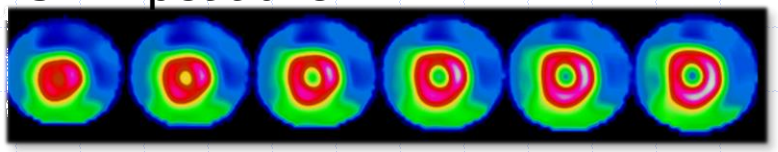
11 MBq/kg MIBI/TF acmé stress
(21 mCi pour 70 kg)

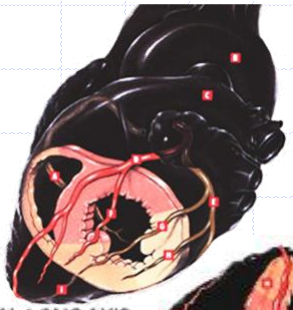
3’-5’ repos
synchro ECG
procubitus/decubitus

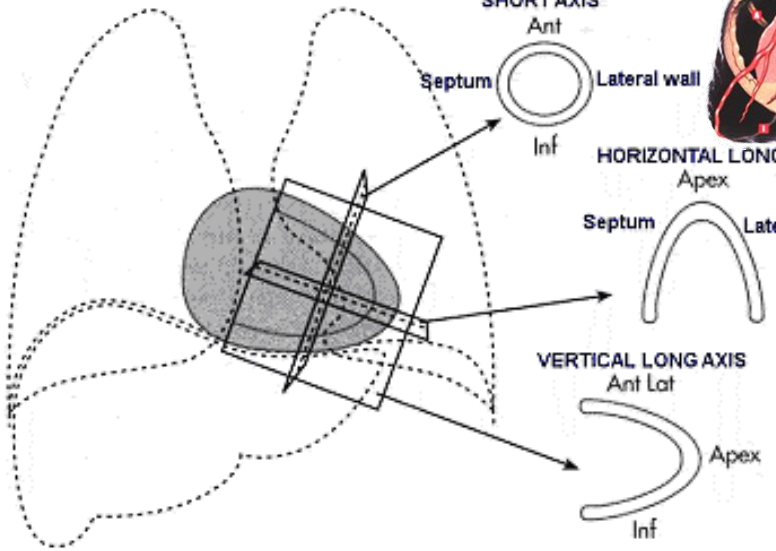
RPF/OSEM BTW 0,4/7

RESULTATS

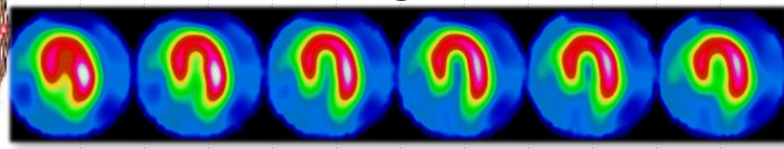
SA = petit axe



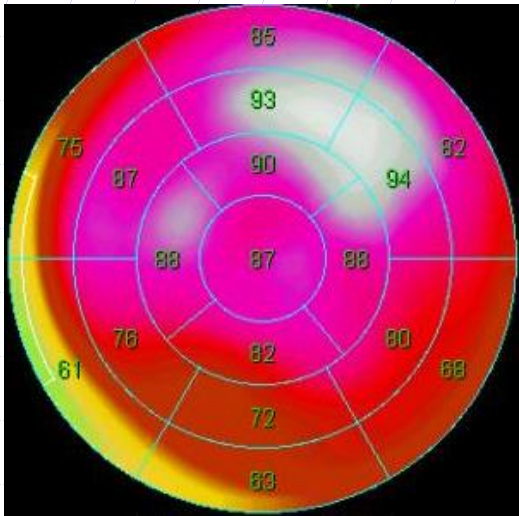


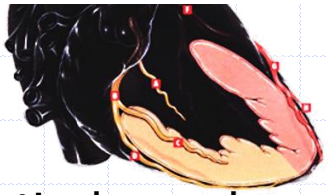


HLA = horizontal grand axe

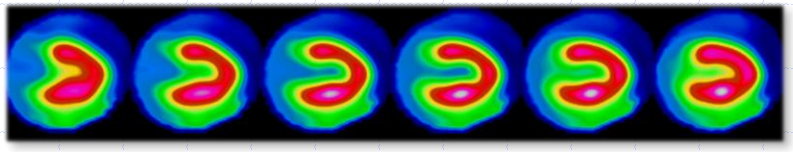


Polaire (Bull's eye)





VLA = vertical grand axe

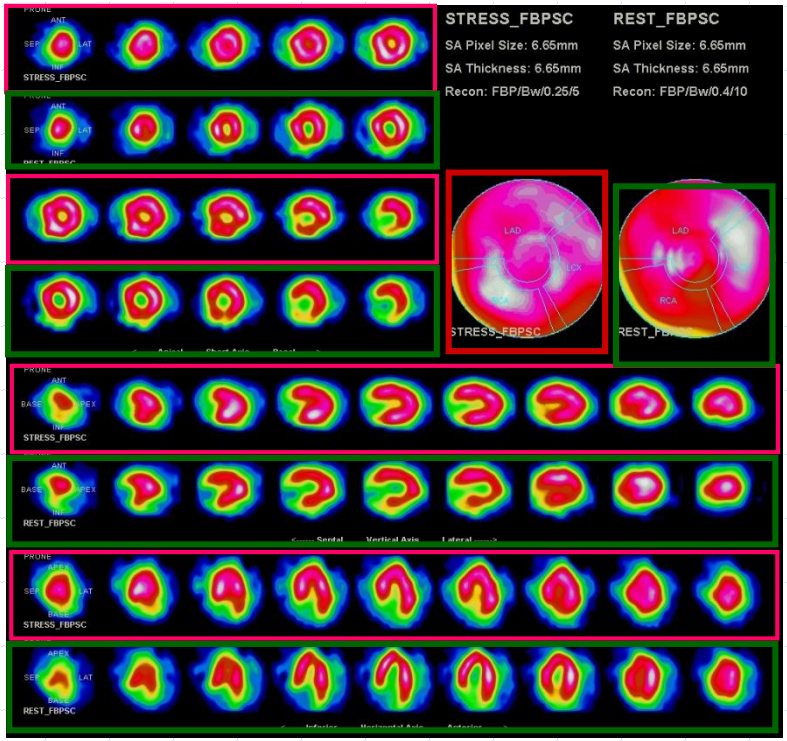


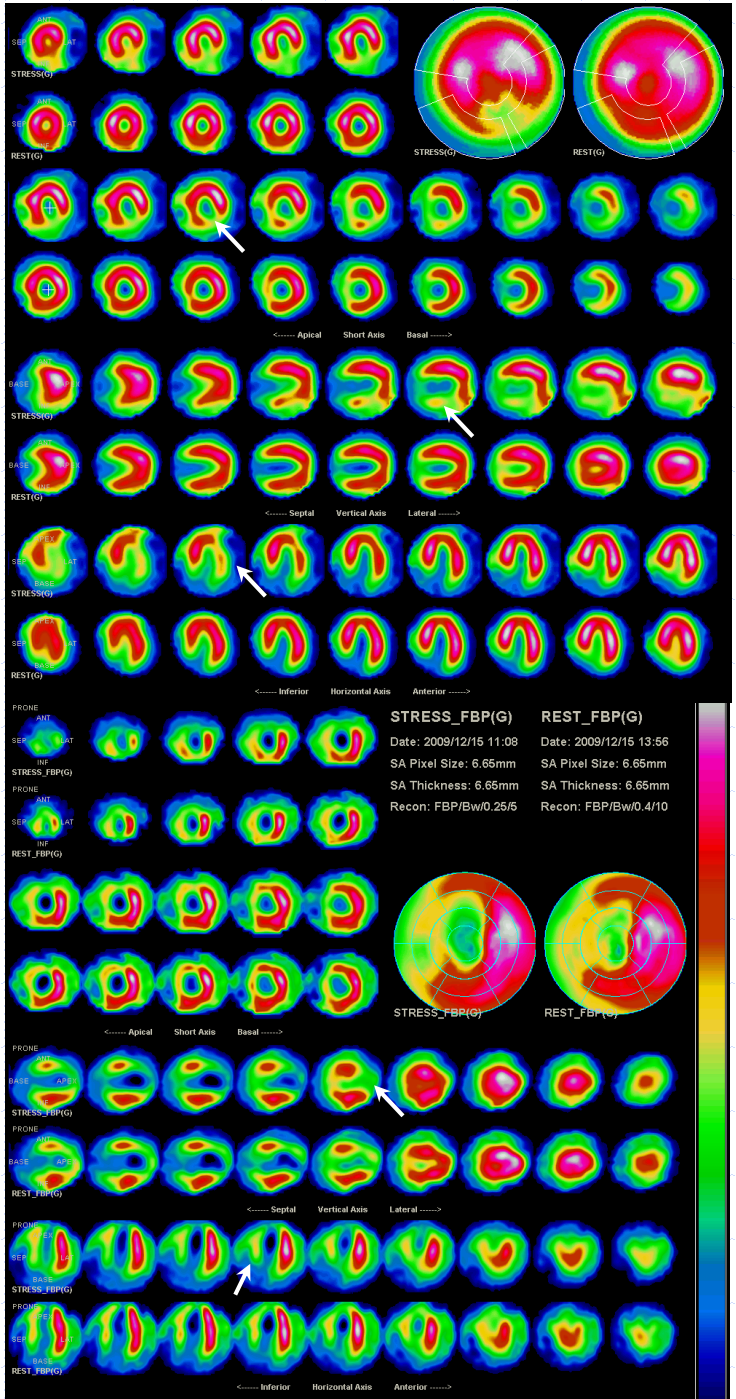
PARTICULARITES EN CZT CARDIO

- Sensibilité x 5-10:
  - protocoles écourtés, exposition,
  - TEMP dynamique…
- Résolution en énergie : ^{123} I / ^{99}Tc
- Résolution spatiale/2: intérêt clinque ?

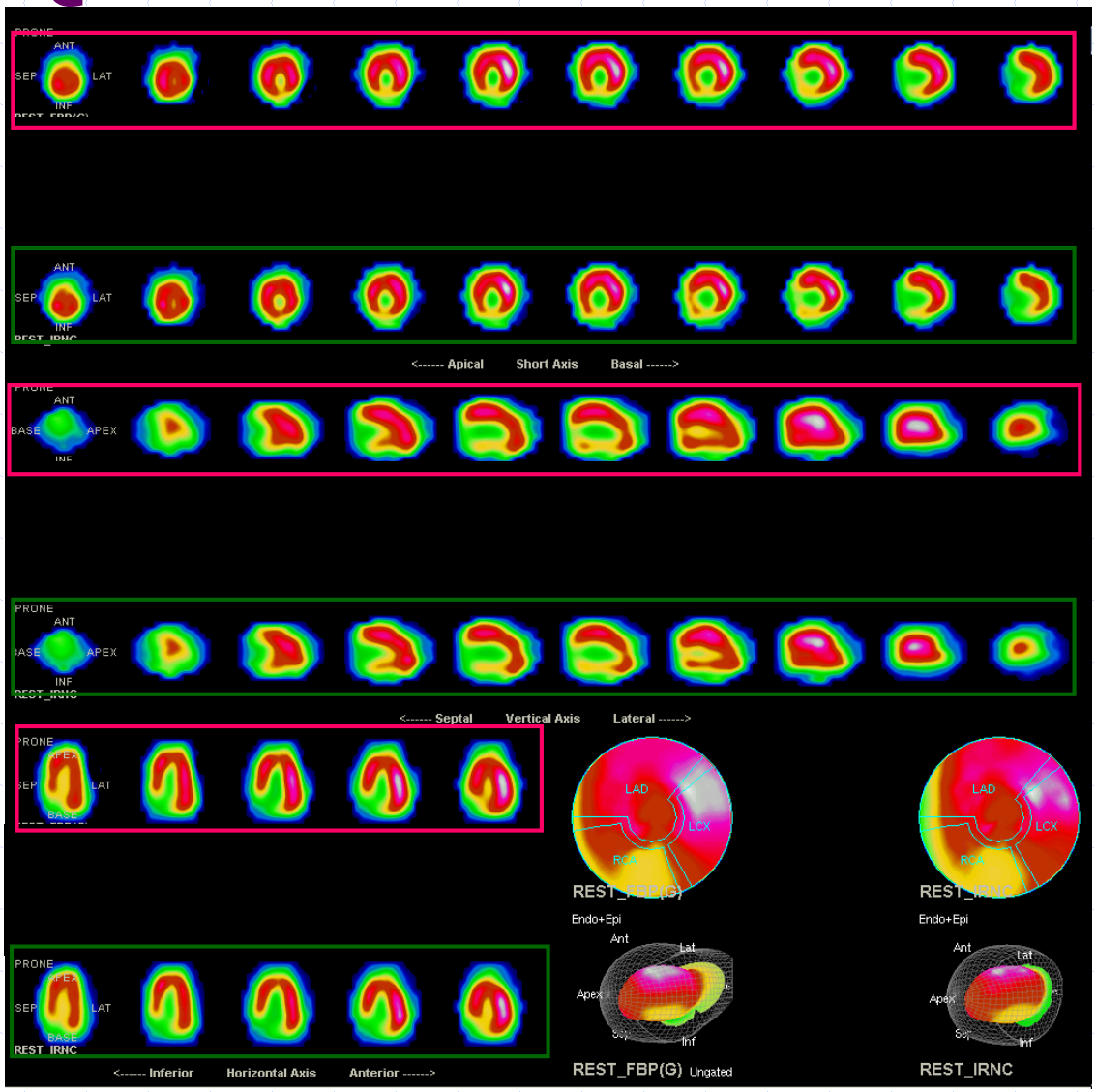
- Bougé du patient non détectable
- Artefacts à contrôler (10%)
  - De bougé, respiratoire
  - De centrage, activité hors du FOV
- Résolution spatiale/2: QGS ?

CAS CLINIQUES



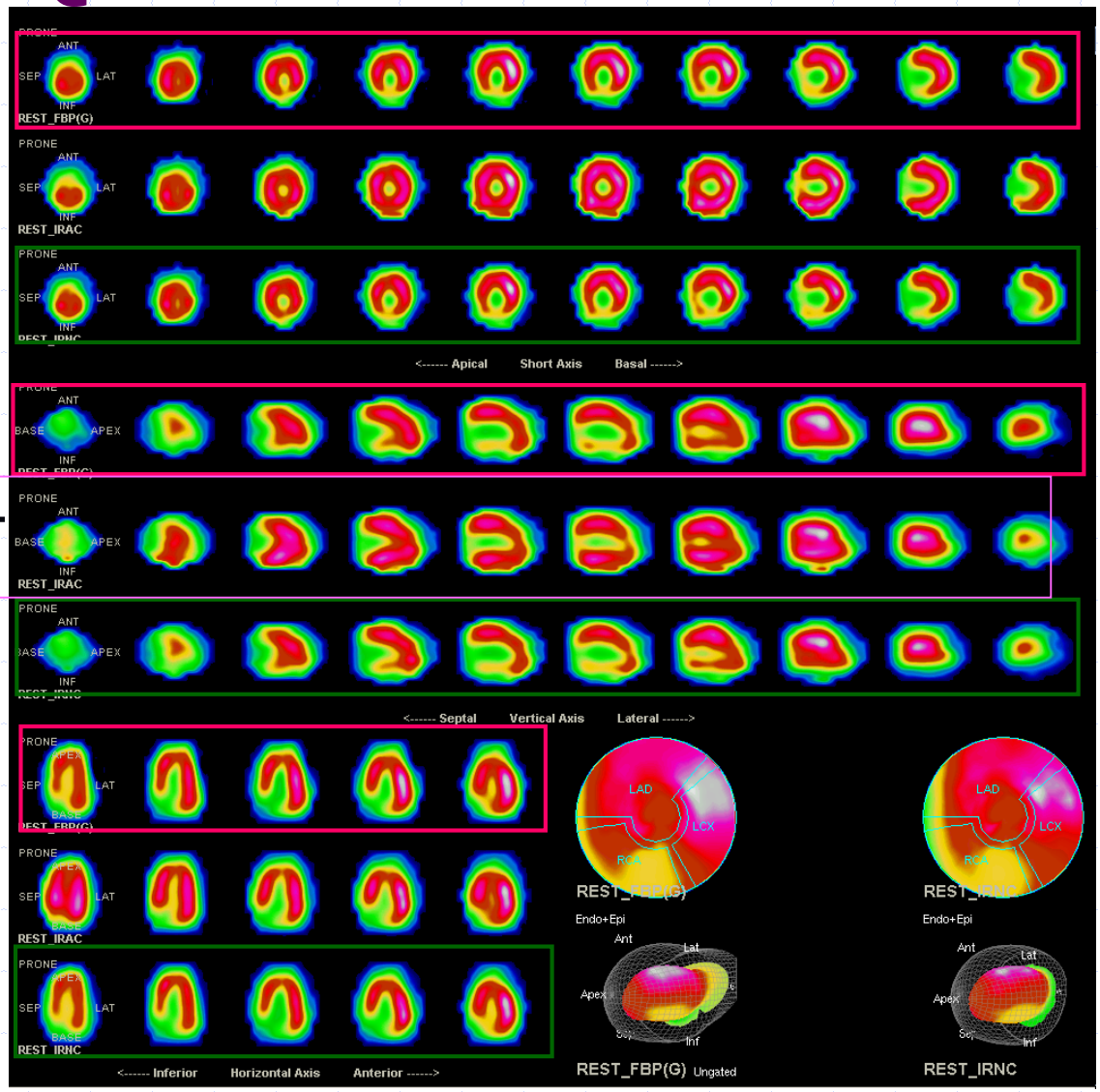


CAS CLINIQUE



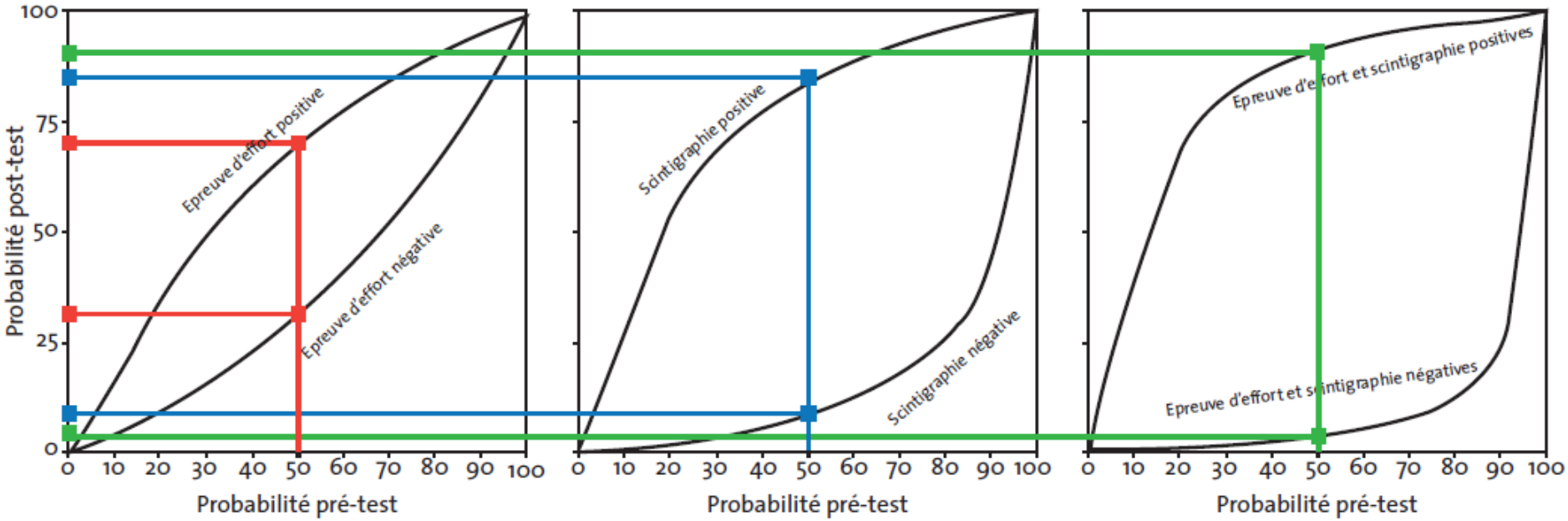
CAS CLINIQUE

Stress + CA par CT



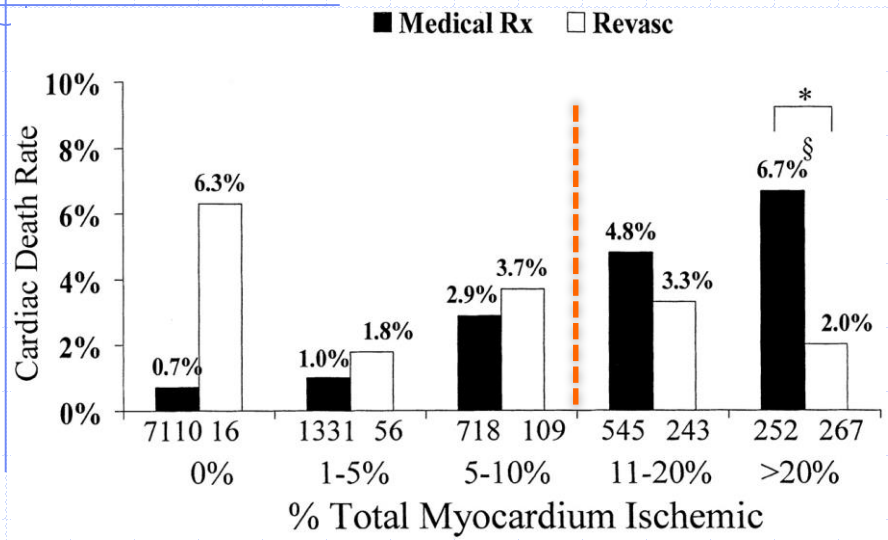
Cq: FP en inférieur
Mauvaise spécificité de la TSM jusque aux années 2000.

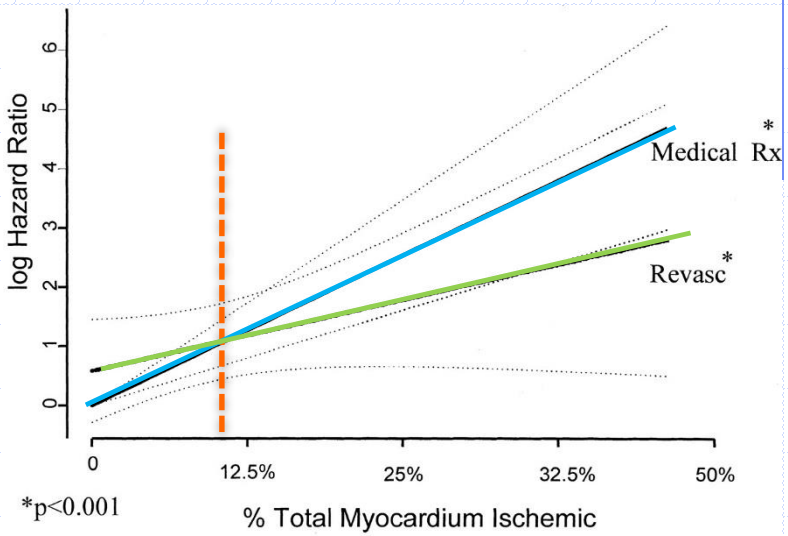
IMPLICATION CLINIQUE



D'après G Vanzetto (CHU Grneobles). Adapté de Underwood et al. Eur J Nucl Med Mol Imaging 2004

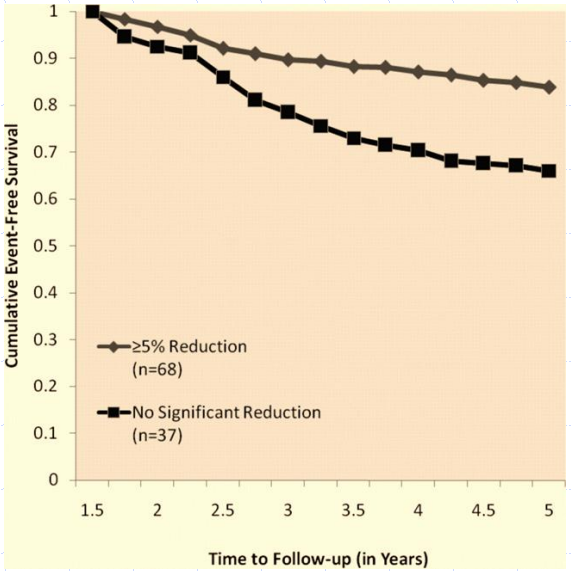
IMPLICATION CLINIQUE





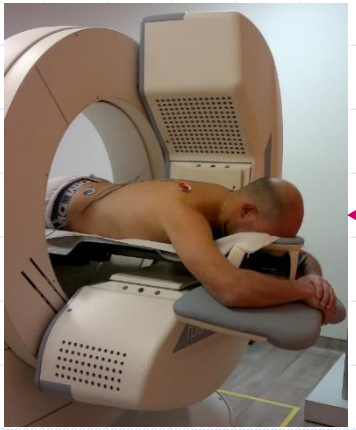
Ischémie > 10% ⇒ angioplastie
Ischémie < 10% ⇒ ttt médical

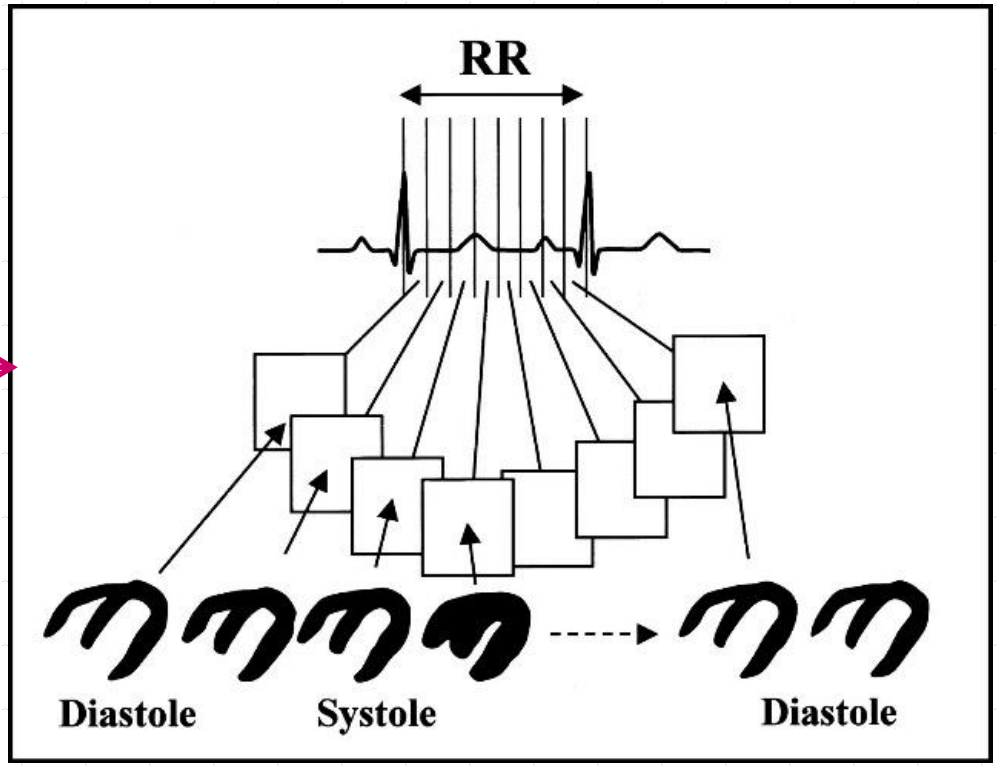
Objectif : - 5% du myocarde ischémié

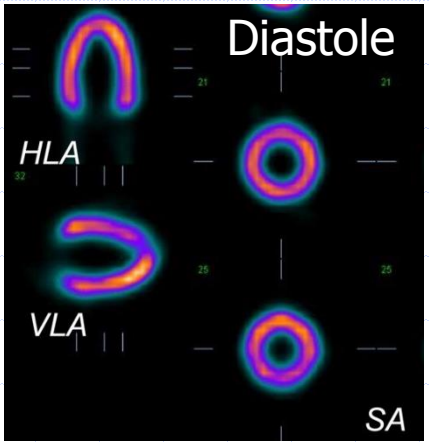


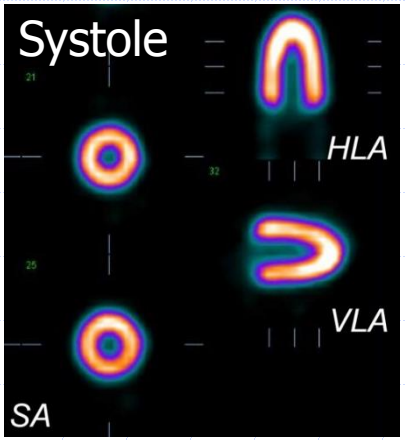
Hachamovitch et al. Circulation 2003

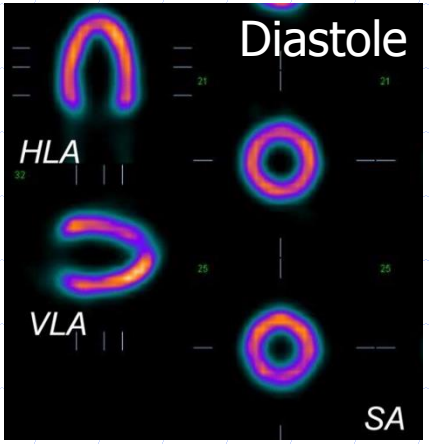
SYNCHRONISATION ECG











SYNCHRONISATION ECG

Eur J Nucl Med Mol Imaging (2007) 34:1107–1122
DOI 10.1007/s00259-007-0405-6

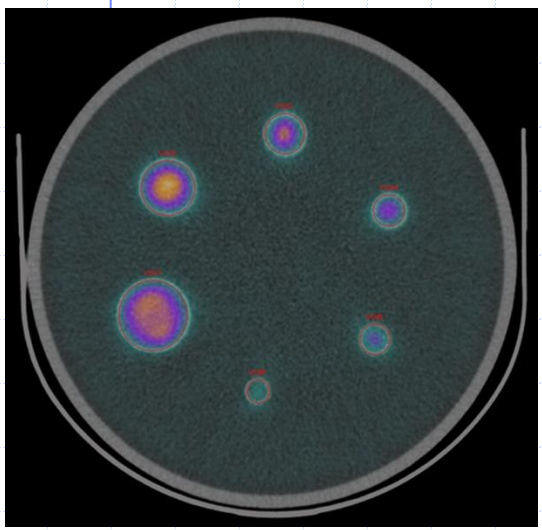
REVIEW ARTICLE

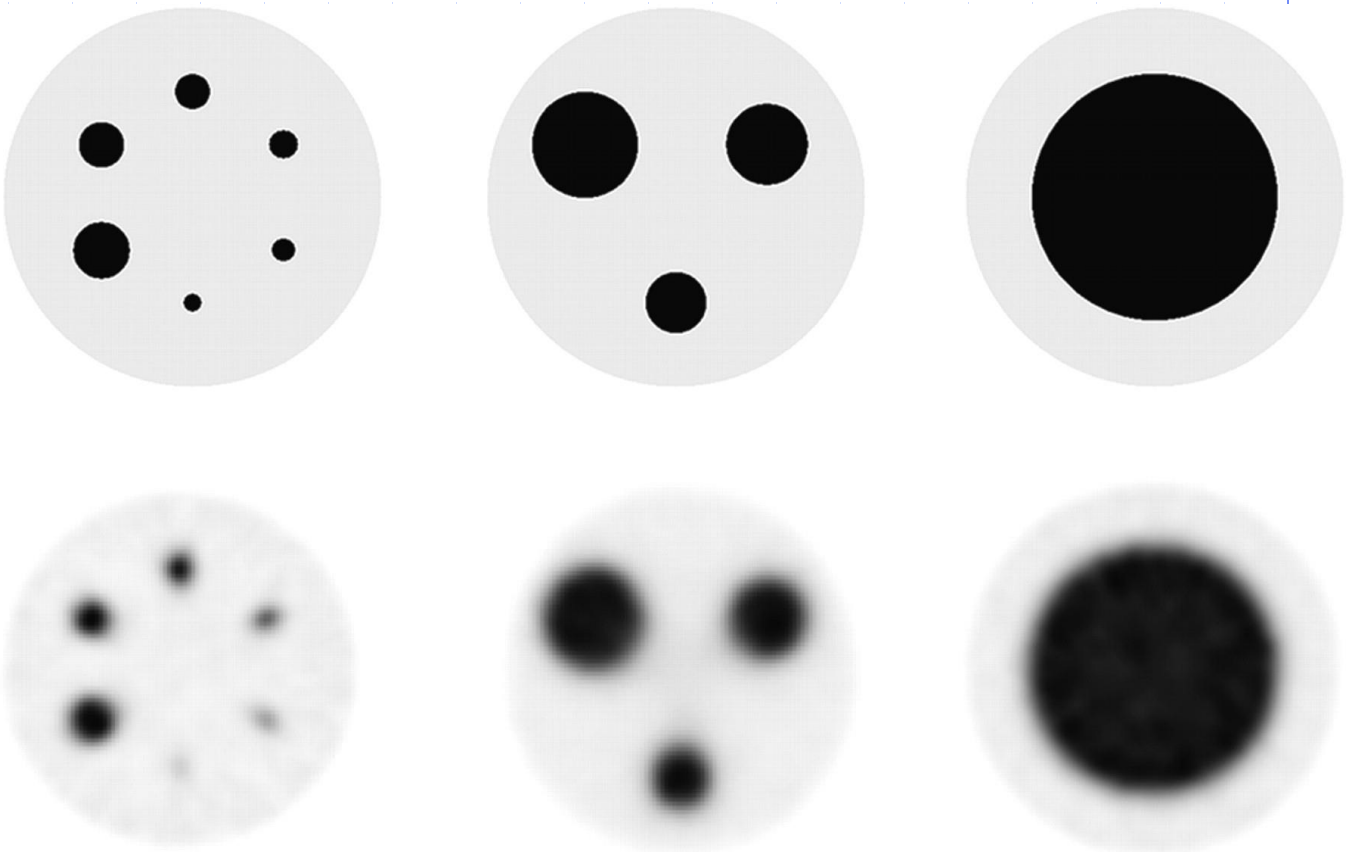
The expanding role of left ventricular functional assessment using gated myocardial perfusion SPECT: the supporting actor is stealing the scene

Roberto Sciagrà

- **Effet de volume partiel**
- **Segmentation** des données scintigraphiques
  - Identifier les artefacts d'atténuation
  - Evaluer la sévérité d'une ischémie
  - Evaluer le pronostic CV à 3 ans
  - Se ≈ 90% Sp ≈ 85%

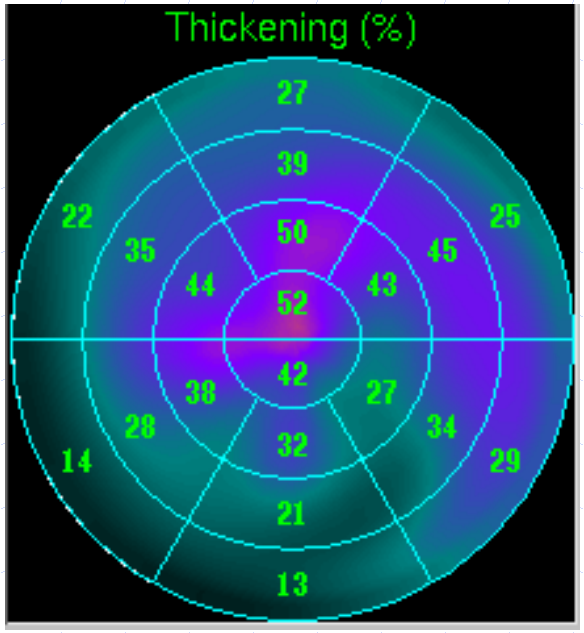
EFFET DE VOLUME PARTIEL

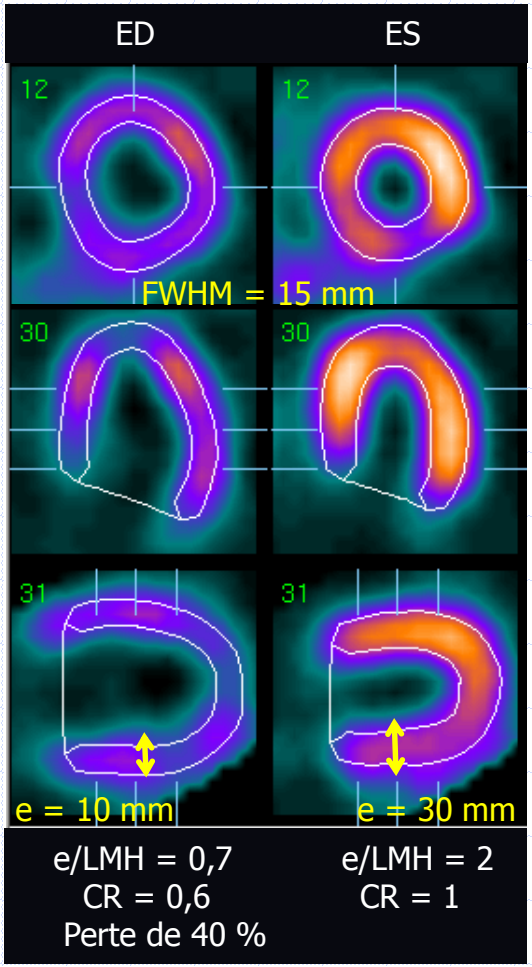




Johannes Zeintl et al. J Nucl Med 2010;51:921-928

APPLICATION





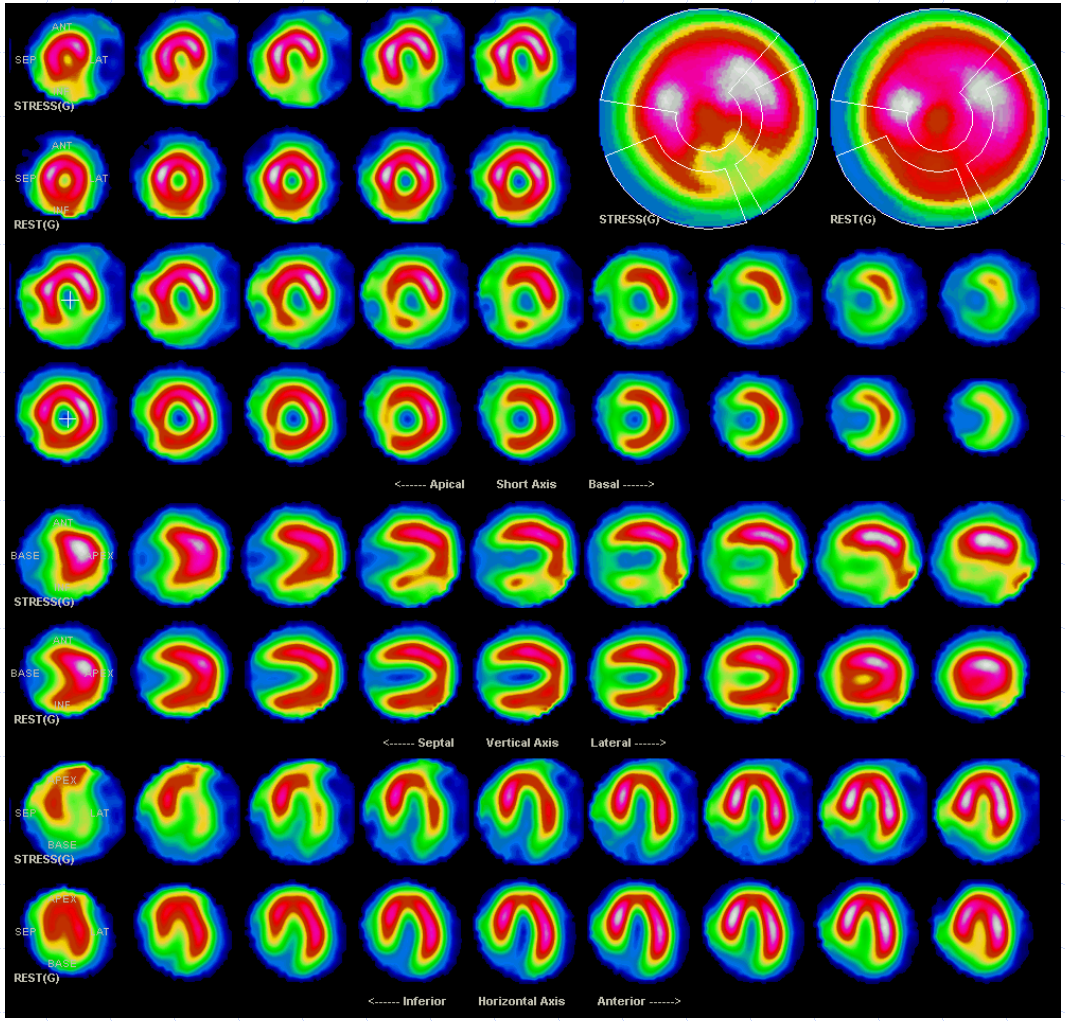
Un épaississement normal prouve :

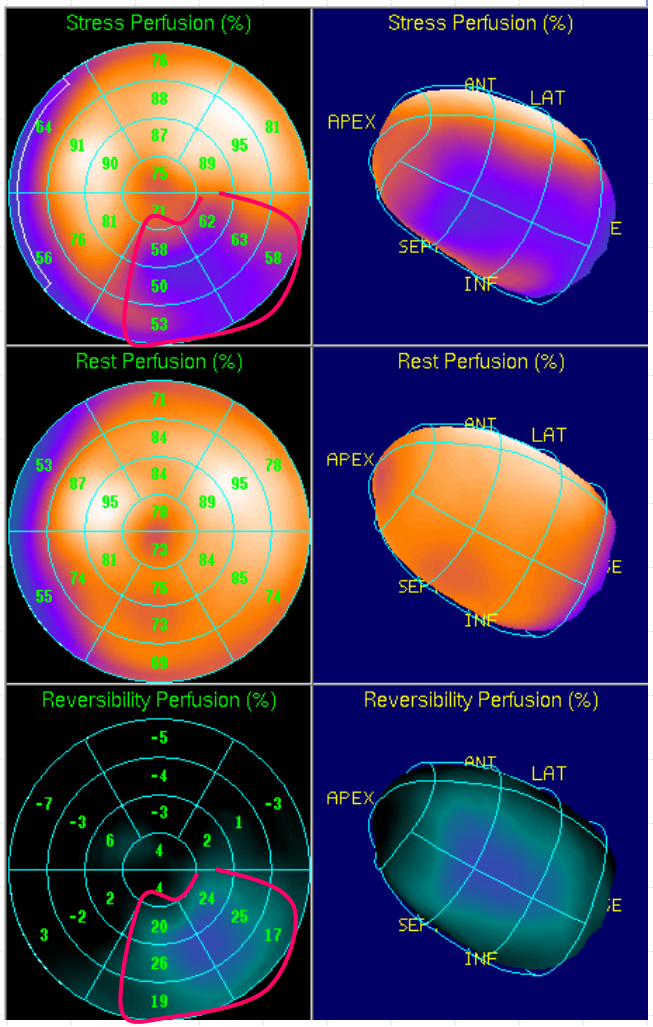
- que le myocarde se contracte donc,
  n'est pas nécrosé, ni sidéré, ni hibernant

ES ≡ Echocardiographie sous dobutamine

JR Galt et al. IEEE Trans Med Imaging 1990; 9:144-150

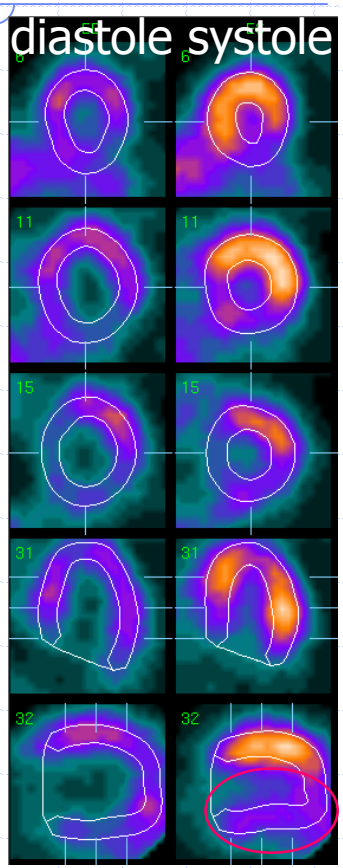
CC: ♂ 54 ANS HIV ASYMPTOMATIQUE

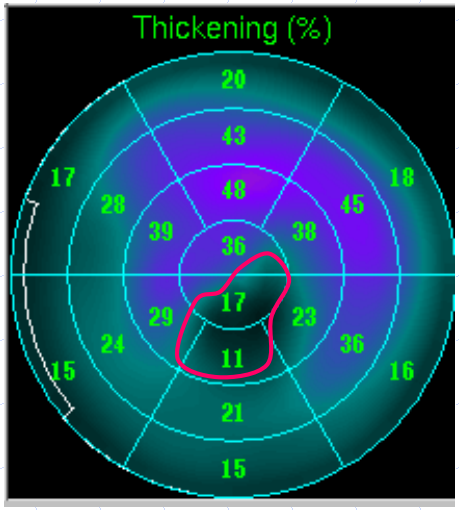


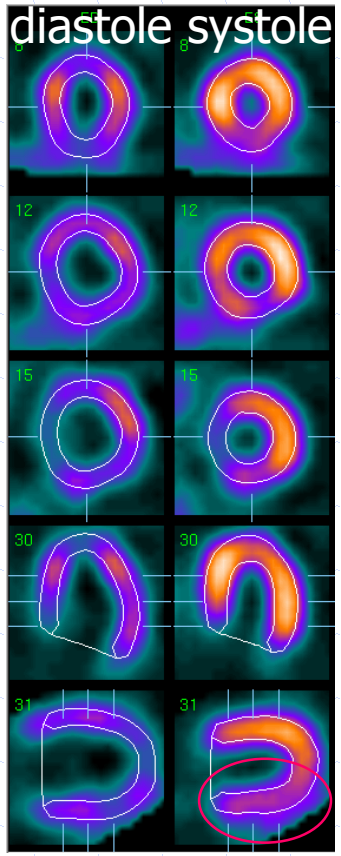


J Am Coll Cardiol 2002;39:991-8 - Clin Nucl Med 2009;34(10) :731-3

CC: ♂ 54 ANS HIV ASYMPTOMATIQUE







EFFORT

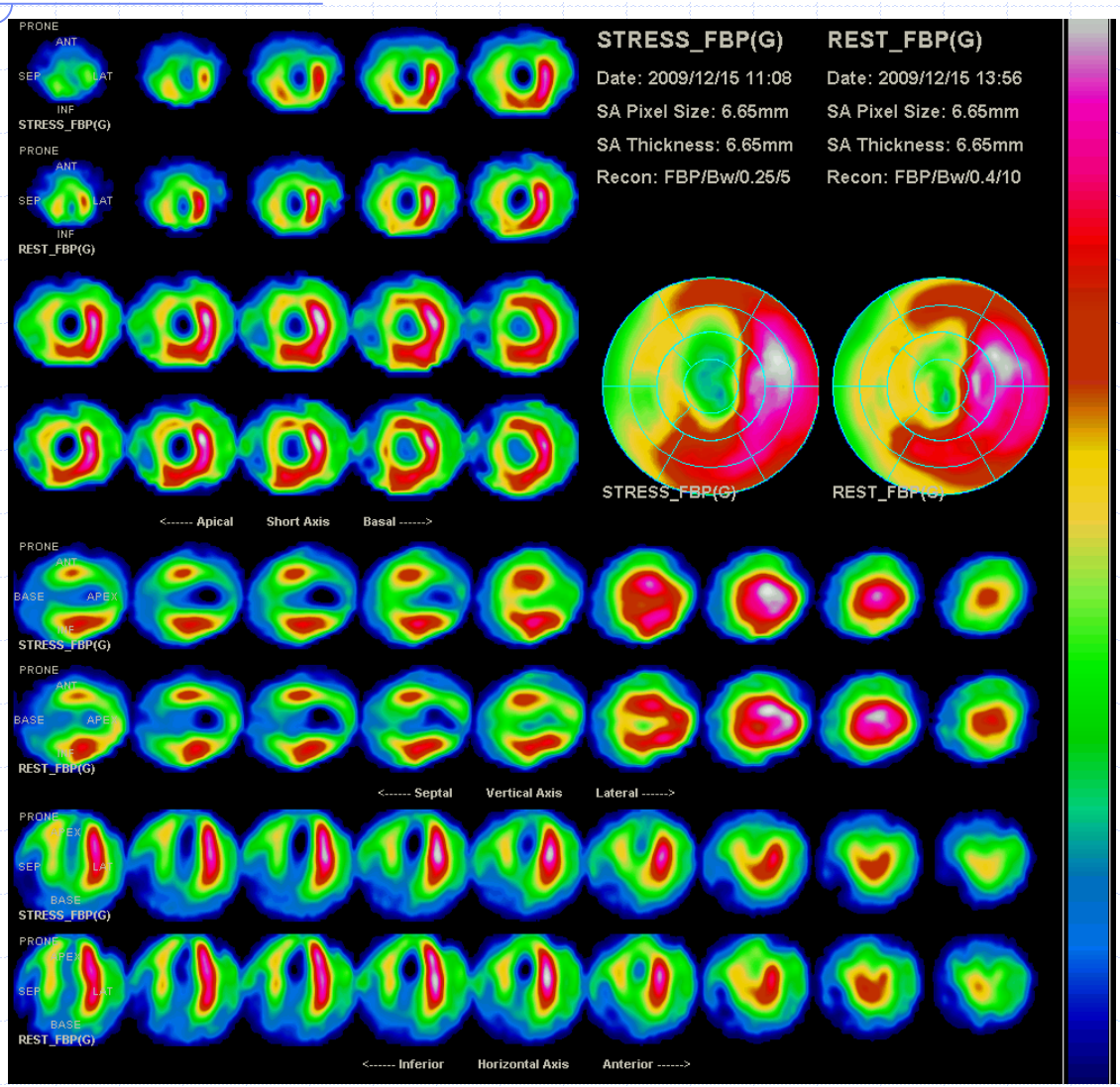
ES(apico-inf) = 11-17%

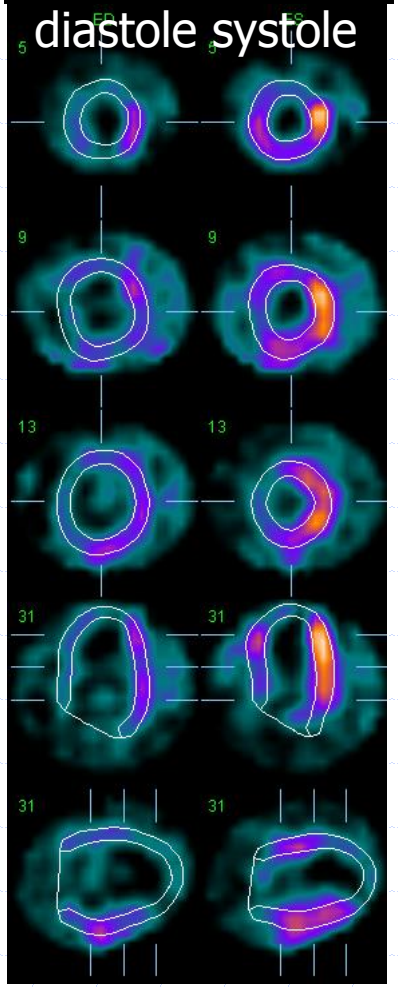
REPOS

ES(apico-inf) = 32-42 %

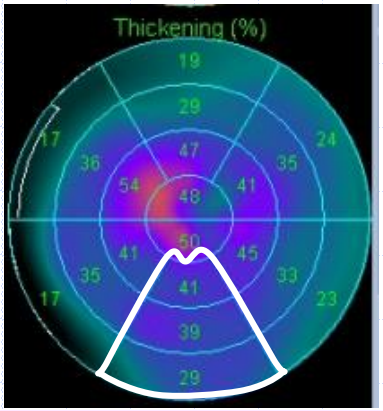
Sidération d'effort réversible : sténose > 80%

CAS CLINIQUE

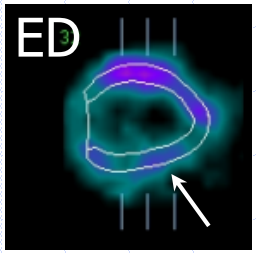


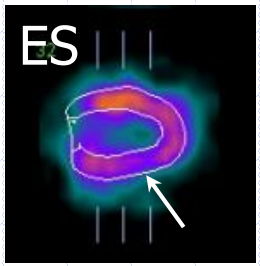


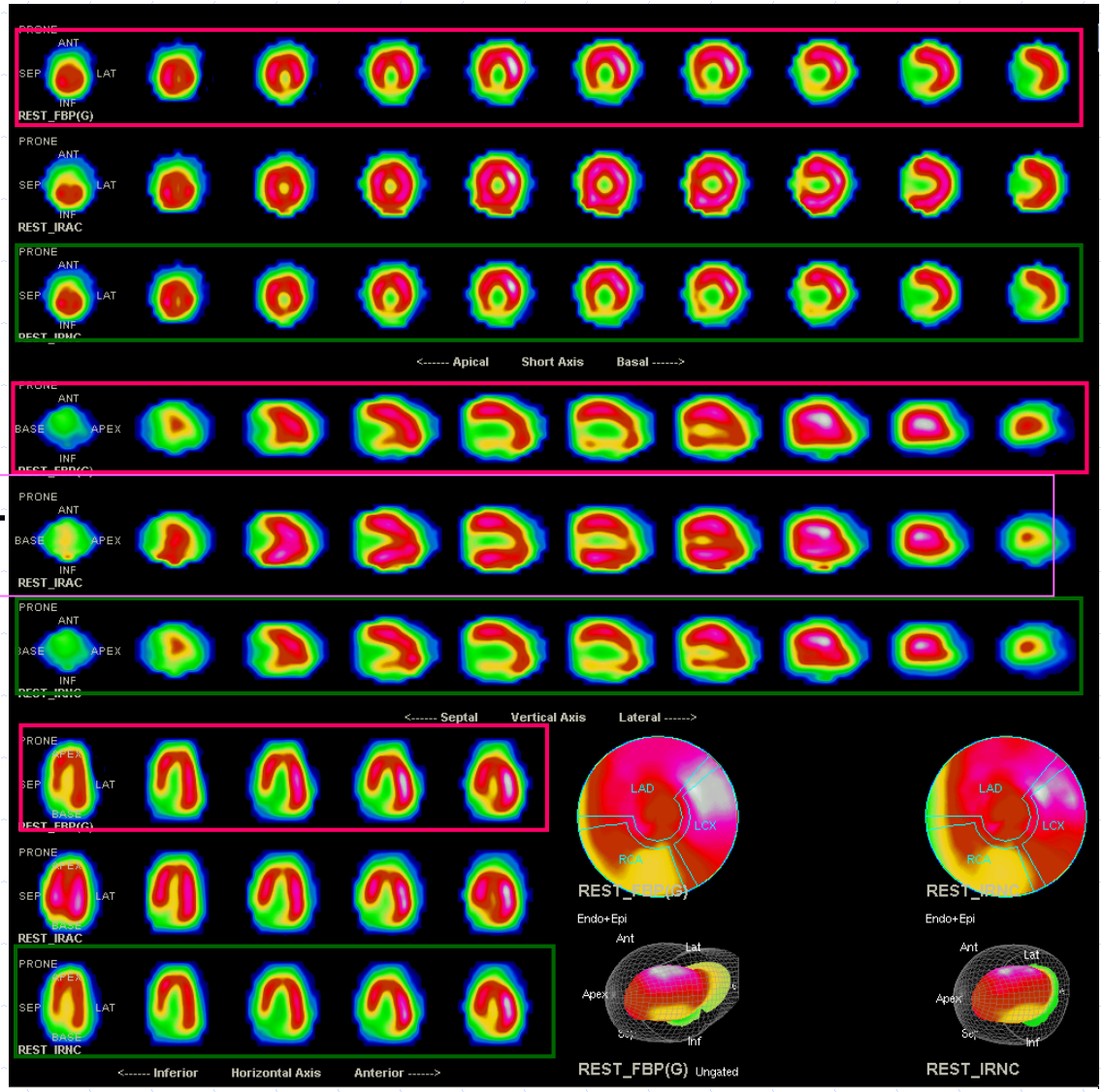
CAS CLINIQUE



Stress + CA par CT







Benkiran et al. Nucl Med Com 2015; 36(1):69-77

CA OU EPAISSISSEMENT ?

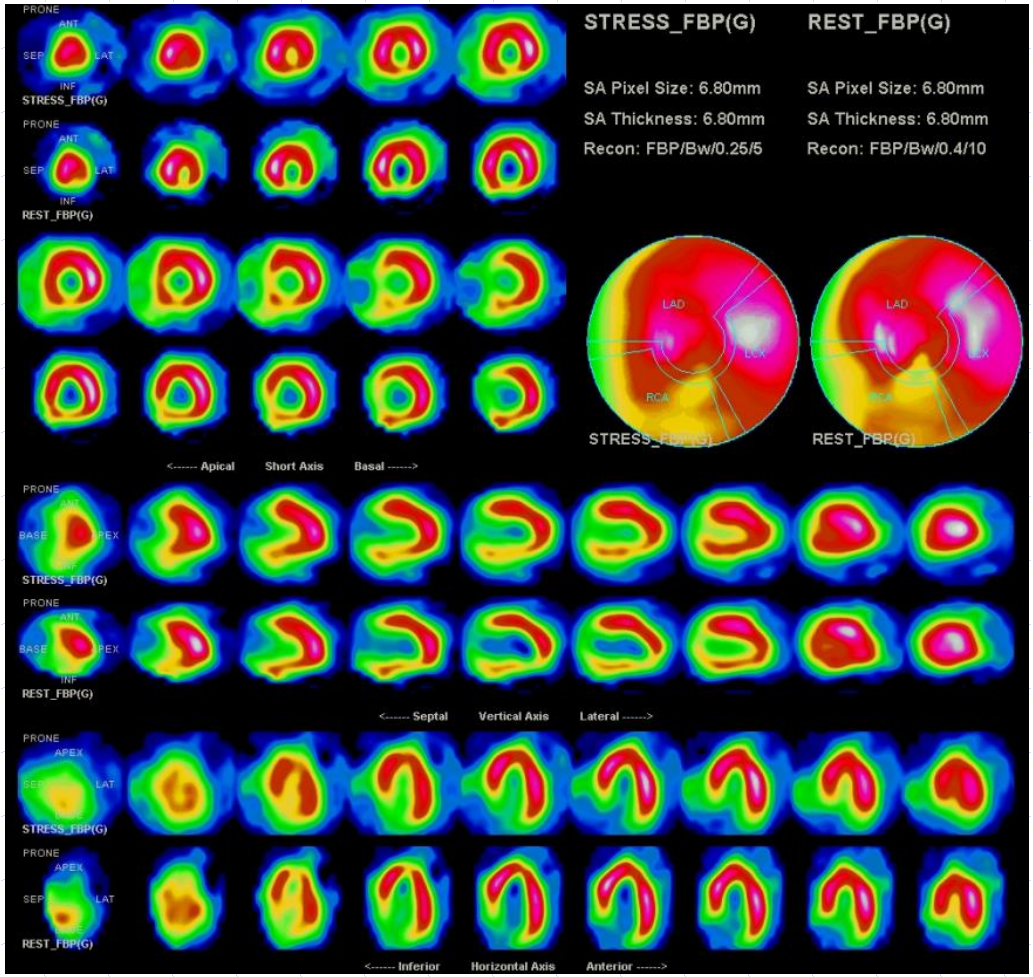
Bateman 2005: N=116 CA *Mowatt: N=3032 (méta)*		**BMI < 30**	**BMI > 30**	**Tous patients**	**ECG d'effort**
Sensibilité (%)	NC	90	87	88	64
	CA	90	82	86	
Spécificité (%)	NC	64	41	50	77
	CA	82	76	79	

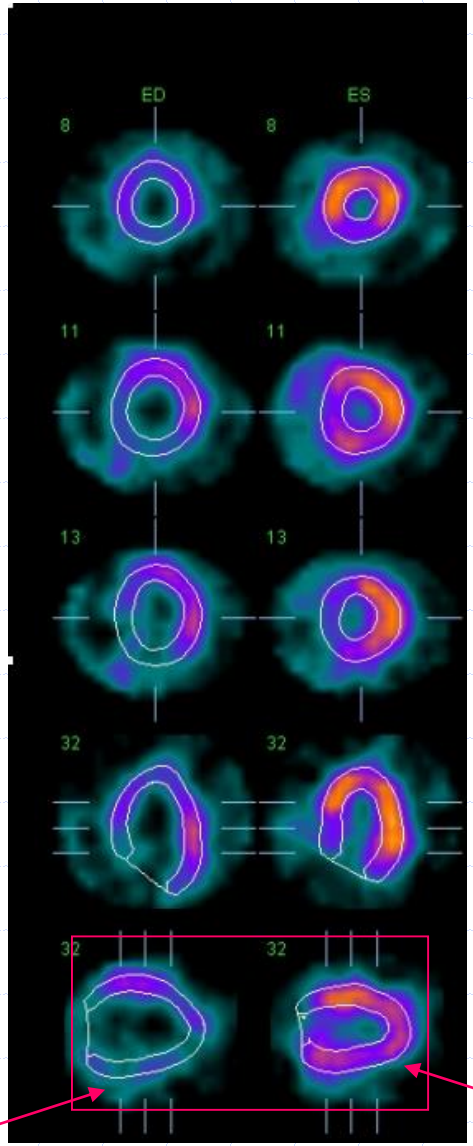
Benkiran 2015 : N=70 *(suivi 2 ans, 13 CA)*	**TSM**	**+ ES**	**+ TDM**
Sensibilité %	77	69	67
Spécificité %	60	98	81
Exactitude %	63	93	79

versus sténoses > 50 %

JM Links J Nucl Cardiol 2002;9:183-187-T.M. Bateman.Semin Nucl Med 2005;35:37-51-G. Mowatt. Health Technology Assessment 2004; 8(30):1-222; M. Benkiran Nucl Med Comm 2015; 36(1):69-77

CAS CLINIQUE





Examen normal (AC, autres explorations inutiles)

SPIRALE ISCHEMIQUE

STRESS	REPOS	VIABILITE	FONCTION SYST EPAISSISSEMENT	DIAGNOSTIC
N HYPO	N HYPO	N HYPO	N	Normal
± N	± N	± N	HYPO	REMODELAGE
HYPO	N	(N)	N	ISCHEMIE
HYPO	± N	(± N)	HYPO stress	SIDERATION
HYPO	HYPO	Redistribution Tl ou hyper FDG	HYPO	HIBERNATION
HYPO	HYPO	HYPO	HYPO	NECROSE

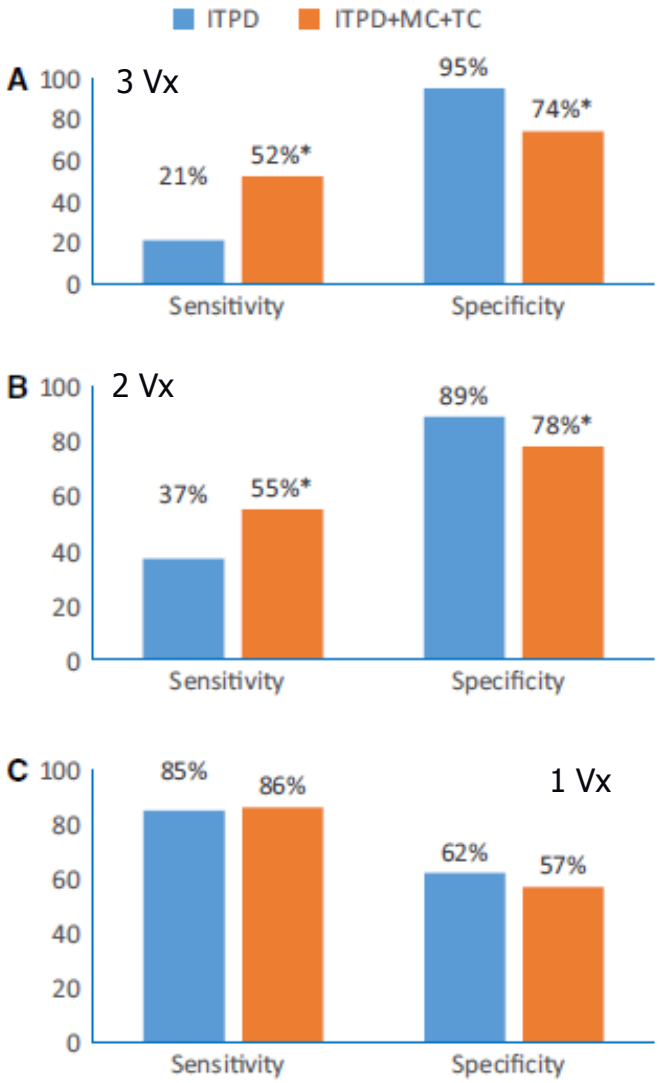
⇒ TEP

+ Etude possible de la réserve contractile
(↑ fonction sous 5 μg/kg/min de dobutamine)

J Narula et al. JACC 2000; 36

Epaississement systolique

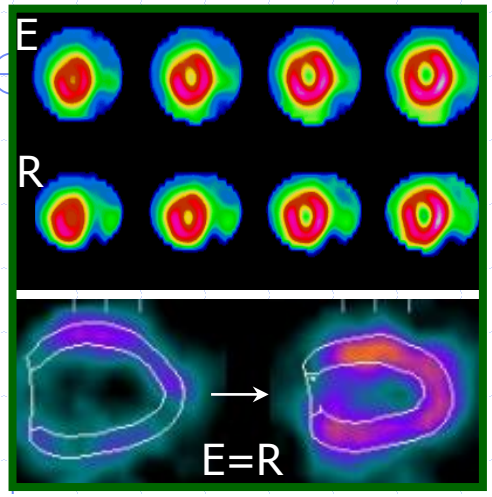
- Sp ↑ via les artefacts d'atténuation
  - Plus efficace qu'une correction d'atténuation par TDM
- Se ↑ si tri/bi-tronculaires
- Permet de détecter les ↓ > 80% ∅
- Prédit un remodelage VG (> 62,53 mL/m²) post IDM
  - Seul FR indépendant en analyse multivariée



T. Sharir J Nucl cardiol 2018;25:754-7; Emmet JACC 2002;39:991-8; S Karimi-Ashtiani J Nucl Med 2012;53-1392-00; Wei Yang J Nucl Cardiol 2018;25:742-53

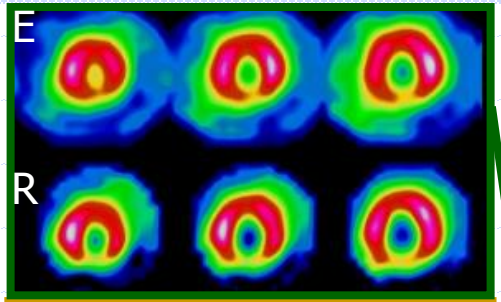
SYNTHESE

NORMAL

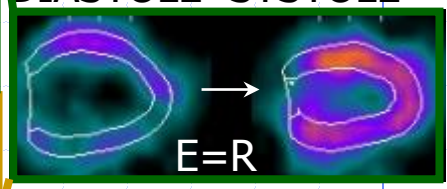


DIASTOLE SYSTOLE

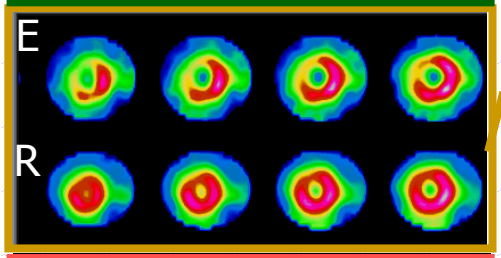
NORMAL (ARTEFACT)



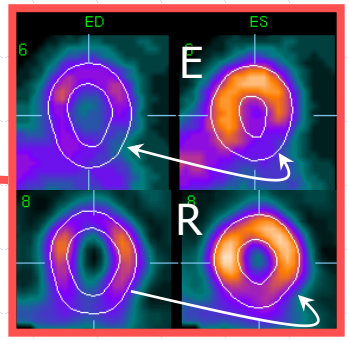
DIASTOLE SYSTOLE



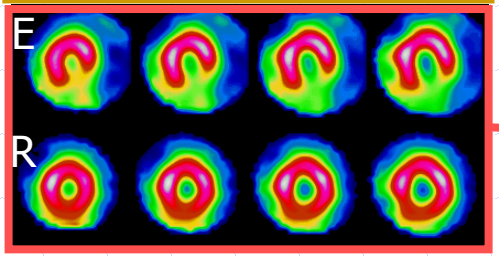
ISCHEMIE 50%<∅<79%



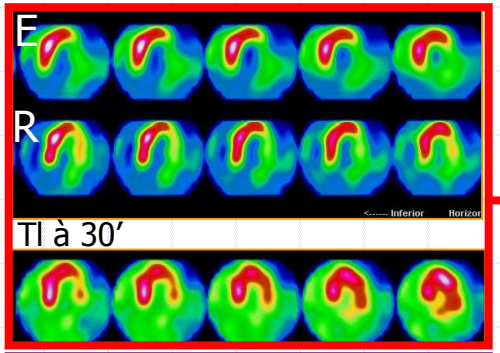
DIASTOLE SYSTOLE

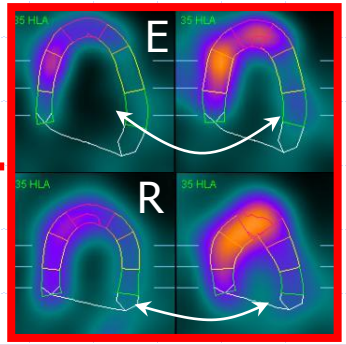


SIDERATION D'EFFORT ∅ < 80%

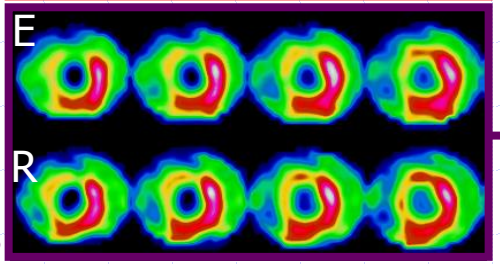


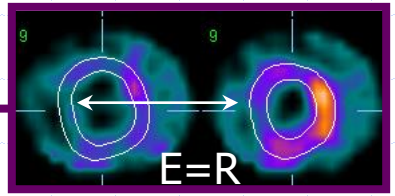
ISCHEMIE E/R VIABLE (HIBERNATION)





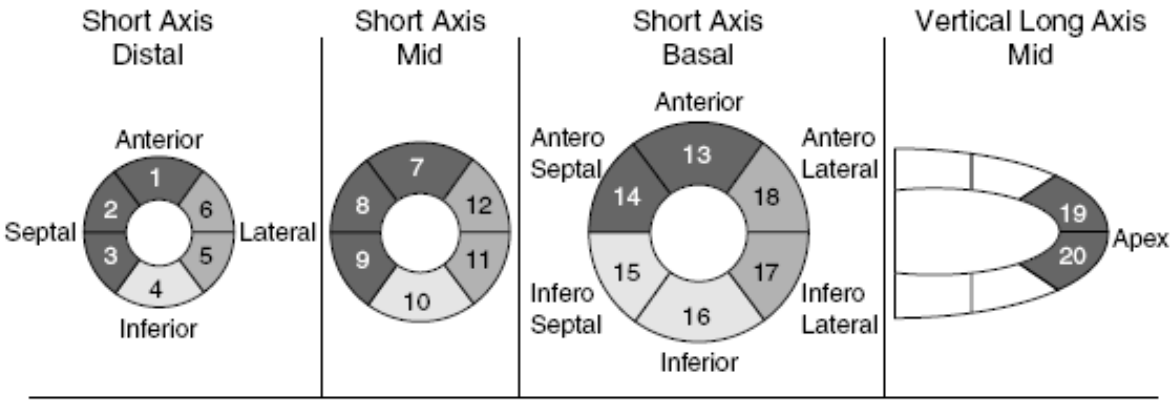
NECROSE





T. Sharir. - J Nucl cardiol 2006;13(4):495-506- L Emmet JACC 2002;39:991-8

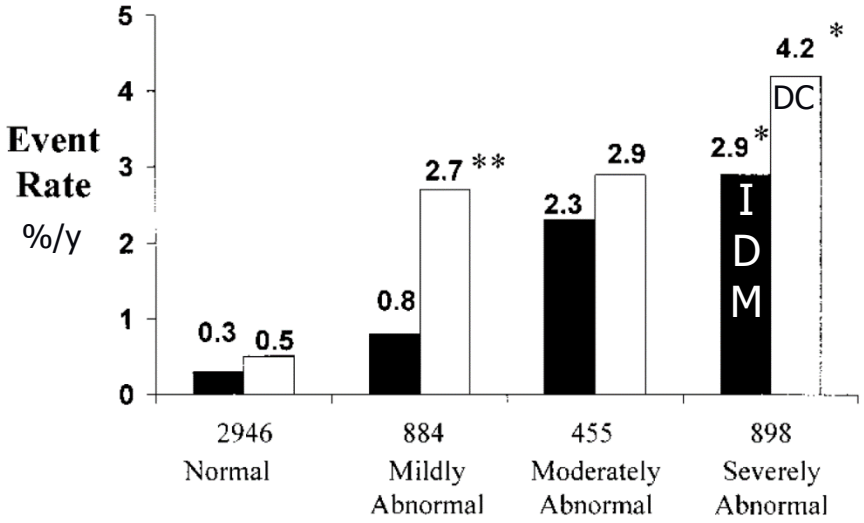
ANALYSE SEMIQUANTITATIVE



0 = Normal
1 = Slight reduction of uptake
2 = Moderate reduction of uptake
3 = Severe reduction of uptake
4 = Absent radioactive uptake

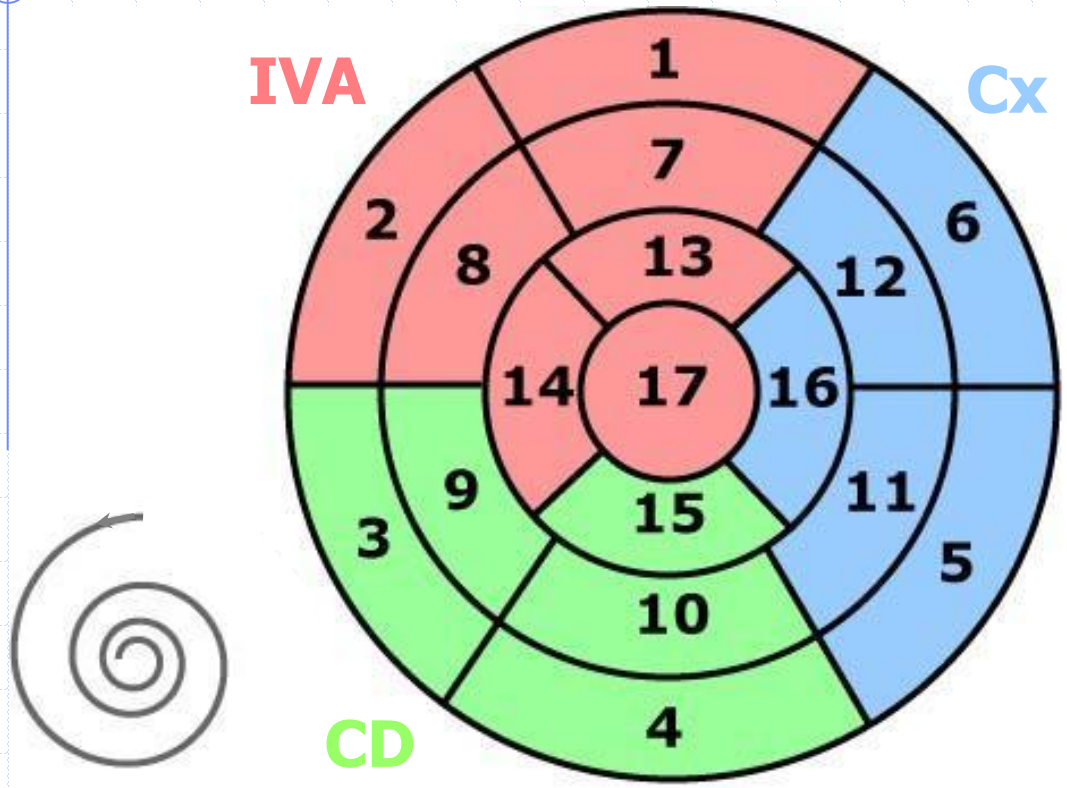
LAD LCX RCA

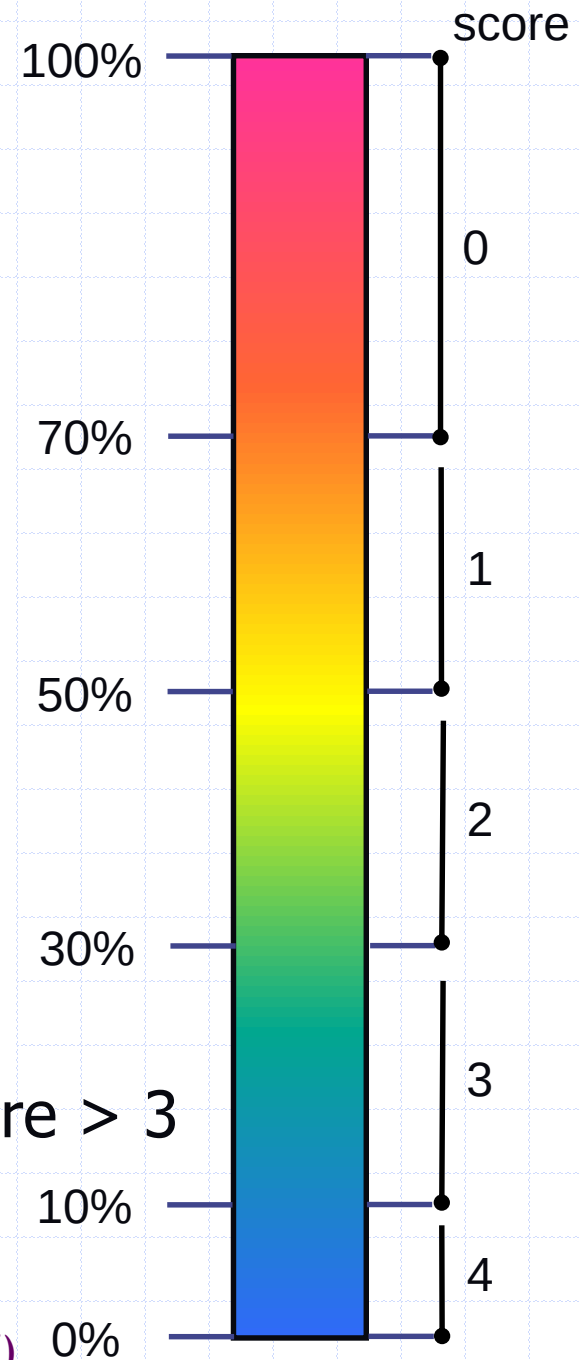
Un segment ≈ 5% du VG



Hachamovitch et al.Circulation. 1998;97:535-543

17 SEGMENTS



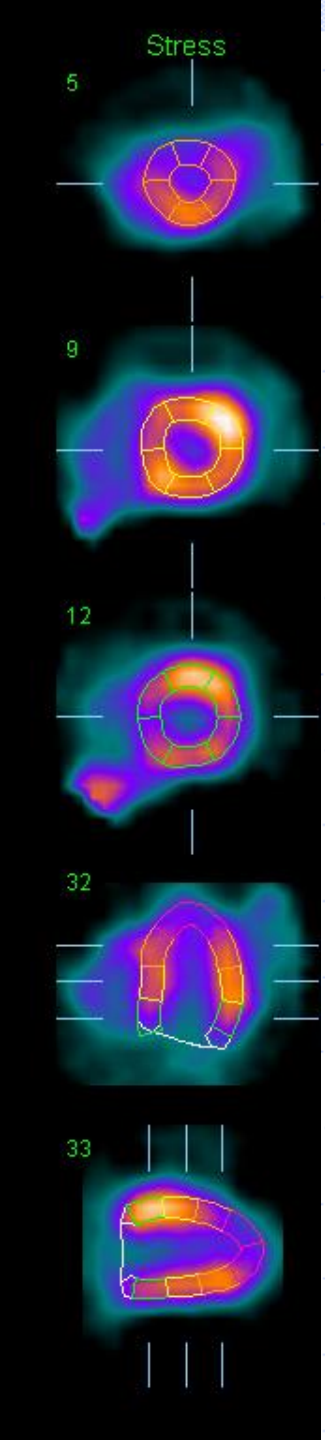


hypo-perfusion si score > 3

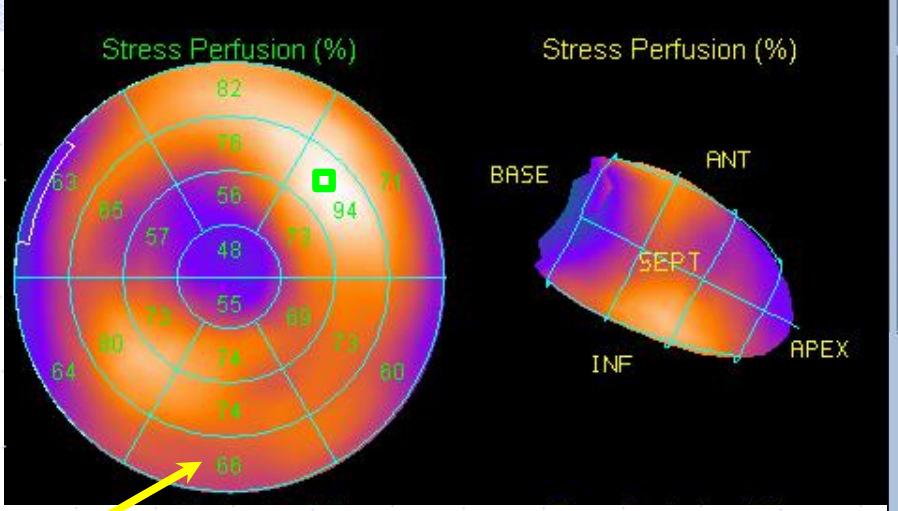
☺ diagnostic/pronostic, idem en écho

☹ reproductibilité

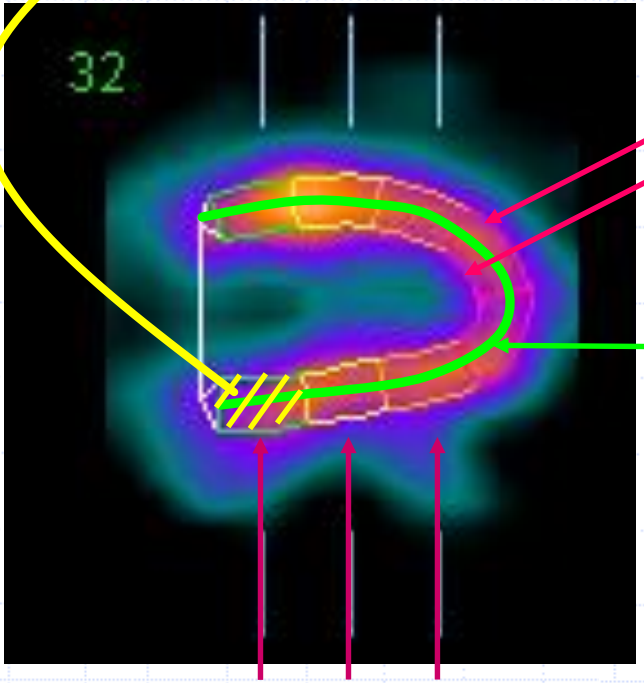
B. Hesse et al. EANM/ESC procedural guidelines. EJNM 2005;32(7)



QPS



activité totale dans le segment % du max

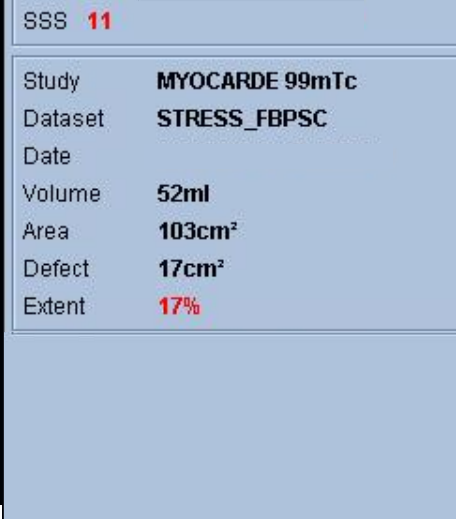


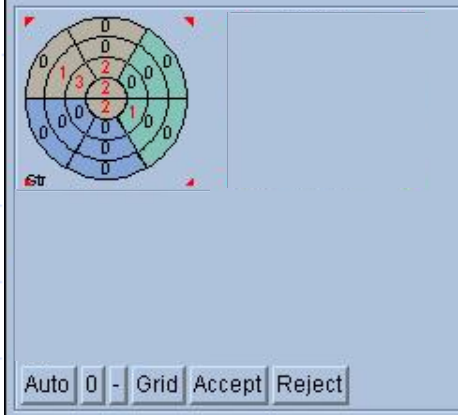
S épicardique

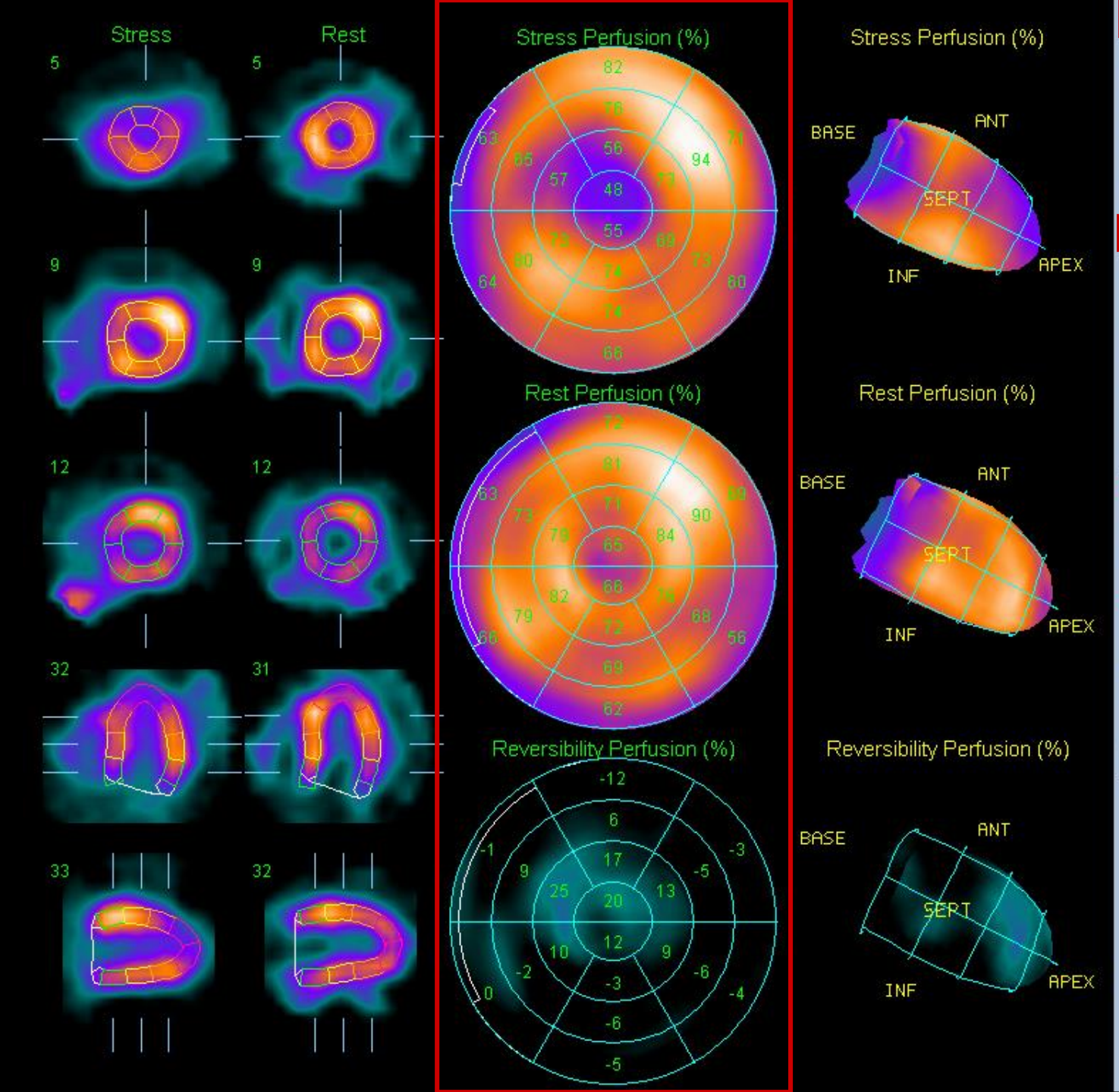
S éndocardique

S médio-VG
+ fit ellipse

grille sur ellipsoïde







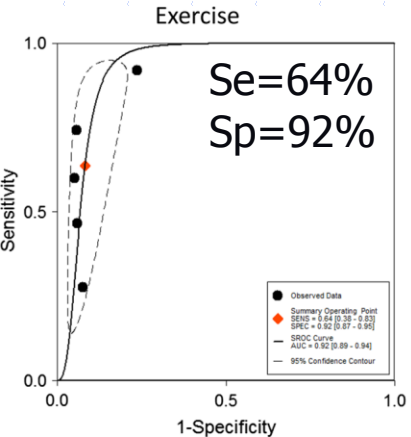
SSS/SRS/SDS reproductible

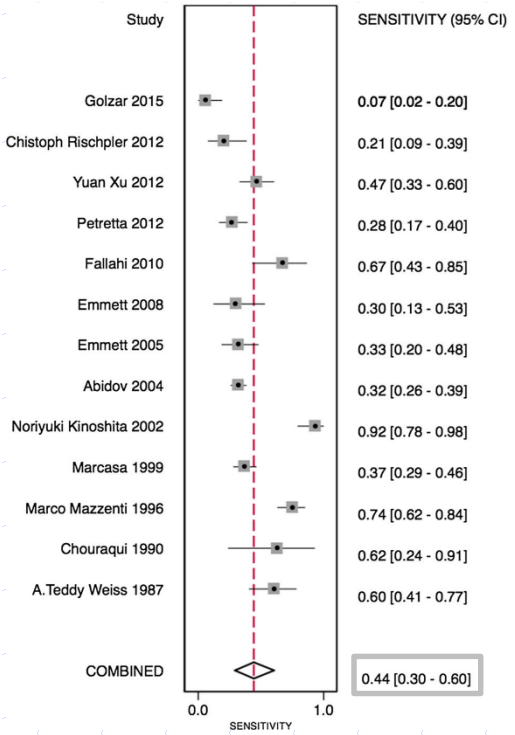
⇒ diagnostic

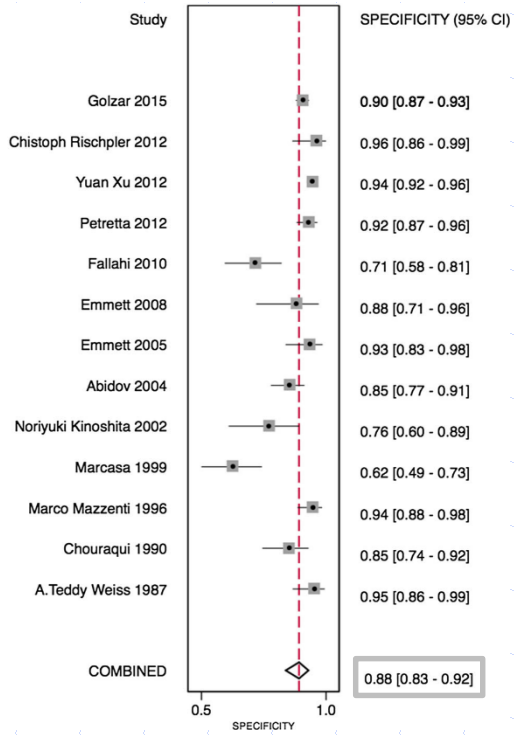
⇒ pronostic

Dilatation ischémique transitoire

- DEF = V_{effort} / V_{repos} > 1,12-1,38 (sans synchro)
- Causes :
  - ischémie sous
    -endocardique diffuse
  - sidération de stress
- Sp = 88 % pour
  maladie coronaire diffuse
  même si perfusion
  homogène (DNID)

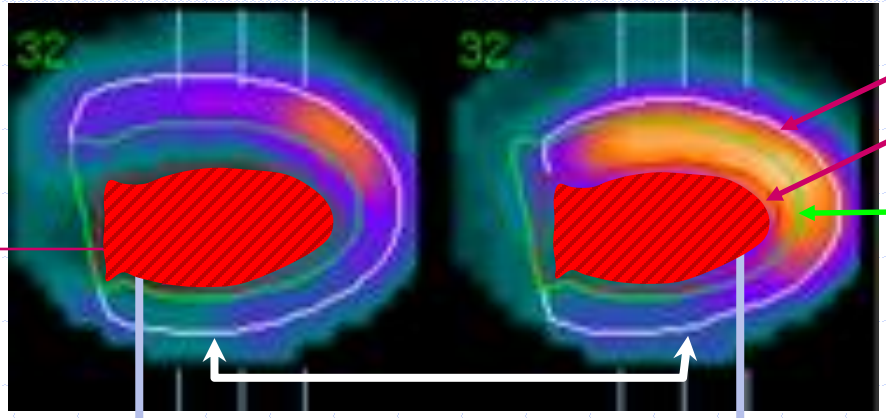






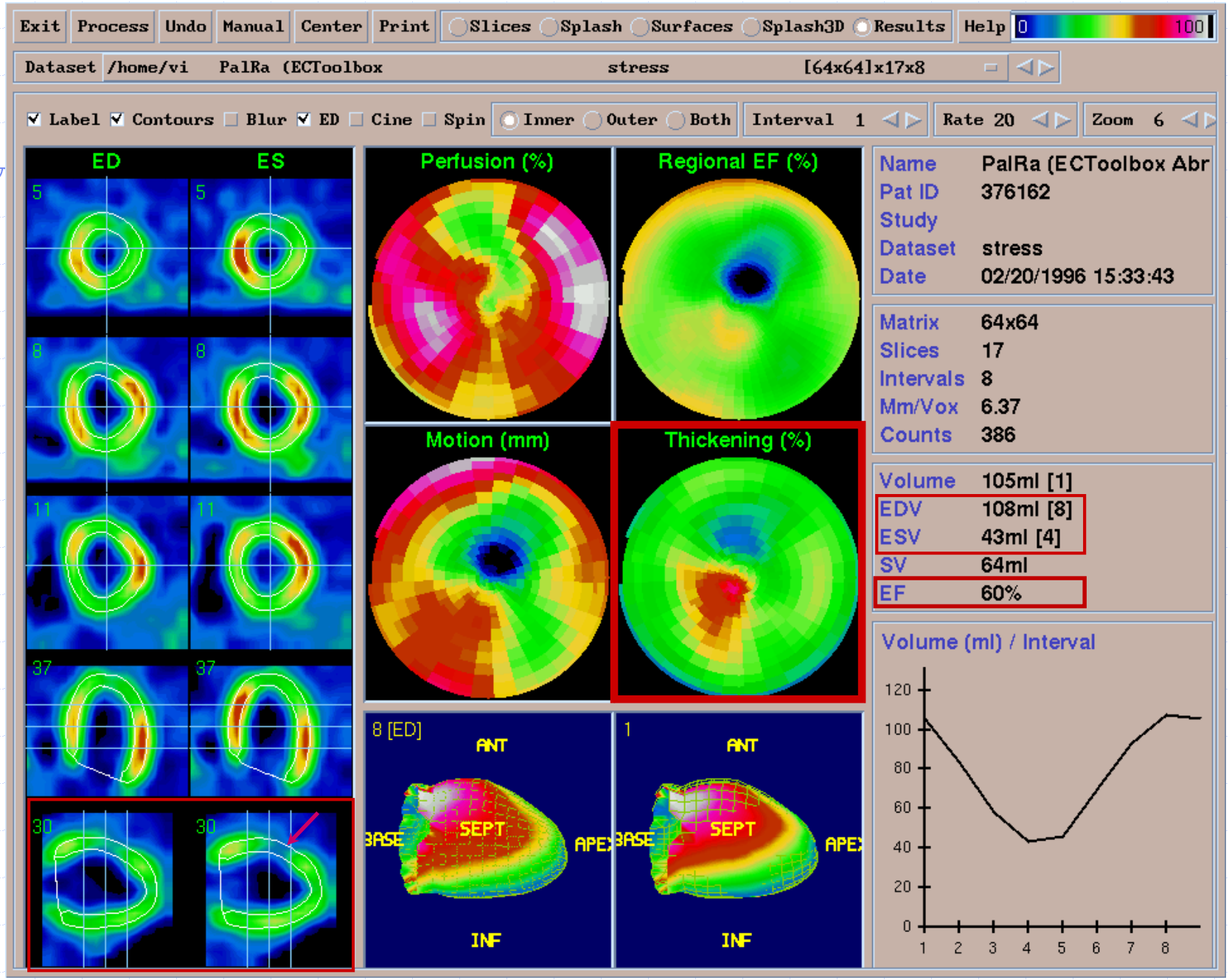
T Sharir J Nucl Cardiol 2018;25:738-741 – M Alama J Nucl Cardiol 2018;25:724-37

QPS → QGS: FONCTION SYSTOLIQUE



- Cinétique segmentaire
  - Déplacement de la surface endocardique
  - Épaississement systolique
- Fonction ventriculaire gauche
  - Variation du volume endocardique

$$FEVG = \frac{V_{endo}^{TD} - V_{endo}^{TS}}{V_{endo}^{TD}}$$


Exit
Process
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Dataset /home/vi PalRa (ECToolbox stress [64x64]x17x8
Label
Contours
Blur
ED
Cine
Spin
Inner
Outer
Both
Interval 1
Rate 20
Zoom 6
ED
ES
5
5
8
8
11
11
37
37
30
30
Perfusion (%)
Regional EF (%)
Motion (mm)
Thickening (%)
8 [ED]
1
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SEPT
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APEX
INF
Name PalRa (ECToolbox Abr
Pat ID 376162
Study
Dataset stress
Date 02/20/1996 15:33:43
Matrix 64x64
Slices 17
Intervals 8
Mm/Vox 6.37
Counts 386
Volume 105ml [1]
EDV 108ml [8]
ESV 43ml [4]
SV 64ml
EF 60%
Volume (ml) / Interval
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60
40
20
0
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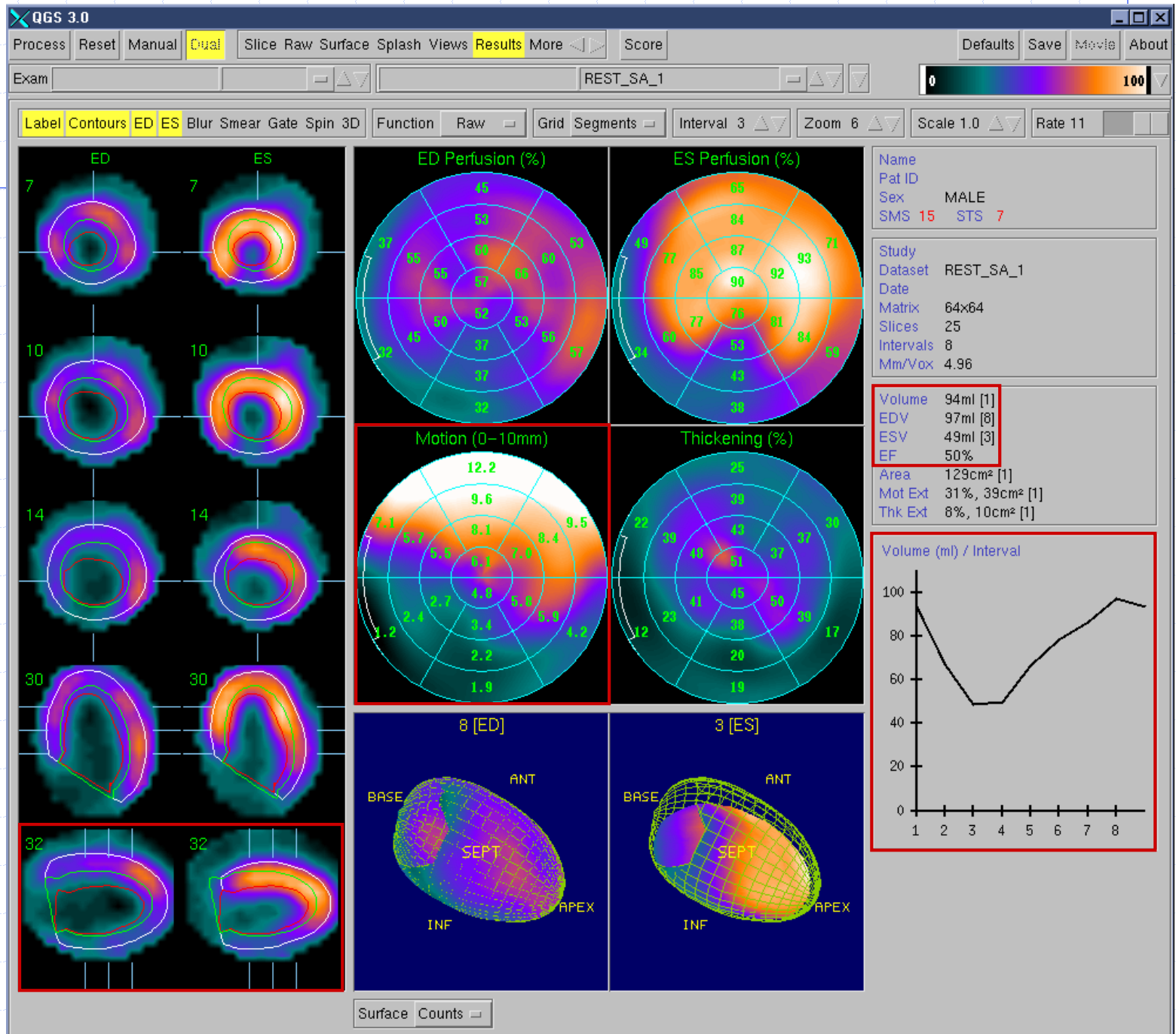
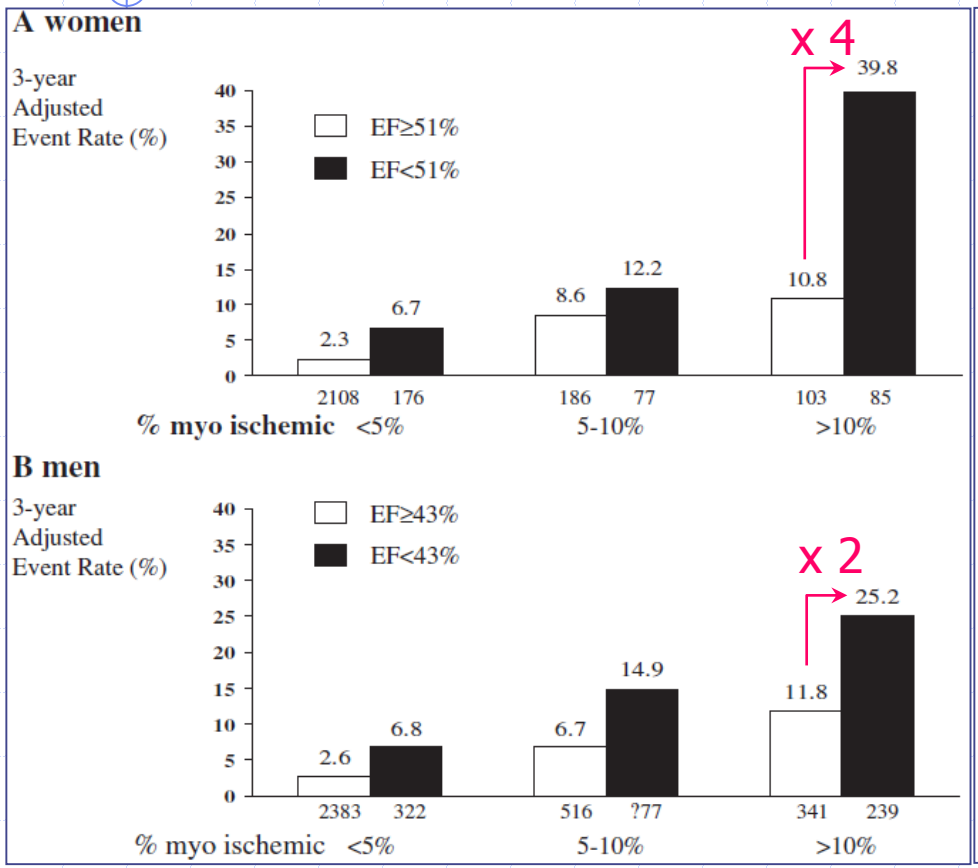
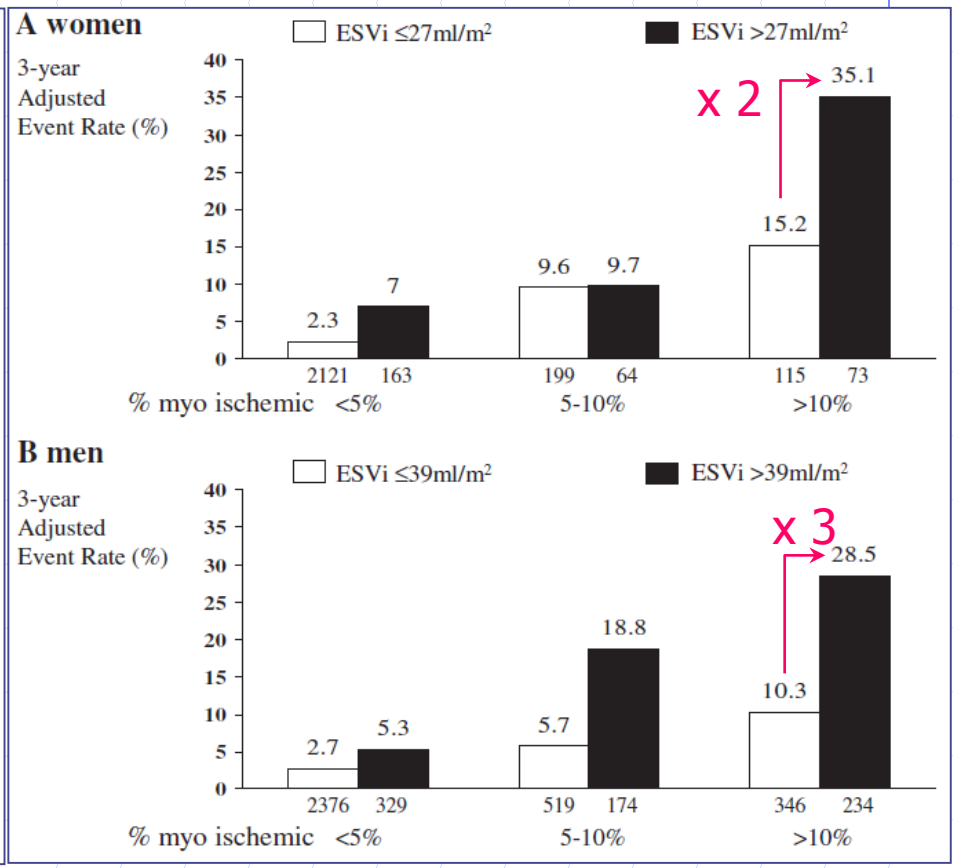
8


QGS 3.0
Process
Reset
Manual
Dual
Slice Raw Surface Splash Views Results More
Score
Defaults
Save
Movie
About
Exam
REST_SA_1
0
100
Label Contours ED ES Blur Smear Gate Spin 3D
Function Raw
Grid Segments
Interval 3
Zoom 6
Scale 1.0
Rate 11
ED
ES
ED Perfusion (%)
ES Perfusion (%)
Motion (0–10mm)
Thickening (%)
8 [ED]
3 [ES]
ANT
BASE
SEPT
APEX
INF
Name
Pat ID
Sex MALE
SMS 15 STS 7
Study
Dataset REST_SA_1
Date
Matrix 64x64
Slices 25
Intervals 8
Mm/Vox 4.96
Volume 94ml [1]
EDV 97ml [8]
ESV 49ml [3]
EF 50%
Area 129cm² [1]
Mot Ext 31%, 39cm² [1]
Thk Ext 8%, 10cm² [1]
Volume (ml) / Interval
Surface Counts

QGS® : validation clinique

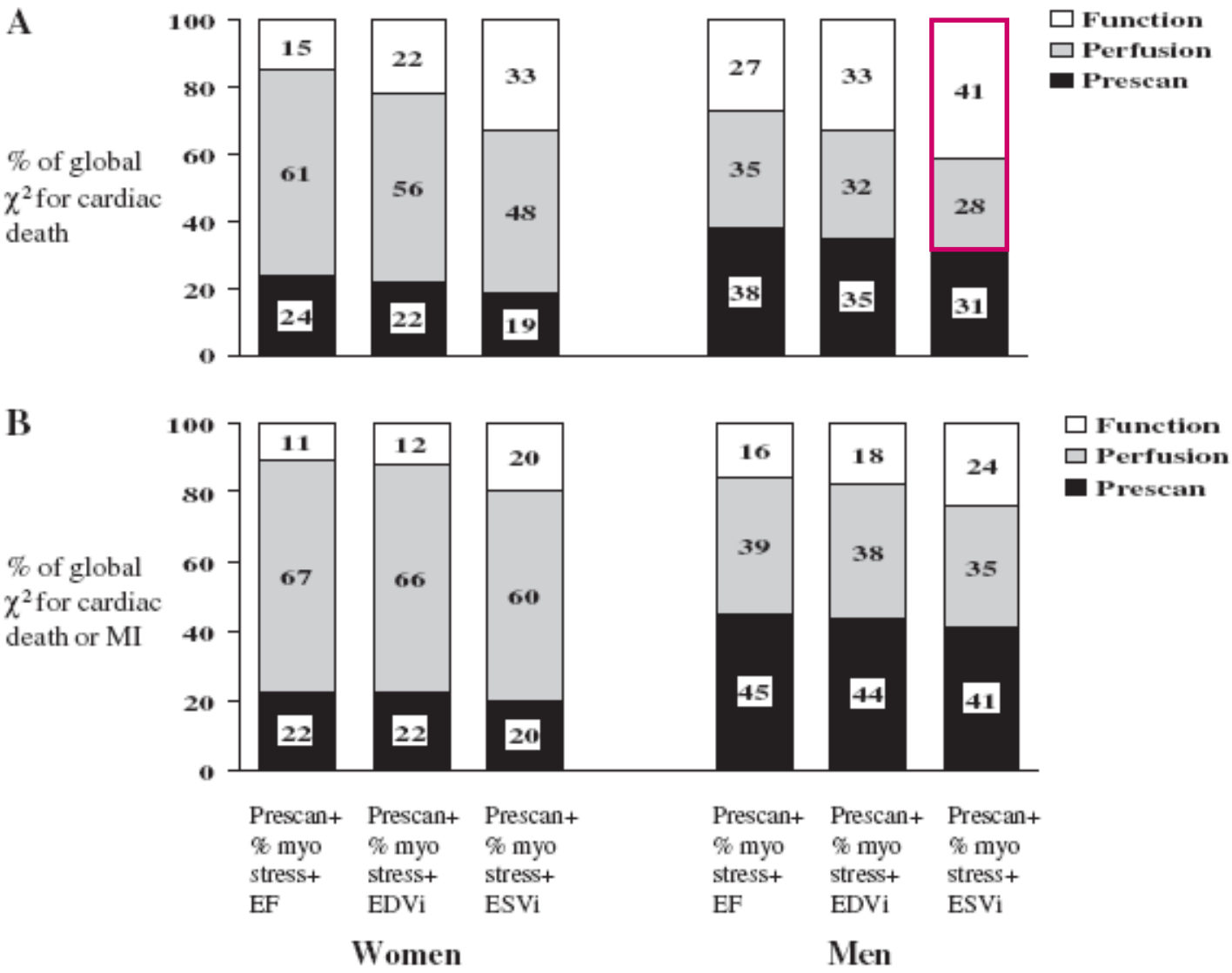




6713 patients = 2735 femmes et 3978 hommes,
suivi 35 ± 14 mois pour IDM ou mort cardiaque

T. Sharir et al. Circulation 1999;100:1035-42 et J Nucl cardiol 2006;13(4):495-506

QGS®



T. Sharir et al. J Nucl cardiol 2006;13

QUANTIFICATION EN TSM

- AVANTAGES
  - Reproductibilité et exactitude > analyse visuelle
  - Quantification de l'ischémie: sidération de stress, ∅<80%
  - Sensibilité sur les coronaropathies diffuses : DIT
  - Quantification du pronostic cardiaque: ESV / FE
  - Prise en compte des artefacts d'atténuation (activité/ES)
  - Évaluation de petites anomalies (recherche)

- CAUSES D'ERREURS
  - Pas d'intégration des mesures (Épreuve de stress, A, ES, M, V, FE)
  - Artefacts :
    - cinétique, atténuation, alignement, diffusé du digestif
  - Base de patients normaux parfois inadaptée
  - Repositionnement des limites (VG, Base) incorrecte

P. Slomka, J Nucl Cardiol 2012;19:338-46 - R Sciagrà, Eur J Nucl Med 2007;34 - MS Rosenthal. JNM 1995;36

SCA & SPECT MYOCARDIQUE DE REPOS

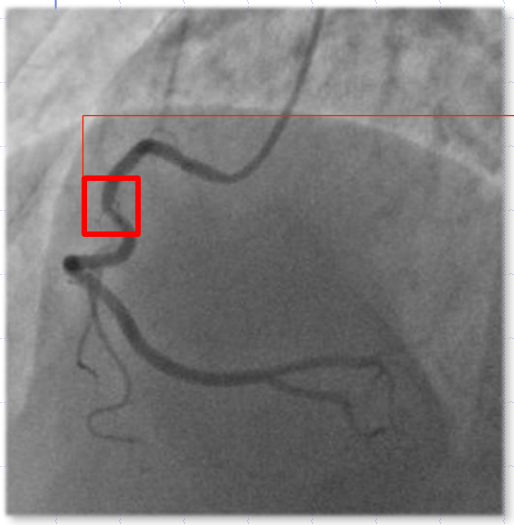
- ECG : 40-65% N
- Troponine US : normale si ischémie sans nécrose
  - Se (cTn T/I) < 40% si angor instable*

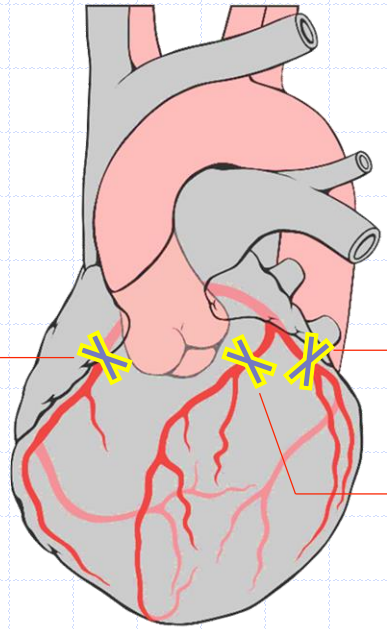
- TSM de repos à moins de 3h de la fin de la douleur :
  - Se >> Tropo 24h, ECG
  - Se = VPN = 99% , Sp = 73 % (12 études, N=4210)
  - 1450$ d'économie moyenne par patient (8 études, N=10739)

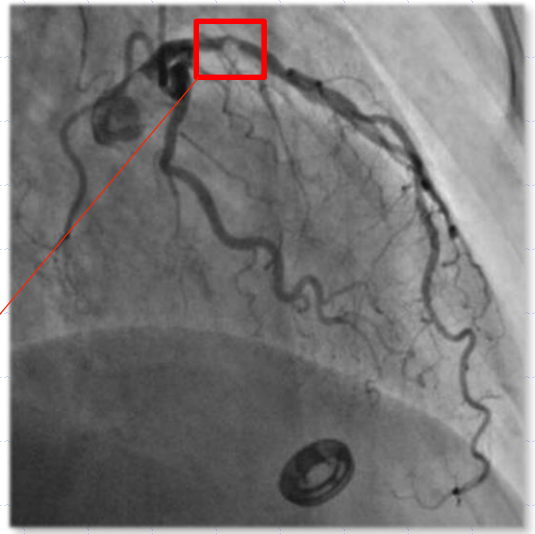
A. Ghatak. Semin NuclMed 2013 43:71-81 – *MD Duca. J Nucl Cardiol 1999;6(6) – L Biliodeau JACC 1991; 18

TRITRONCULAIRES

CD







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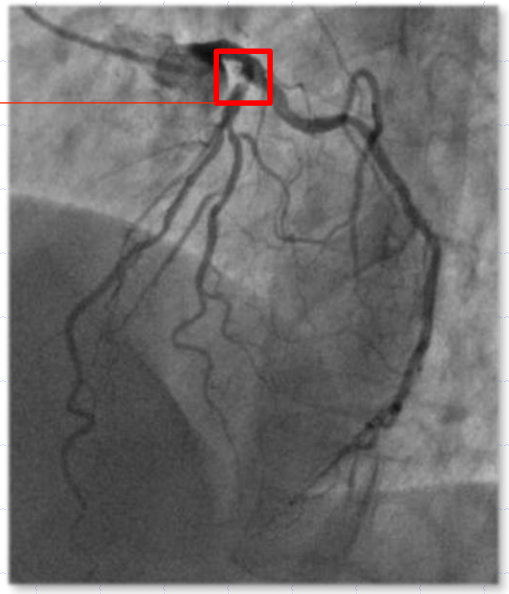
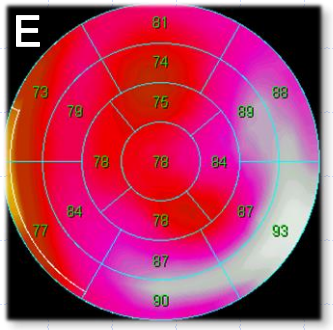
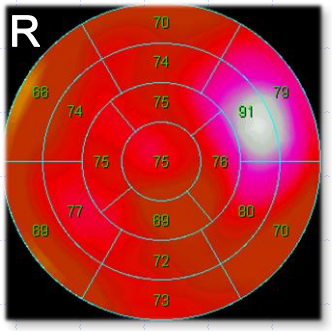


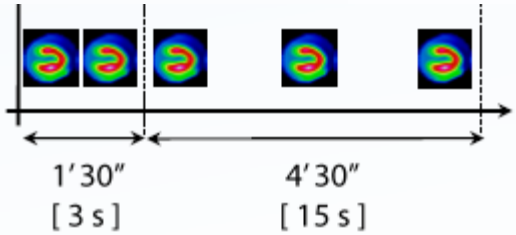
IVA

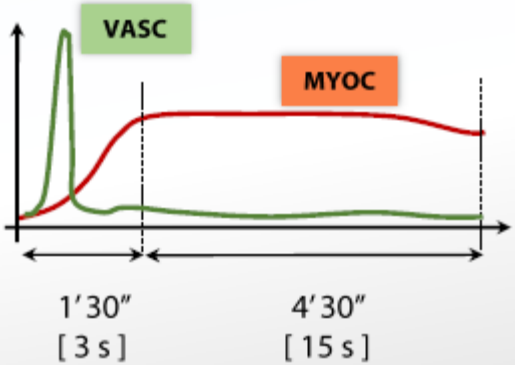


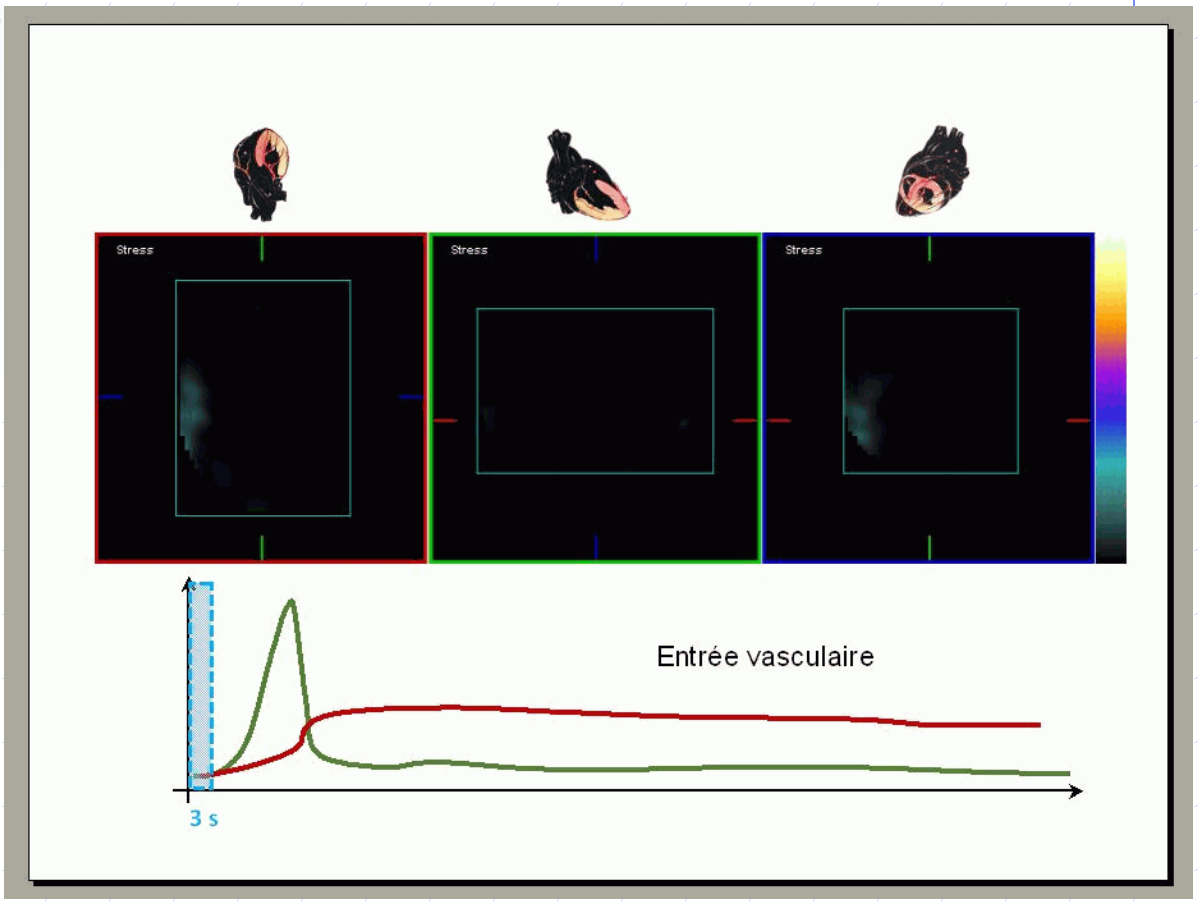


Nécessité d'une quantification absolue et non relative de la perfusion

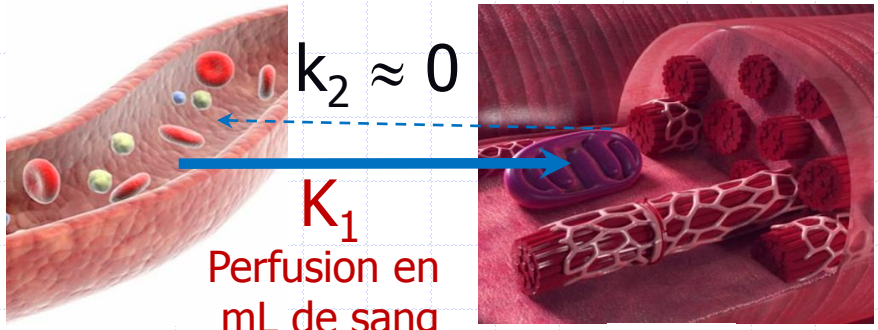
SPECT DYNAMIQUE (LIST MODE)





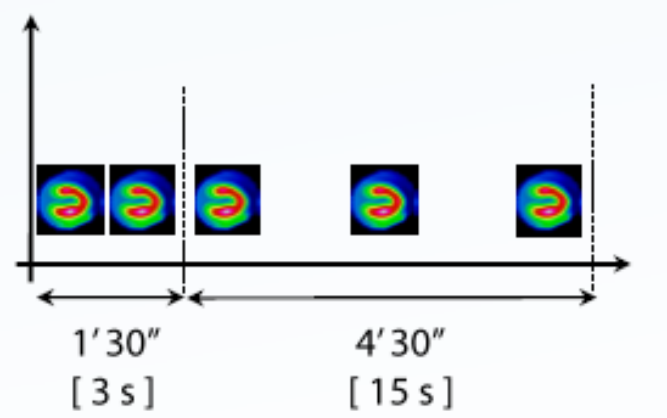


MODELE PHARMACOCINETIQUE



$$\frac{dC(t)}{dt} = K_1.P(t) \Rightarrow \int_0^t \frac{dC(t)}{dt}\,dt = K_1.\int_0^t P(t)dt$$

$$C(t) = K_1.\int_0^t P(t)dt$$

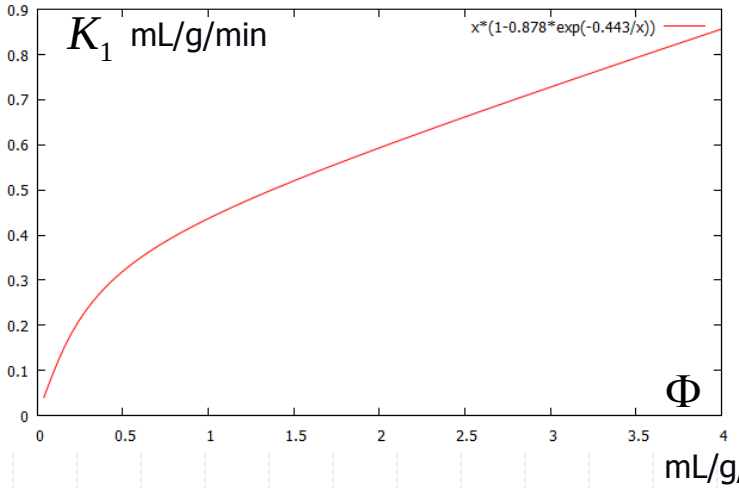


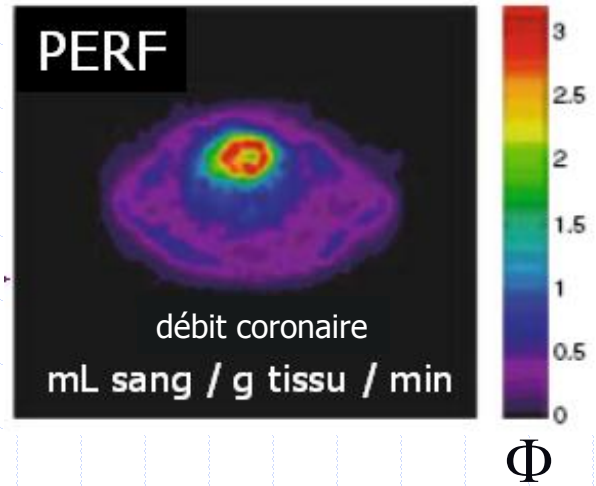
JA Leppo Circ Res. 1989; 65:632-9

RESERVE CORONAIRE EN CZT

Passage de K_1
au débit coronaire Φ :

Renkin-Crone: $K_1 = \Phi.(1-0{,}9.e^{-\frac{0.4}{\Phi}}) = \Phi.EF$



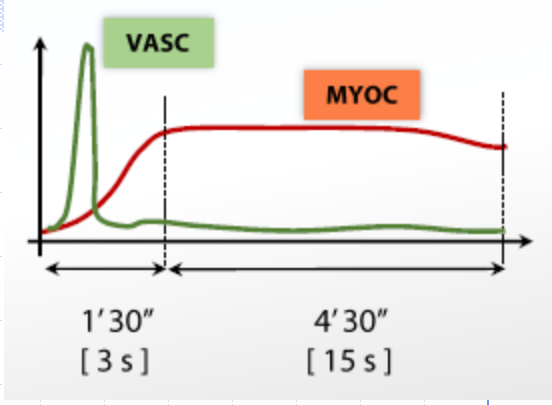


RESERVE CORANAIRE $RC = \frac{\Phi_{stress}}{\Phi_{repos}}$

(Rm: correction EVP et contamination P→C)

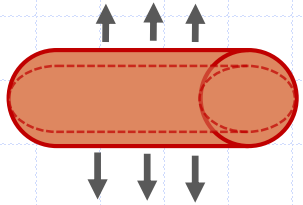
F Ben Bouallègue, et al. *J Nucl Med* 2015; 56:1712–1717 – D Agostini et al. Eur J Med Nucl Mol Imaging 2018; 45:1079-1090

RESERVE CORONAIRE



MIBI
1 mCi
centrage

MIBI repos,
5 mCi



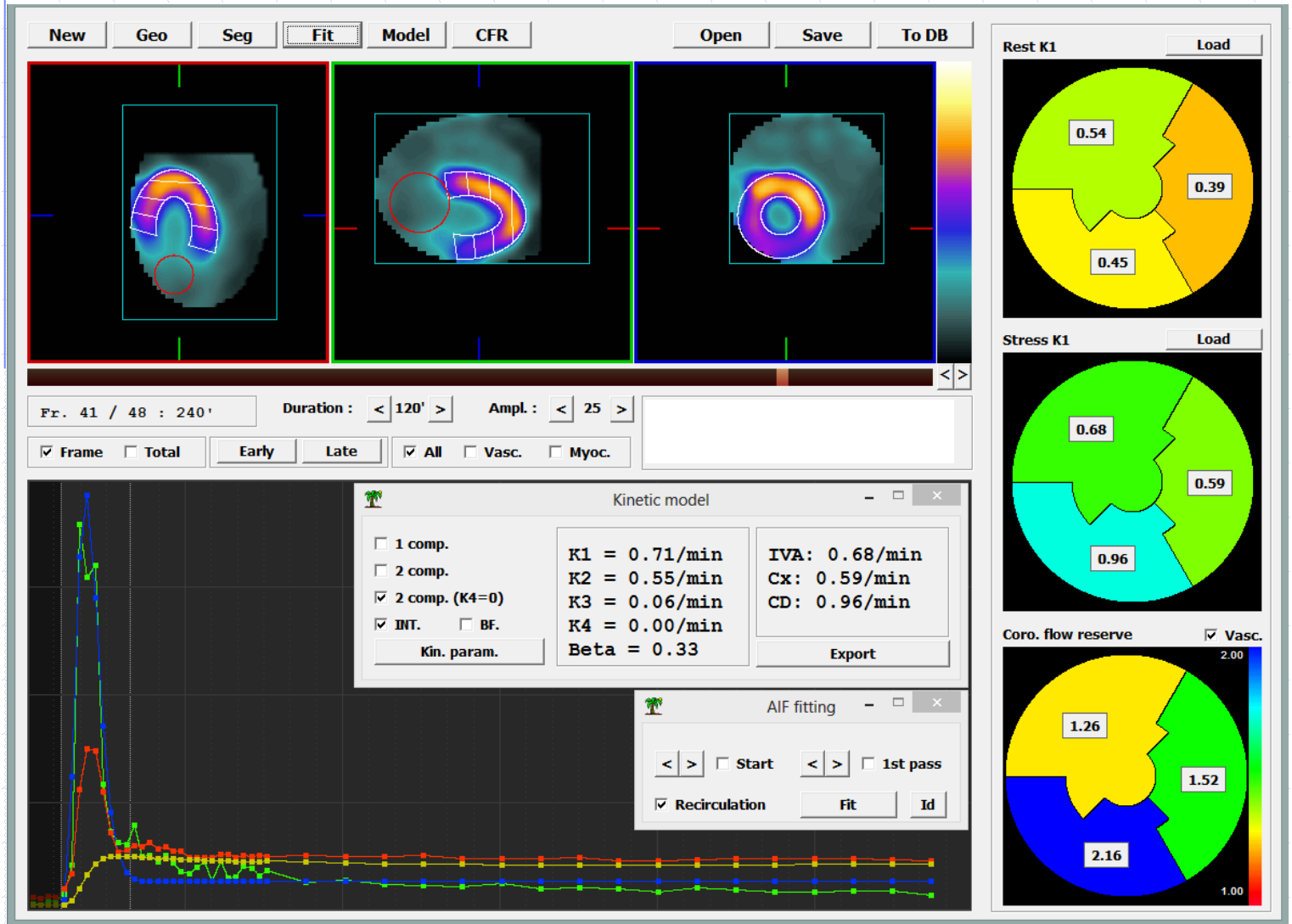
Dipyridamole
0,56 mg/kg sur 4'

MIBI stress,
20 mCi

Φ au repos puis sous stress

$$RC = \frac{\Phi_{stress}}{\Phi_{repos}}$$

Cas clinique

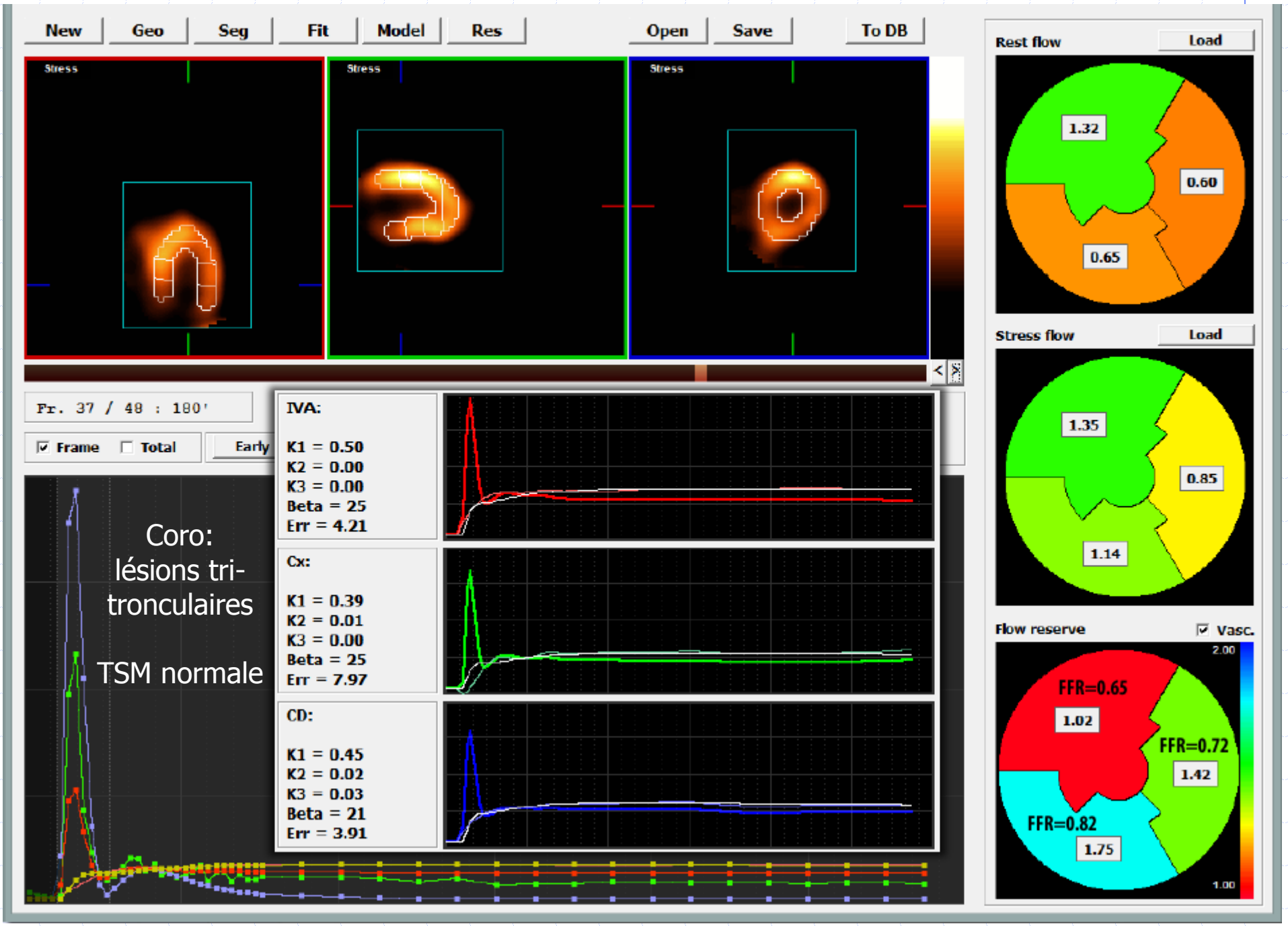


Occlusion CD distale stent H3
+
Lésions serrées bifurc. IVA-DIAG & Cx
à traiter

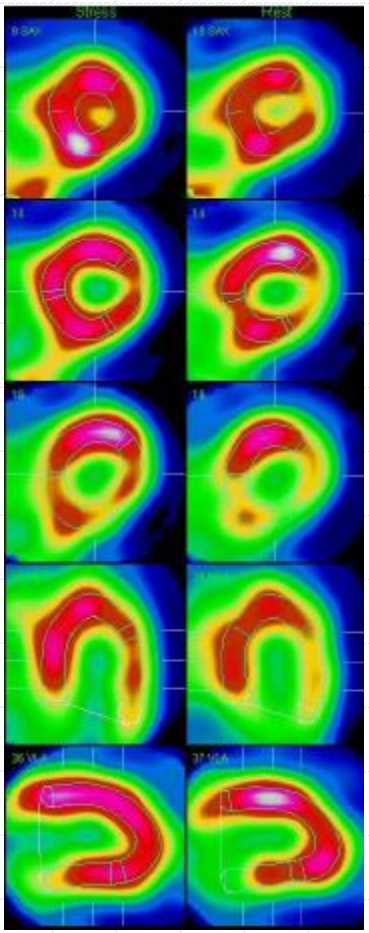
TSM : ischémie inf

F Ben Bouallègue et al
J Nucl Med 2015

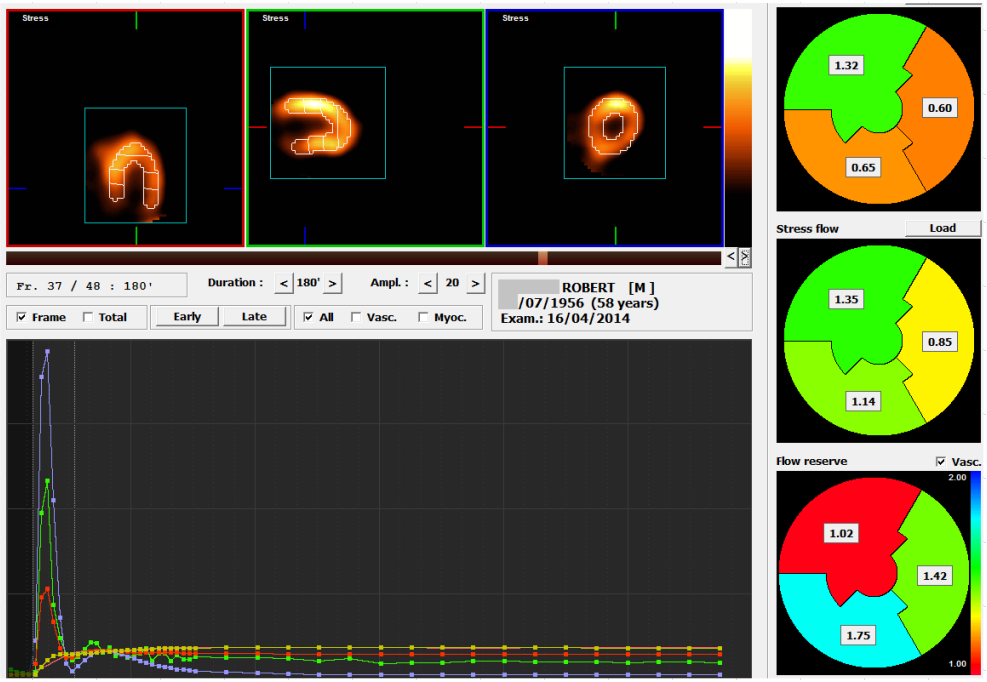
Cas clinique

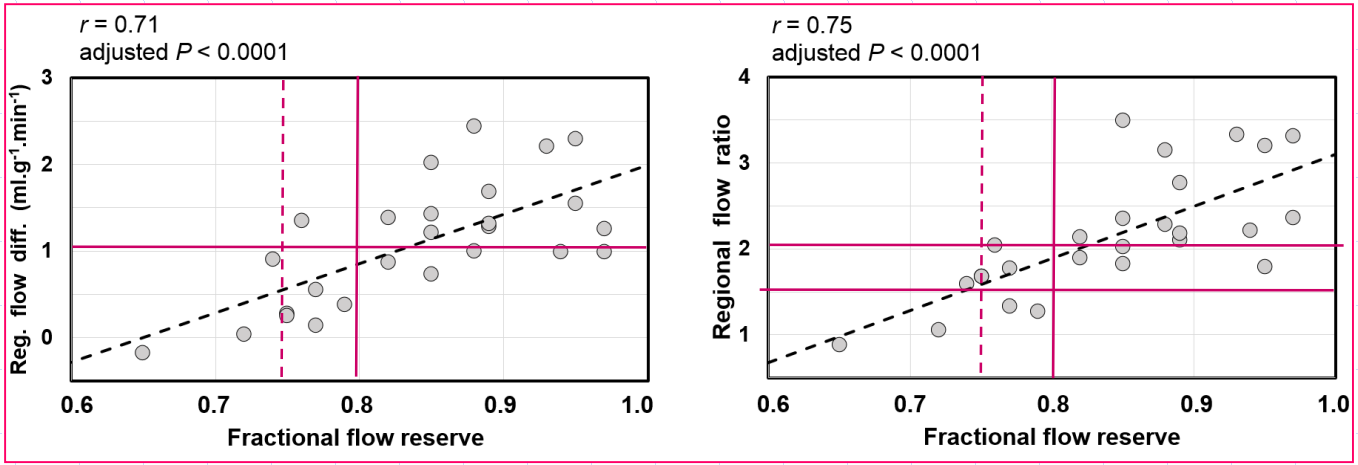


PREMIERS RESULTATS: PERFUSION



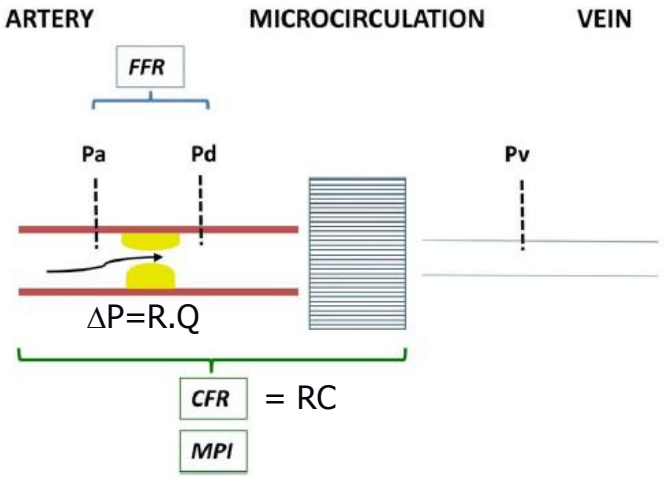
80 % IVA 2
80 % IVA 3
95 % Mg
+
stent sur
95 % CD1

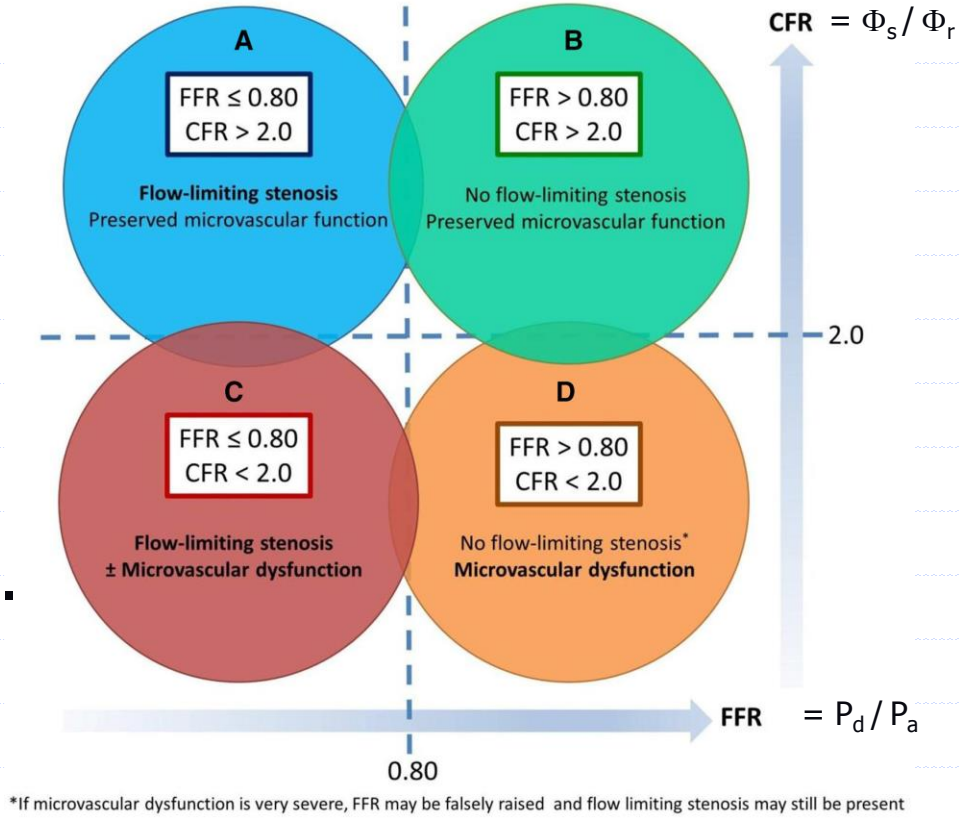




F Ben Bouallègue et al.
J Nucl Med 2015; 56(11):1712-7

COMPLEMENTARITE CFR / FFR





FFR : sténose épicardique unique.

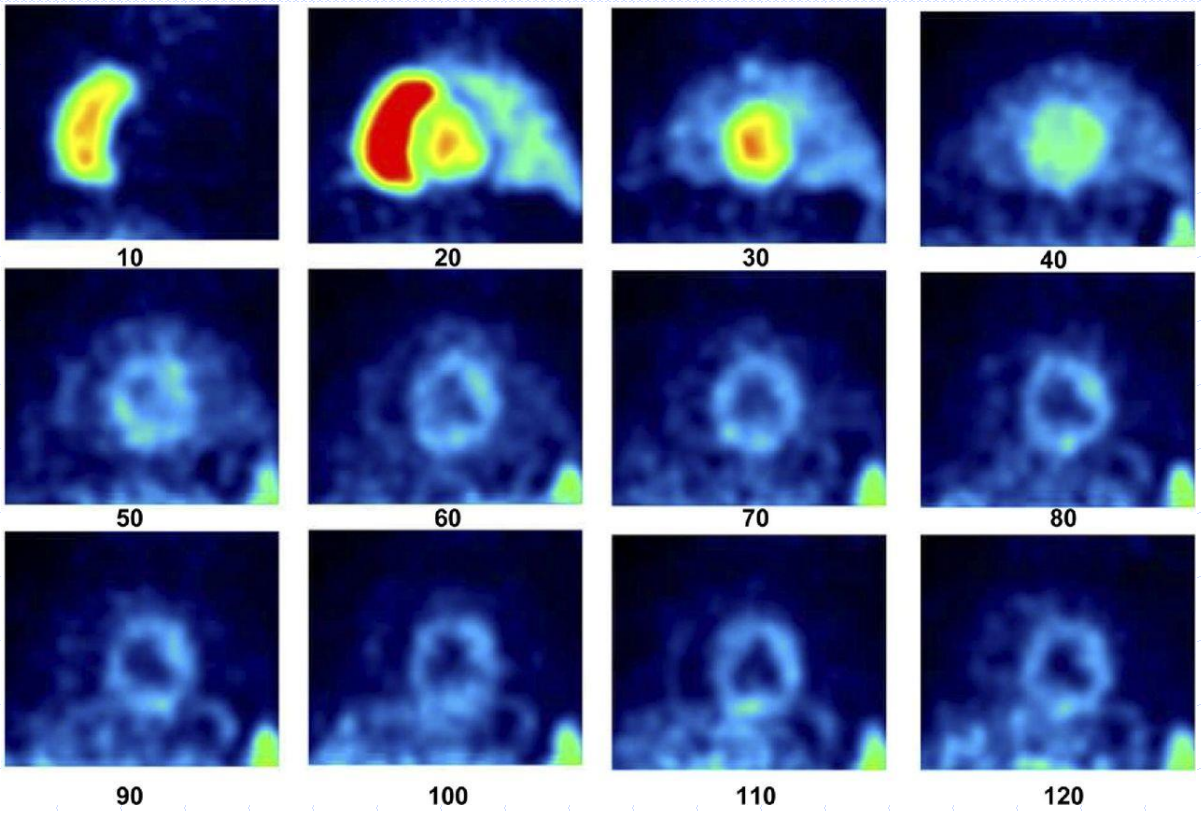
Limitations :

- sténoses étagées
- micro angiopathie
  (IDM récent, HTA, HVG, Diabète, HTG, tabac)
- PVC, P°TD élevées
  (dysfonction diastolique)
- Utilisée dans 6-7% des coro

M Motwani et al. J Nucl Cardiol 2018; 25:104-19

CAS CLINIQUE EN TEP

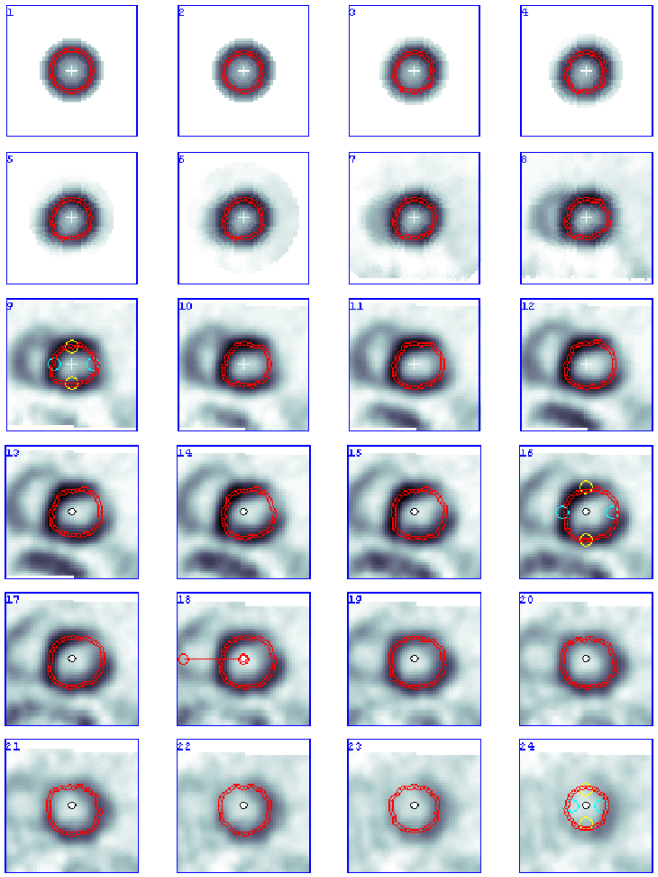
ACQUISITION DYNAMIQUE

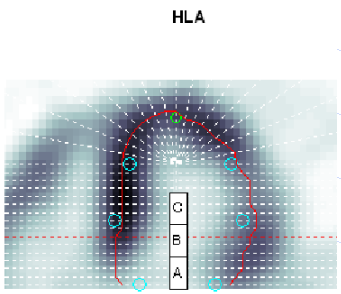


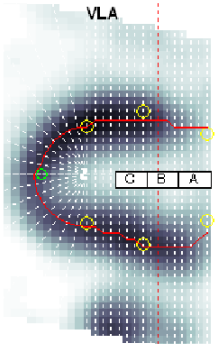
^{15}O-H_2O
^{13}N-NH_3
^{82}Rb
^{18}F-flurpiridaz

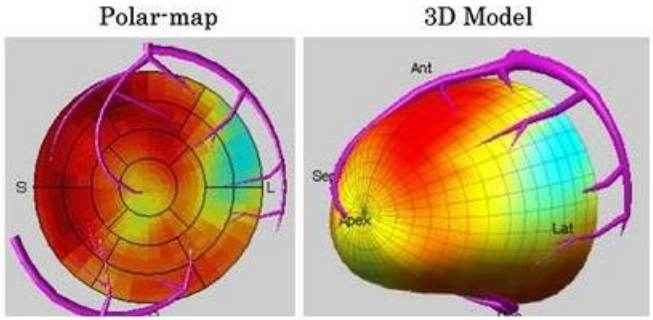
Schindler et al. JACC Cardiovasc Imaging 2010

CAS CLINIQUE EN TEP





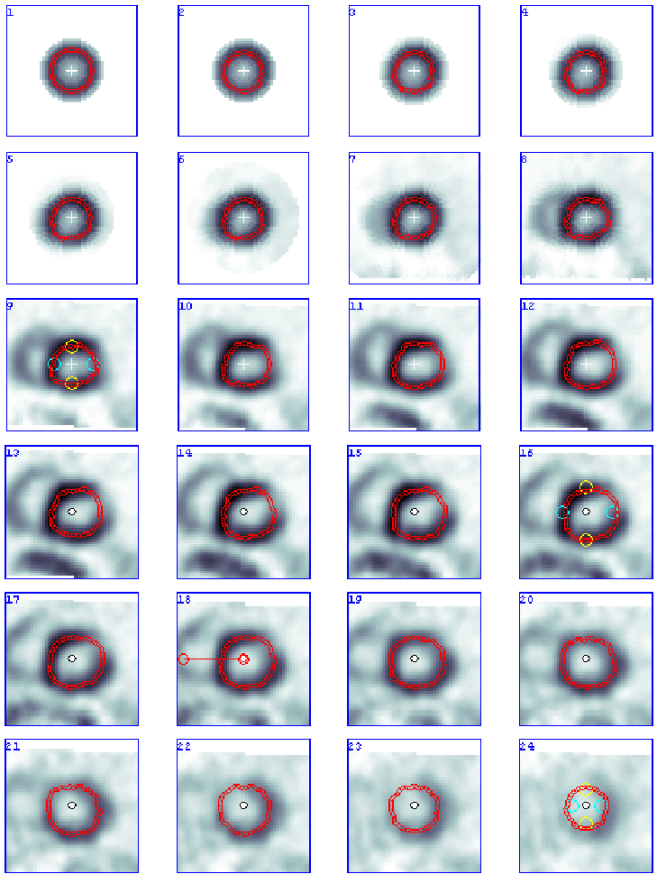


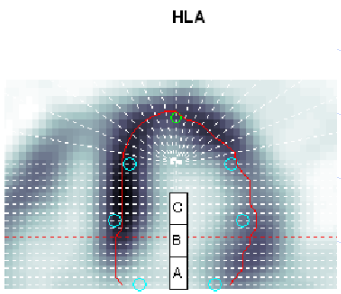


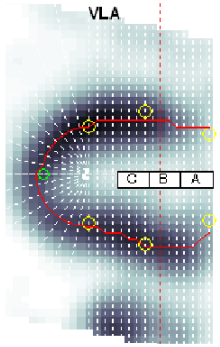
SEGMENTATION

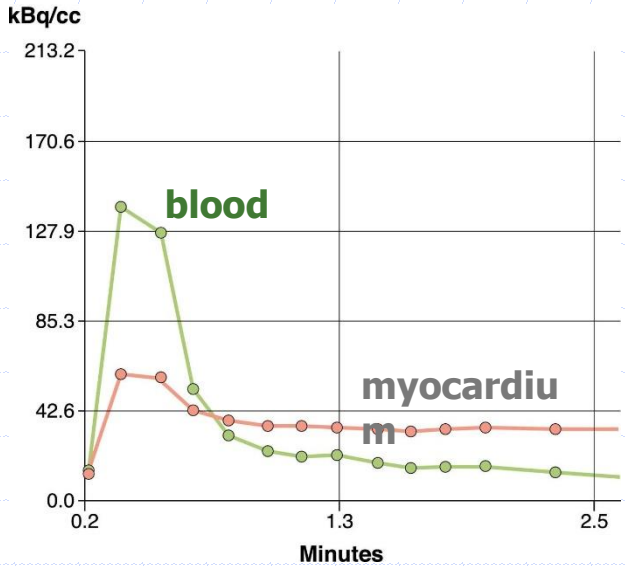
Klein et al. J Nucl Cardiol 2010

CAS CLINIQUE EN TEP

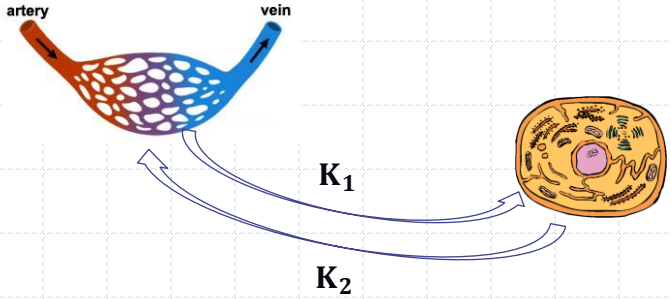








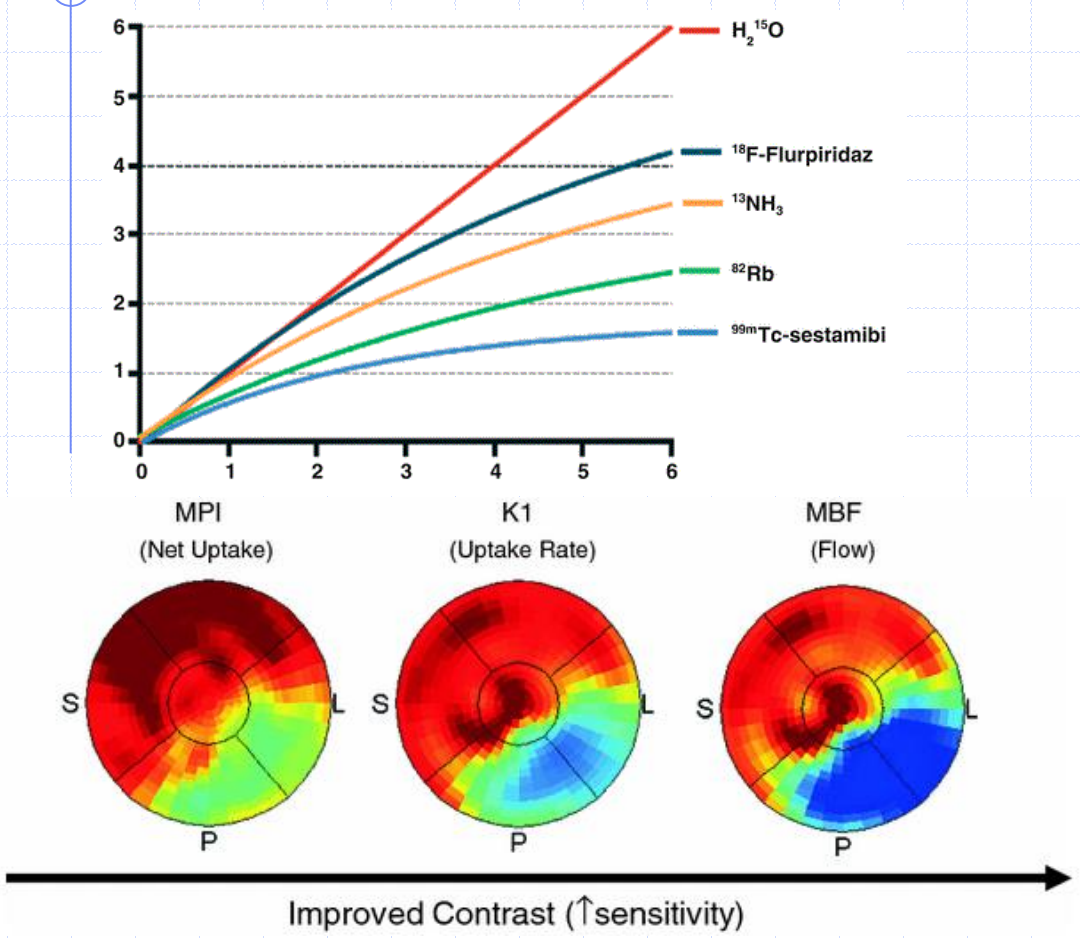
Schindler et al. JACC Cardiovasc Imaging 2010

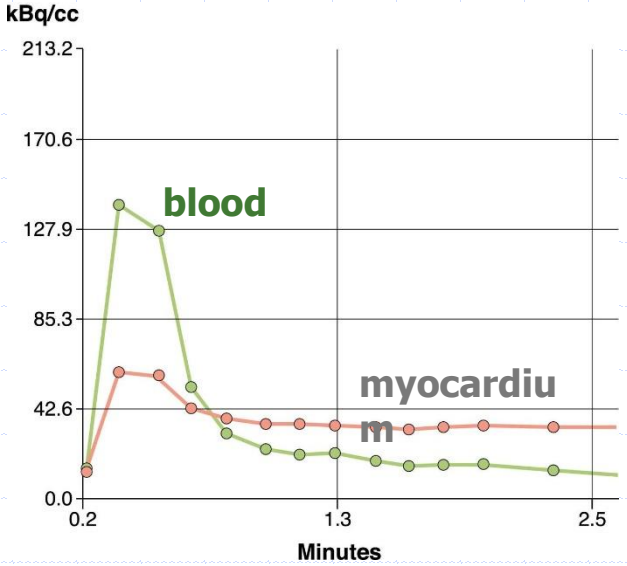


ANALYSE COMPARTIMENTALE

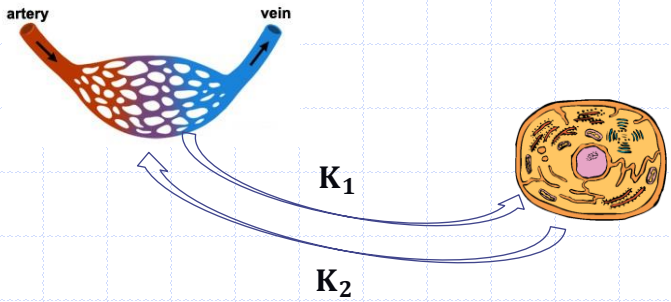
Klein et al. J Nucl Cardiol 2010

CAS CLINIQUE EN TEP





Schindler et al. JACC Cardiovasc Imaging 2010



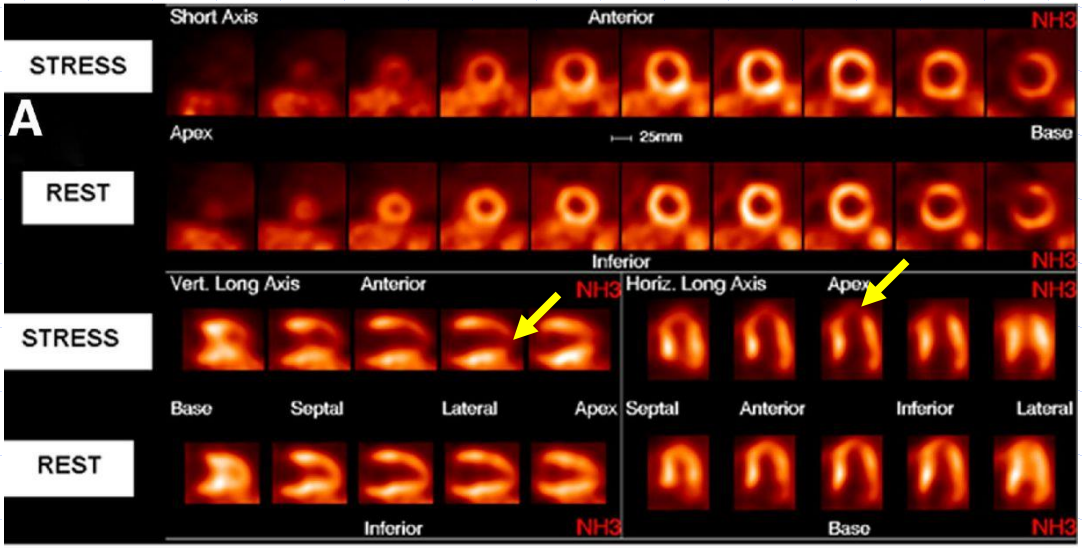
QUANTIFICATION DEBIT/RESERVE

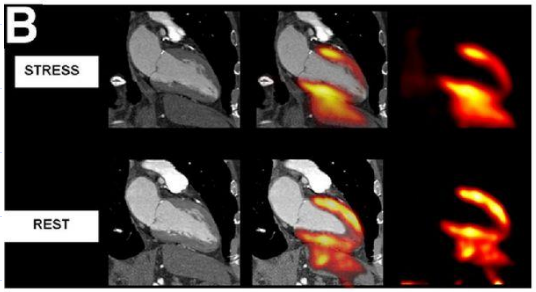
Schindler et al. JACC Cardiovasc Imaging 2010 - Klein et al. J Nucl Cardiol 2010

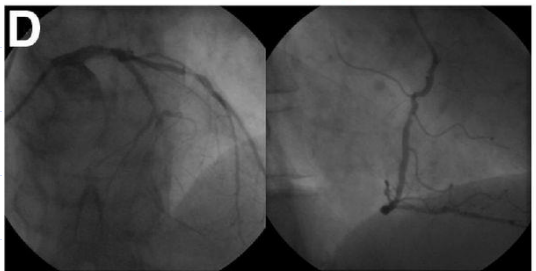
CAS CLINIQUE EN TEP

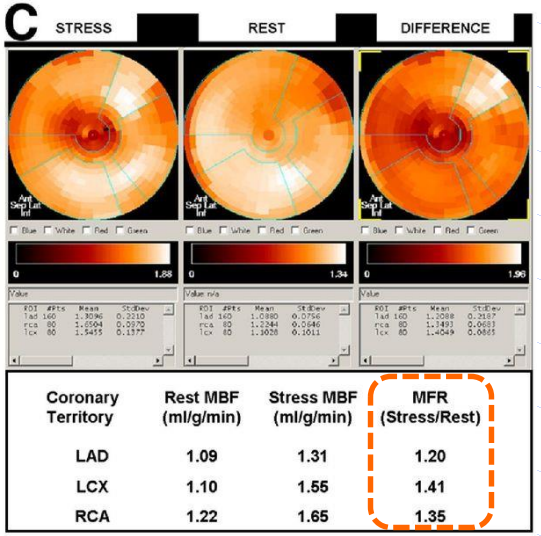
61 ans
Diabète, HTA

Occlusion IVA
Sténose 80% Cx
Sténose 60% CD







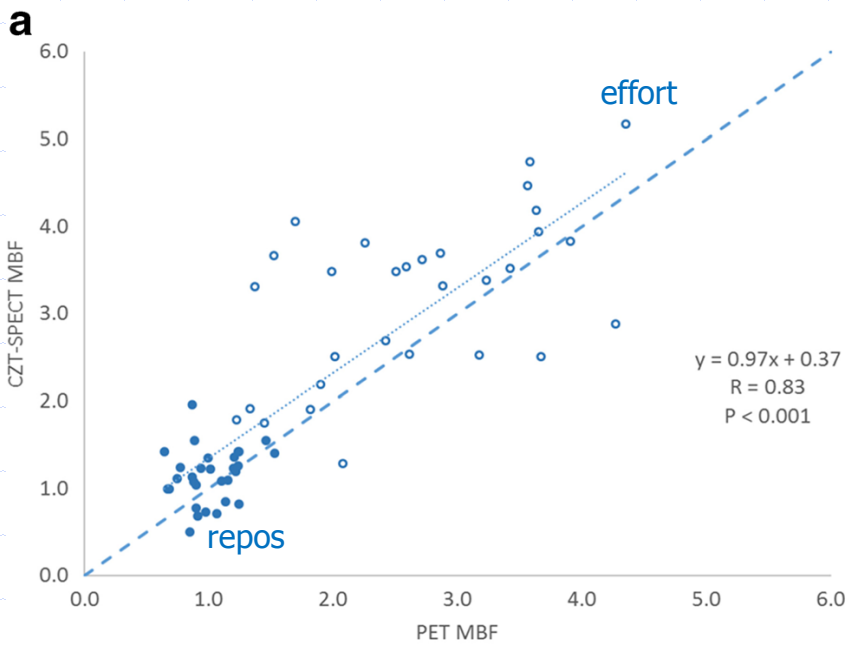


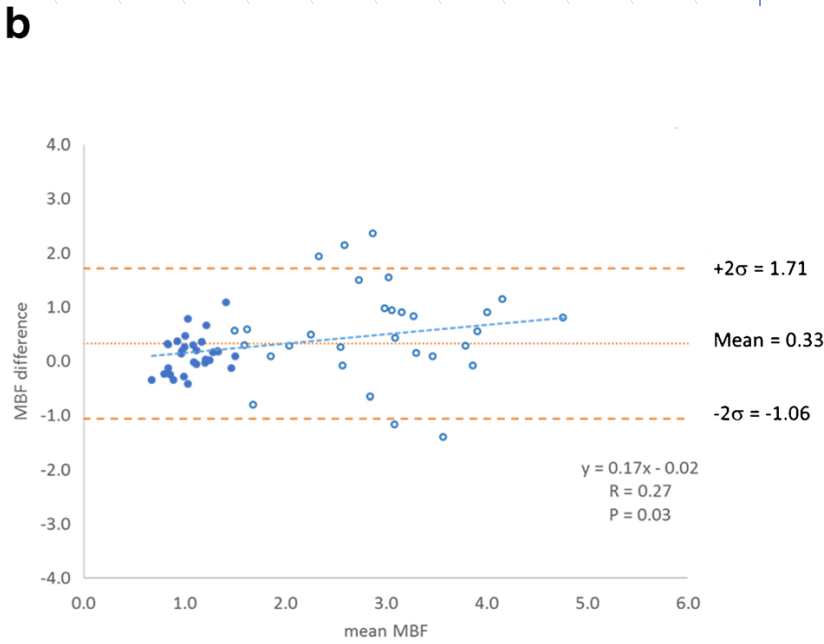
Coronary Territory	Rest MBF (ml/g/min)	Stress MBF (ml/g/min)	MFR (Stress/Rest)
LAD	1.09	1.31	1.20
LCX	1.10	1.55	1.41
RCA	1.22	1.65	1.35

Schindler et al. JACC Cardiovasc Imaging 2010

PET ou SPECT ?

99Tc MIBI

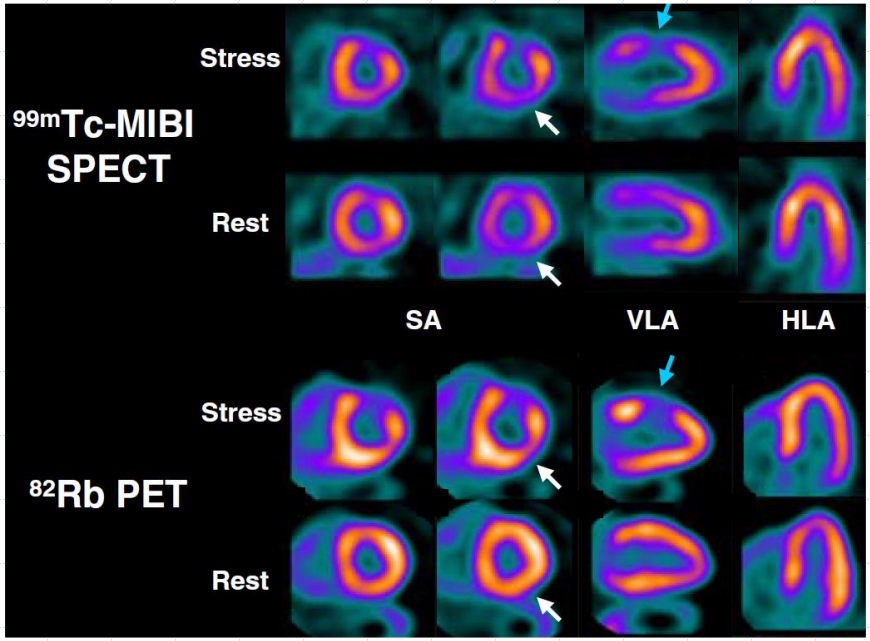


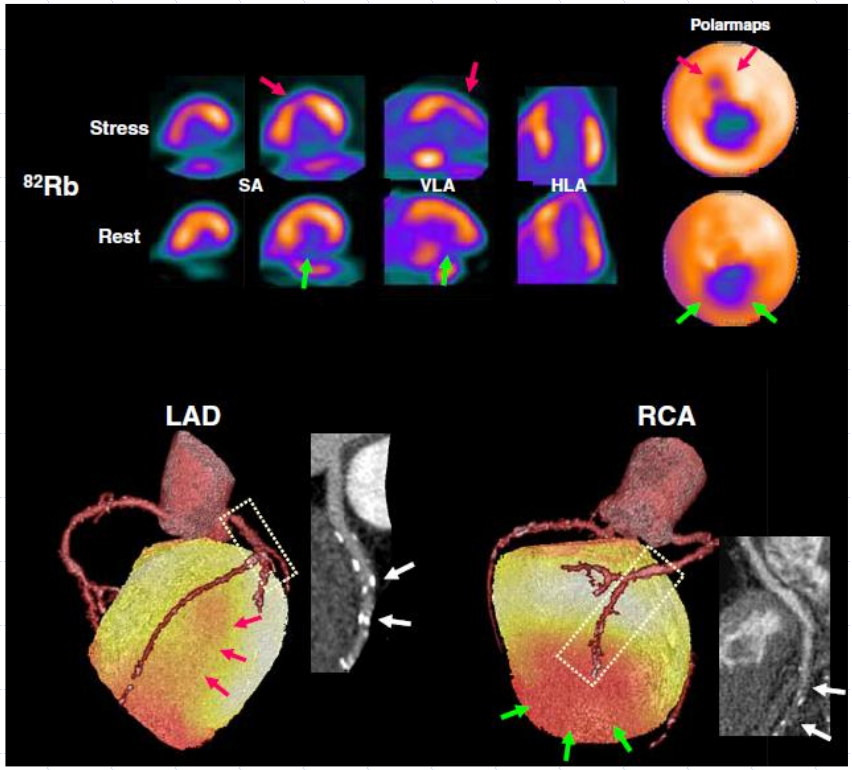


$^{15}OH_2$

Nkoulou et al J Nucl Med 2016 – Agostini et al. Eur J Nucl Med. 2018; 45:1079-1090

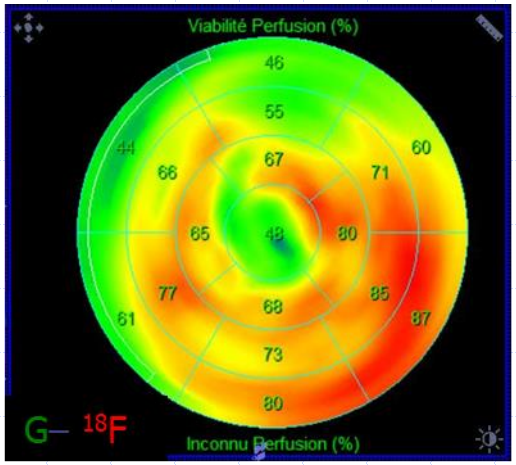
TEP DE PERFUSION

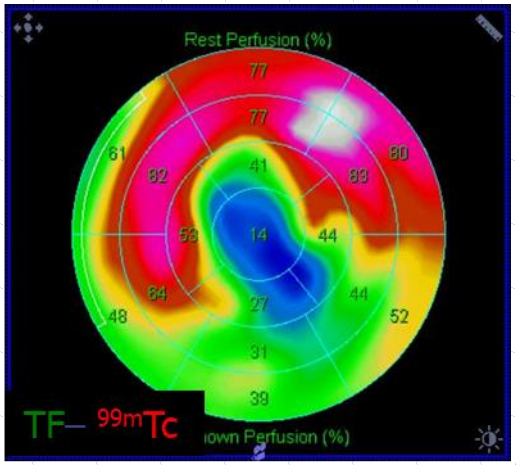




^{87}Rb, ^{13}N, ^{15}O,
^{18}F-flurpiridaz
Analyse dynamique et atténuation mieux gérées
Pb : traceur, coût, disponibilité

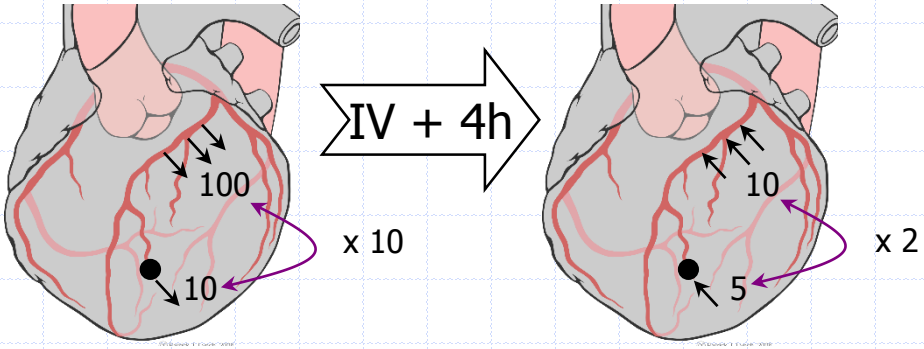
TOMOSCINTIGRAPHIE DE VIABILITE MYOCARDIQUE

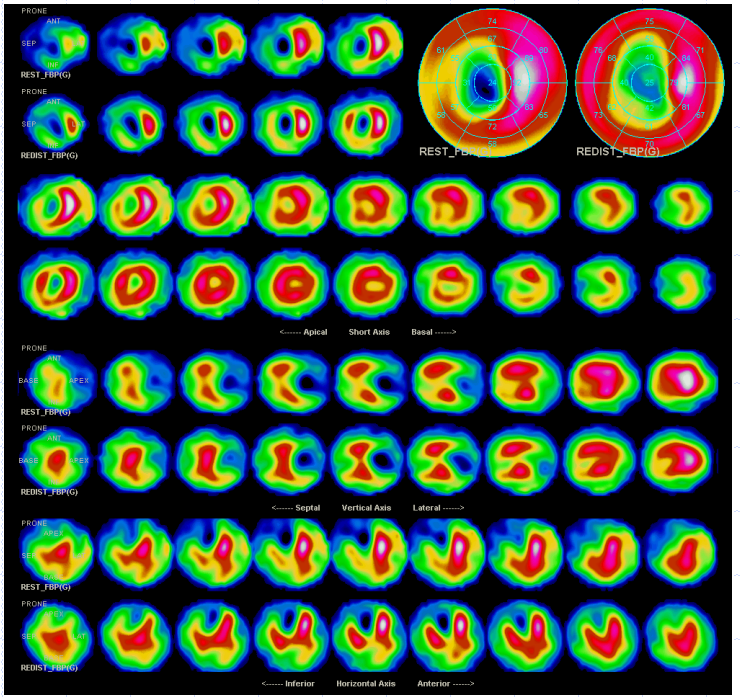




VIABILITE MYOCARDIQUE

Thallium de repos et redistribution à 4 et/ou 24h

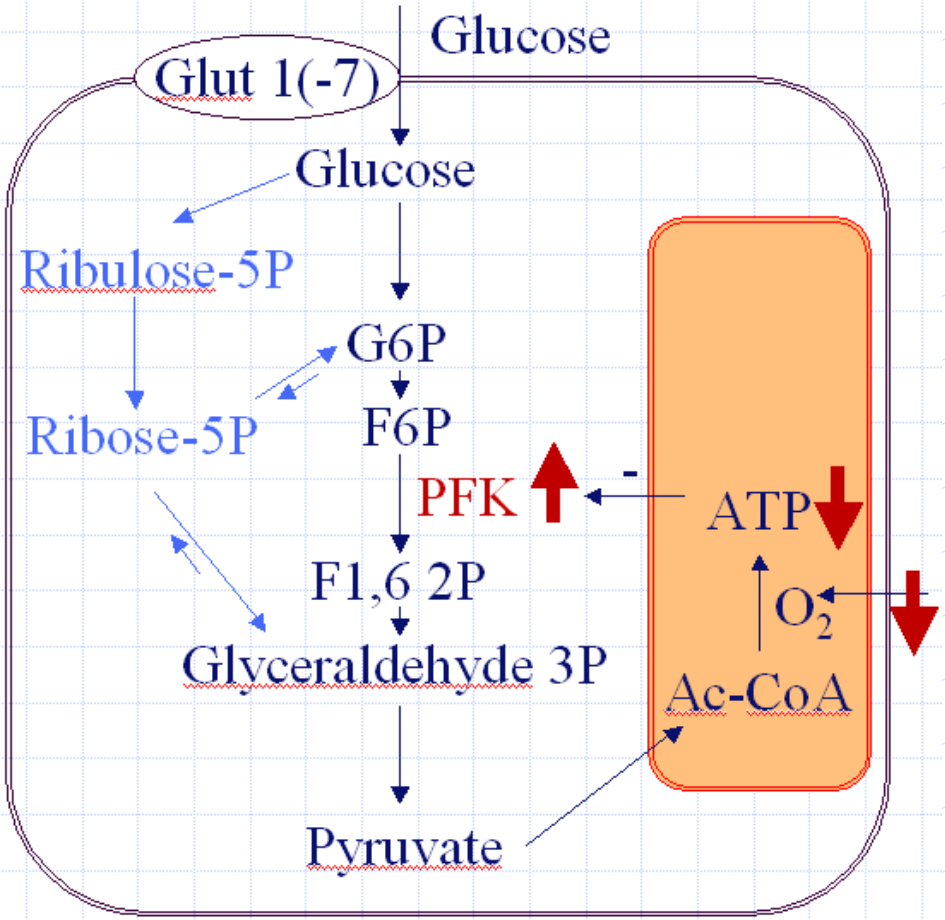




^{201}Tl: Repos / Redistribution à 3h

VIABILITE MYOCARDIQUE

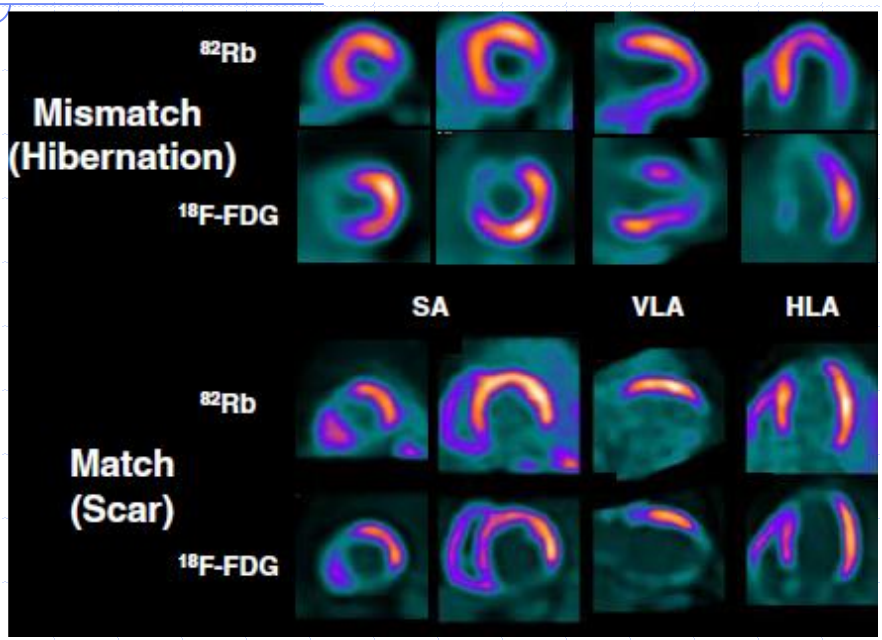
Traceur d'ischémie viable: Glu – ^{18}F

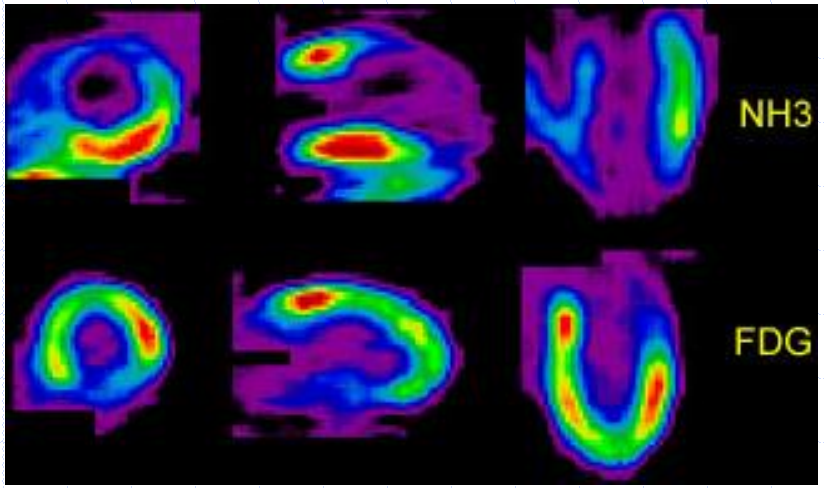


Principe du protocole :
50 g de glucose PO
± Insuline si résistance

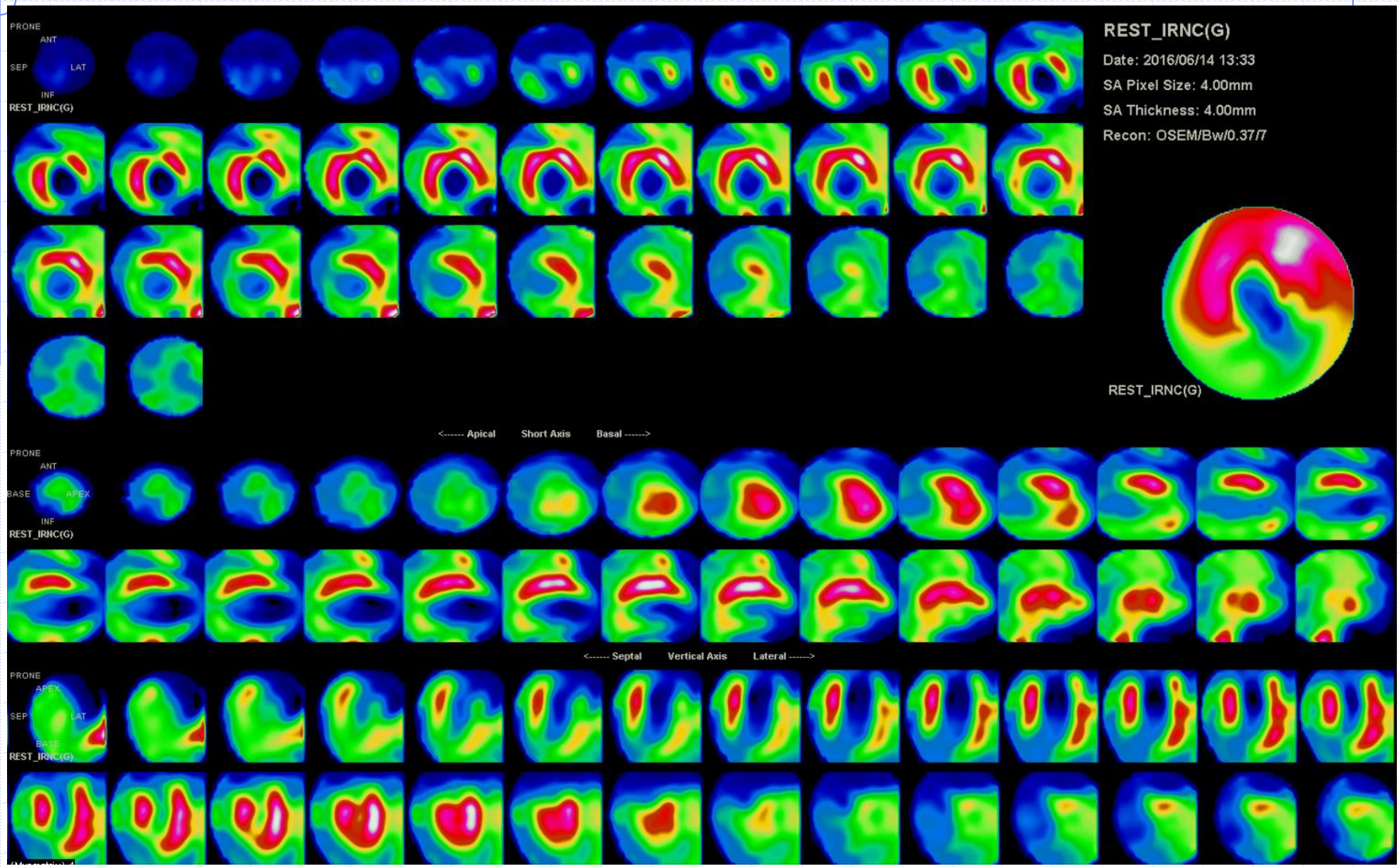
FDG IV quand Gly ↓
TEP à 1h synchronisé

VIABILITE MYOCARDIQUE

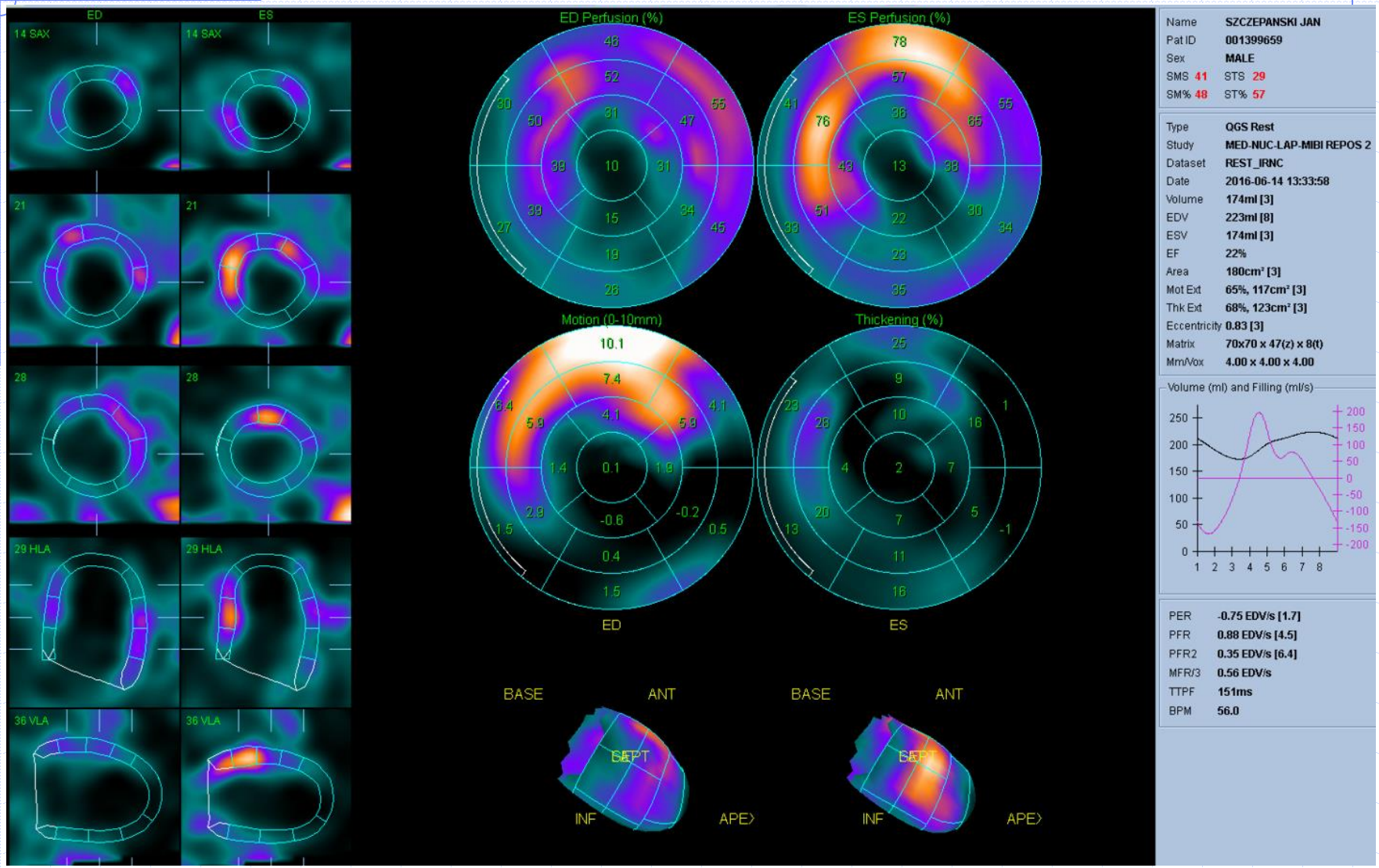




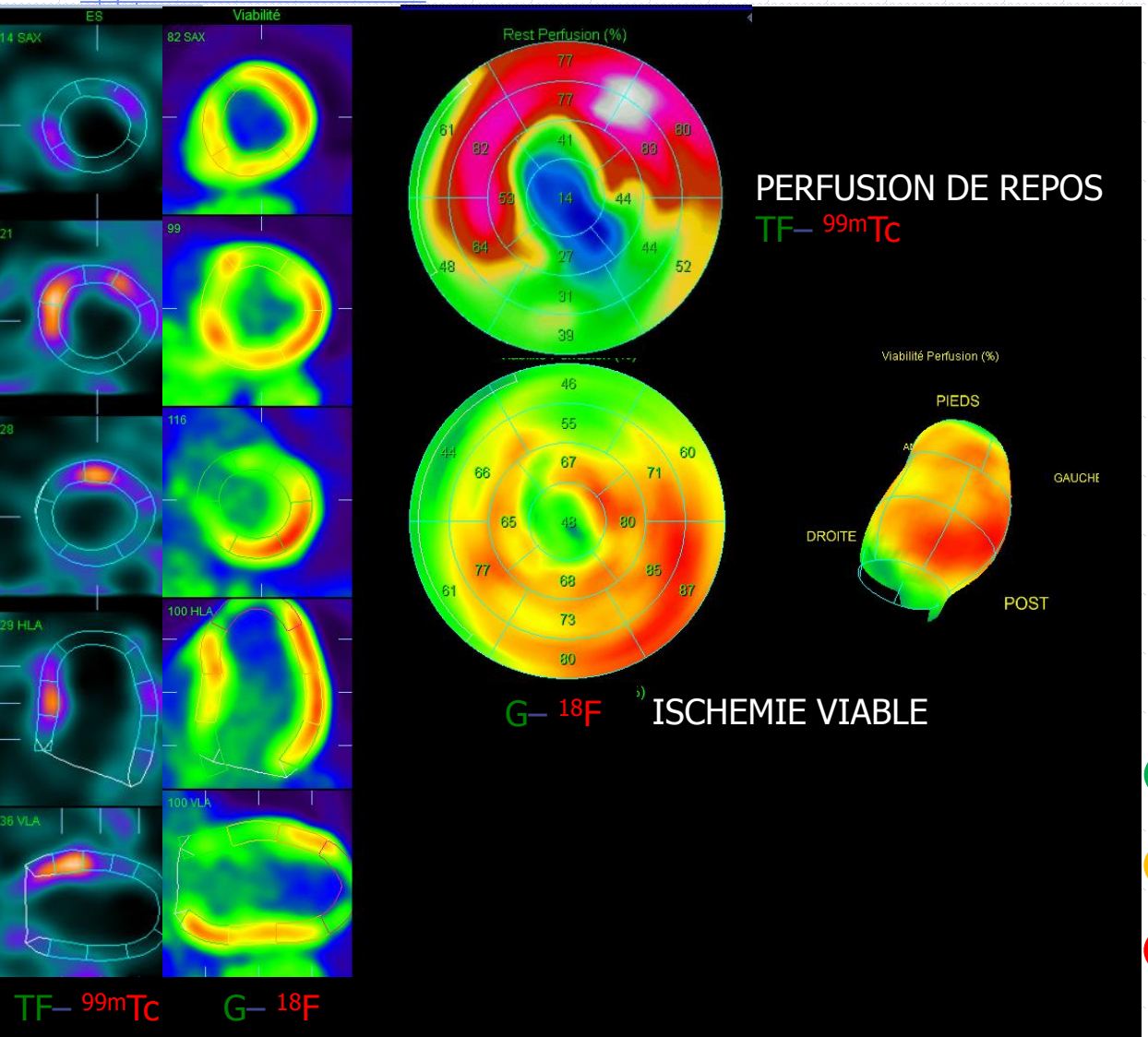
Homme, 49 ans tritronculaire
Occlusions chroniques de l'artère Cx proximale, CD1, IVA2
sténose de Mg1, longue D1, lésion du tronc commun.

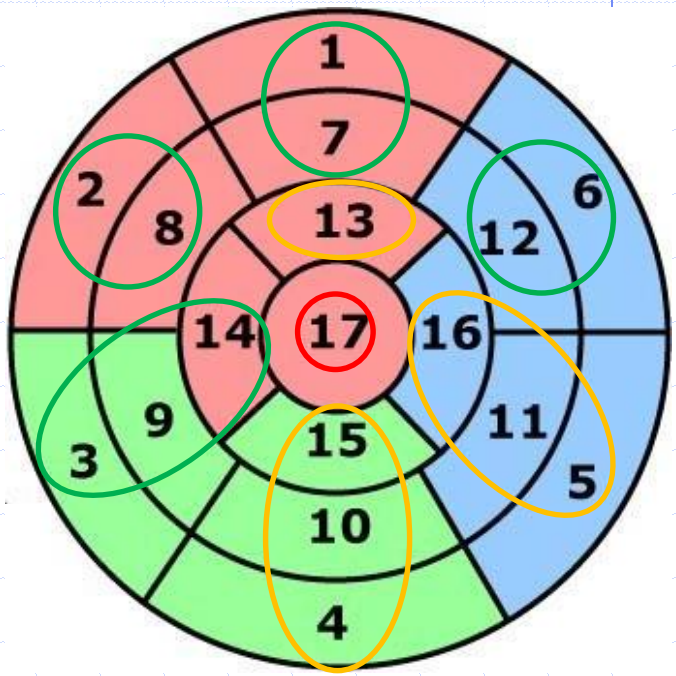


TSM de repos ^{99m}Tc-Tetrofosmine



TSM ^{18}F-DG / ^{99m}Tc-Tetrofosmine



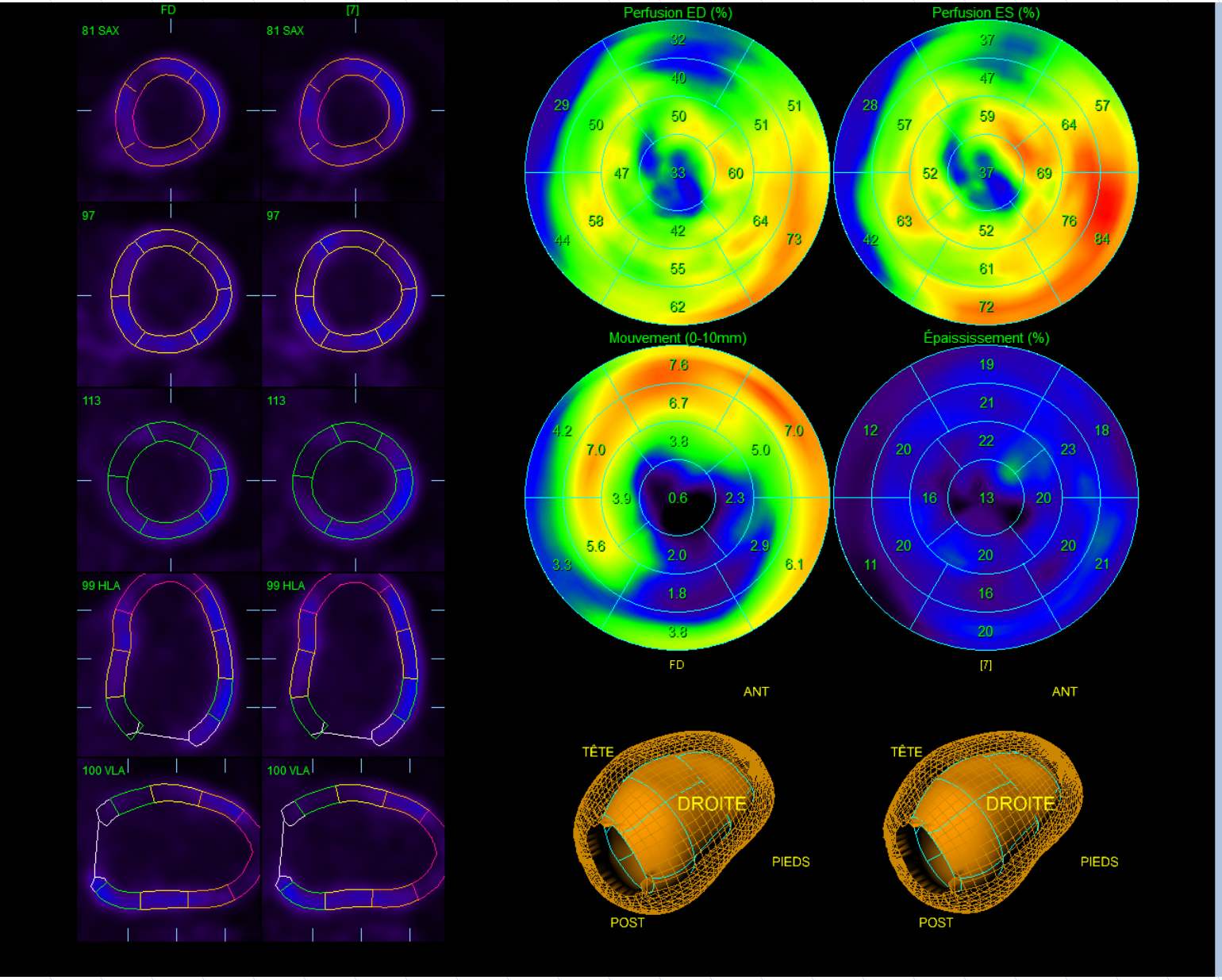


normal au repos

hibernation

nécrose

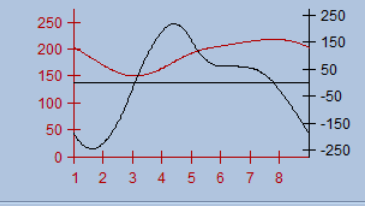
TSM ^{18}F-DG



Nom	SZCZEPANSKI, JAN
ID Pat	001399659
Résultats	RESULTS: Résultats QGS+QPS
Sexe	HOMME
Limites	Pet
3 X par jour	--
LHR	--
SMS 23	STS 16
SM% 27	ST% 31

Étude	PET^12_CardiacGated_Viabilite_FDG (Adu
Ensemble de données	PET Cardiac Corrigé G
Date	2016-06-15 11:37:11
Statut	QC=13.50, IR=0.28 (manuel)
Volume	214ml [7]
DEV	218ml [8]
SEV	150ml [3]
VS	68ml
EF	31%
Mouv Ext	55%, 128cm² [7]
Épaississement Ext	48%, 110cm² [7]
Forme	0.62 [SI ED], 0.54 [SI ES], 0.81 [Ecc 7]
Matrice	200x200 x 75(z) x 8(t)
Mm/Vox	2.04 x 2.04 x 3.00

Volume [ml] et remplissage [ml/s] VG



PER	-1.13 DEV/s [1.6]
PFR	1.00 DEV/s [4.4]
PFR2	0.29 DEV/s [6.1]
MFR/3	0.67 DEV/s
TTPF	186ms
BPM	52.8 (R-R=1136ms) Modifi

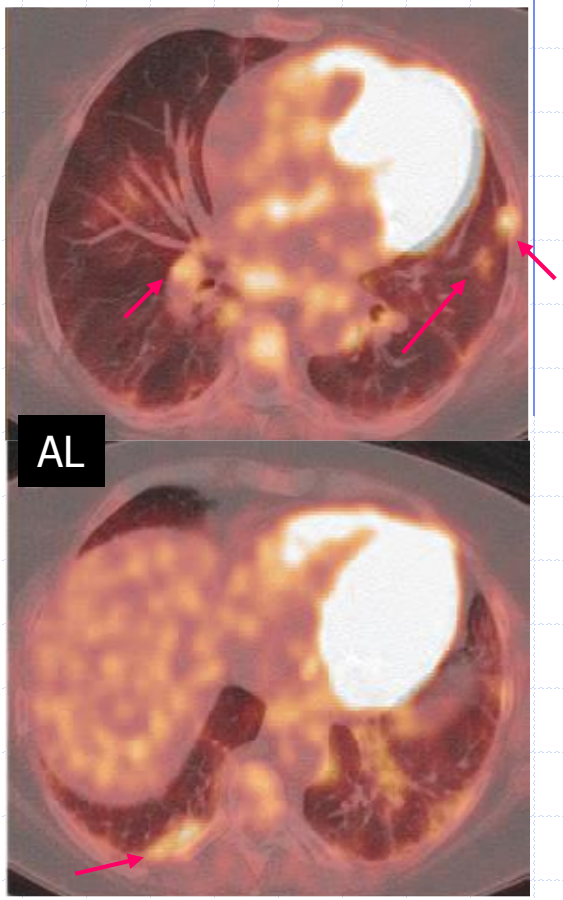
AUTRES INDICATIONS EN TEMP DE PERFUSION MYOCARDIQUE

Maladies de surcharge (amyloses, sarcoïdose)
Vascularite de Kawasaki
Myopathies inflammatoires (TEP FDG + néo associé)
Endocardites et infections vasculaires (TEP FDG)

AMYLOSES CARDIAQUES

Beaucoup de traceurs testés, peu/pas disponibles :
^{123}I-Serum Amyloid Protein, ^{99}Tc-Aprotinine, ^{111}In-antimyosine, ^{131}I-β2–μglobuline

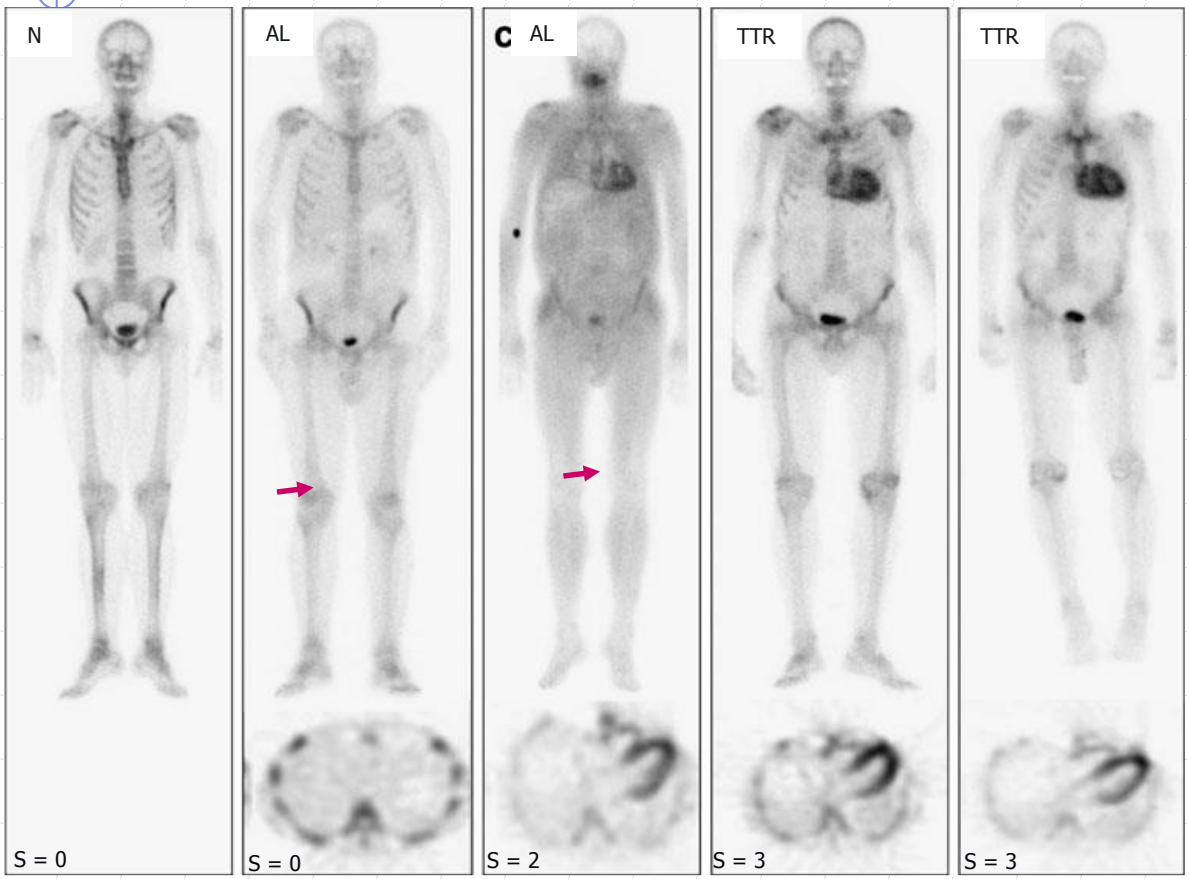
TEP FDG ↔ infiltrats/macrophages → localisation d'amylose
(poumon, cœur, reins, foie, ORL, os, muscles, articulations, nerfs, digestif…)

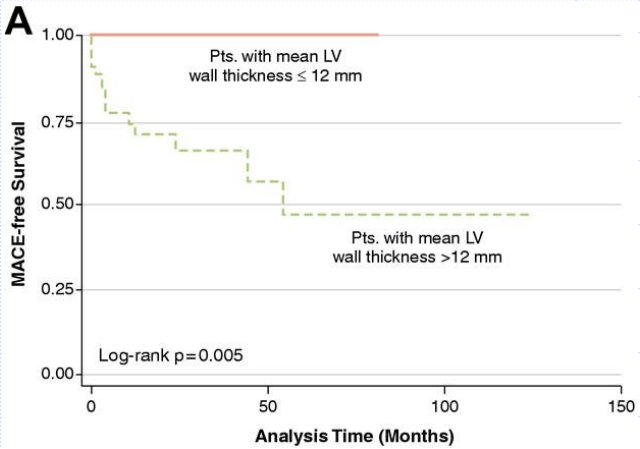


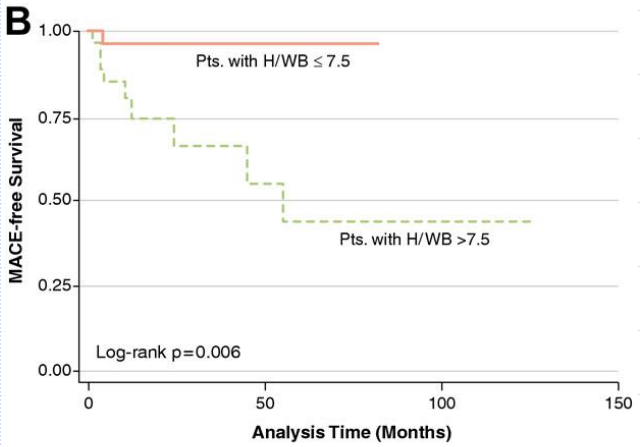
AMYLOSE CARDIAQUE :
→ Cardiomyopathie restrictive, angor, dénervation, troubles du rythme
4 traceurs utiles :
- Diphosphonates ↔ infiltration amyloïde A-TTR
- MIBG ↔ Dénervation → pronostic
- TETROFOSMINE (TSM) ↔ Perfusion
- Traceurs amyloïdes en évaluation

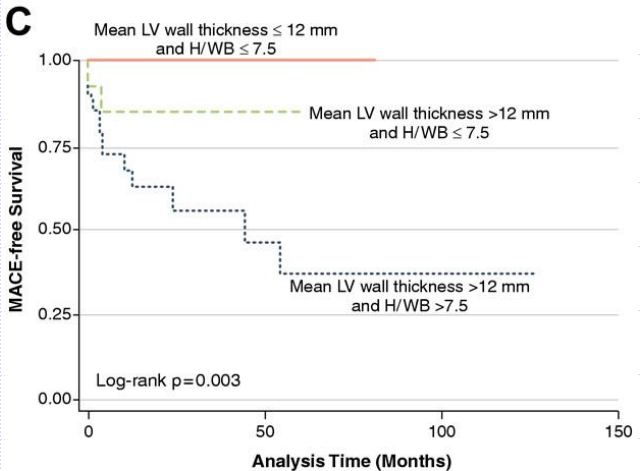
A Mekinian Amyloid 2012 – S Sachchithanantham British Med. Bull. 2013 – W Cytawa Pol J Radiol 2014 - Perugini JACC 2005 – Glaudemans Eut J Nucl Med 2009 – Rapezzi JACC Cardiovx Imag. 2011 – Antony J Nucl Med 2013

AMYLOSES ATTR & HDP



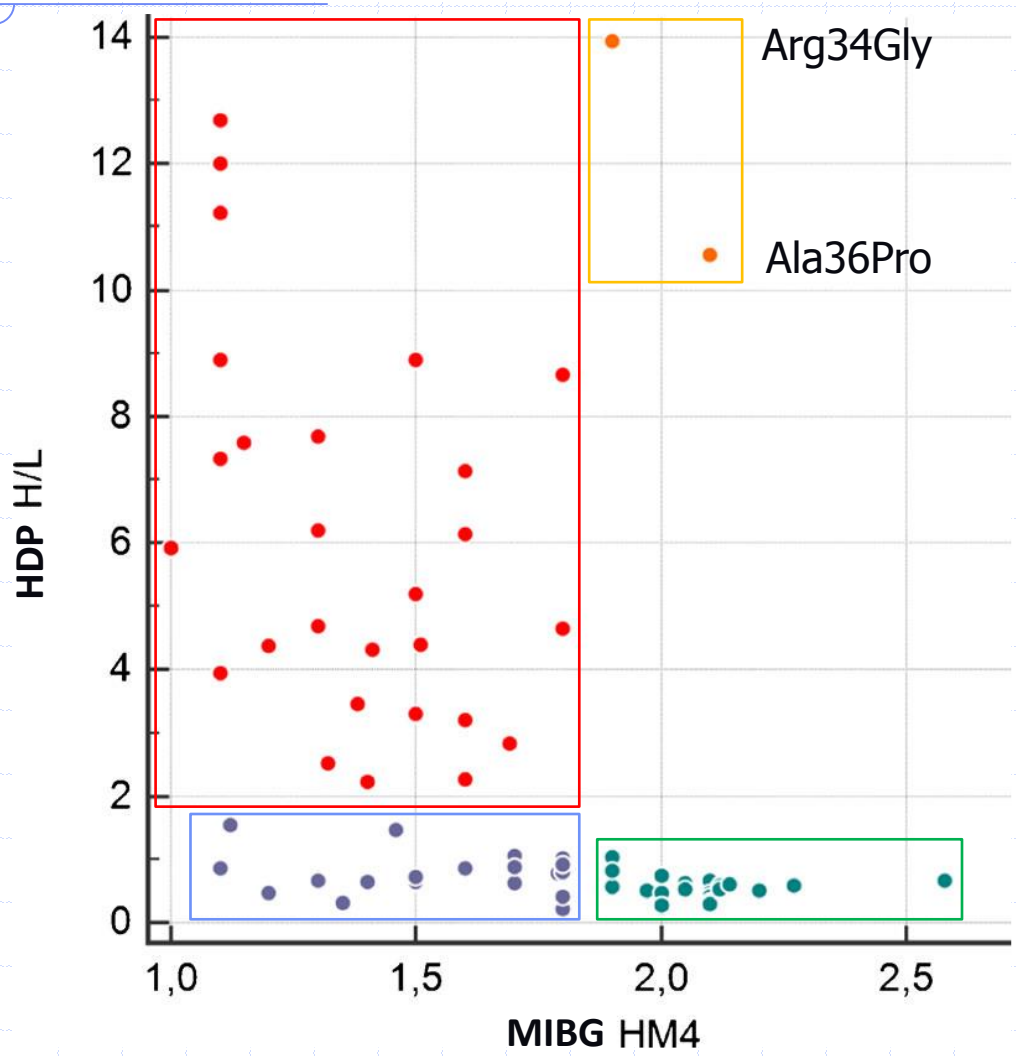


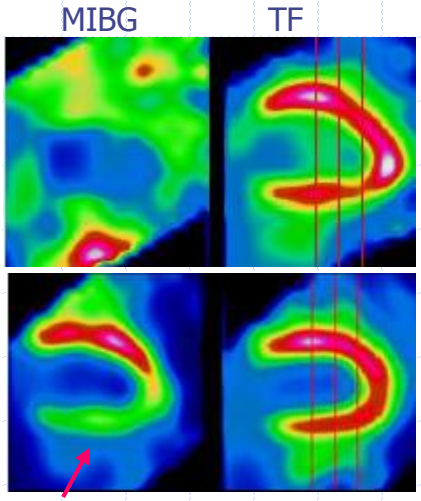




C Rapezzi Eur J Nucl Med 2011;38 et J Am Coll Cardiol Img 2011;4

AMYLOSES TTR & MIBG précoce

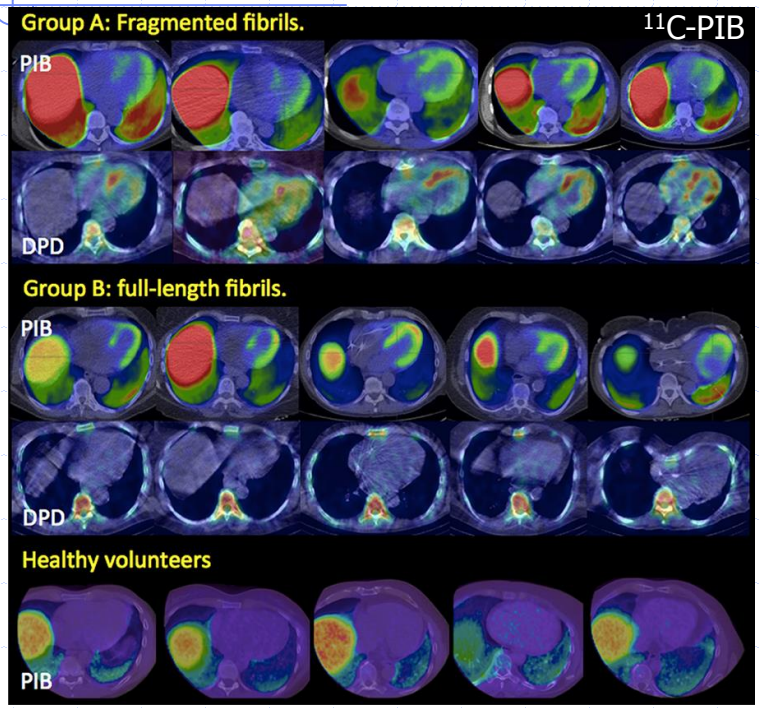


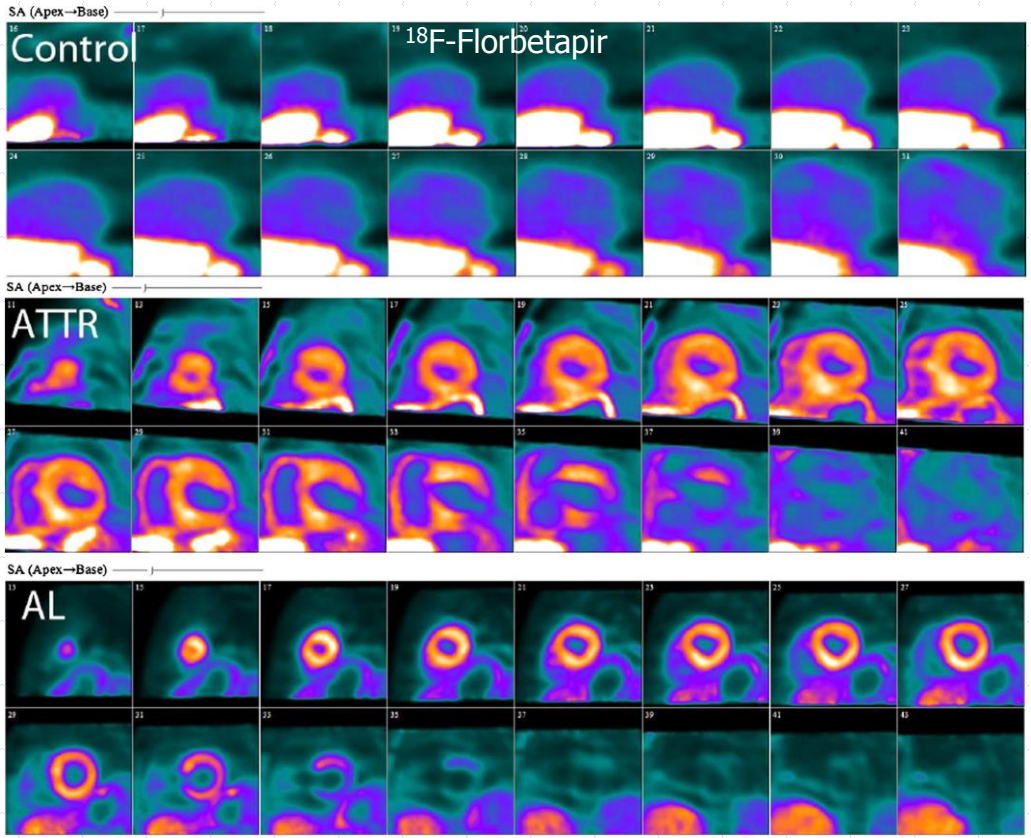


MIBG plus précoce que HDP et échographie

W Noordzij Eur J Nucl Med 2121;39 - E Piekarski Eur J Nucl Med 2018;45

AMYLOSES & TEP



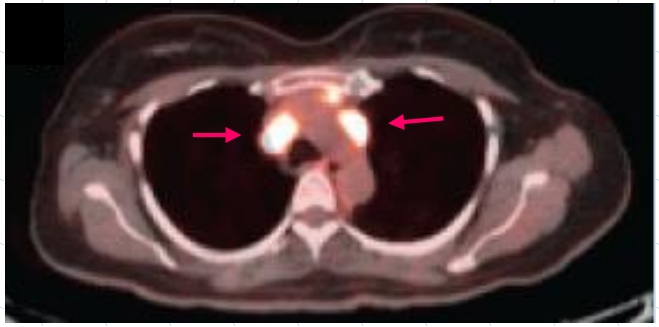


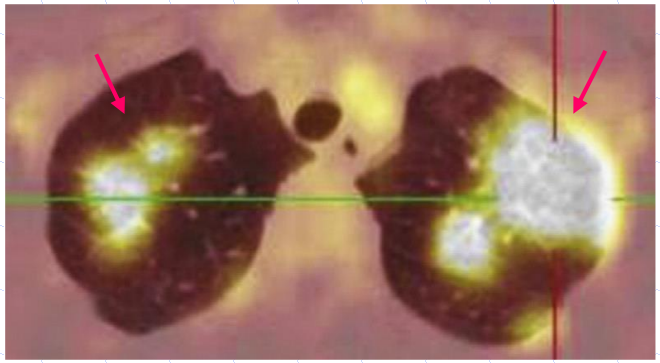
Traceurs amyloïdes sensibles aussi sur AL

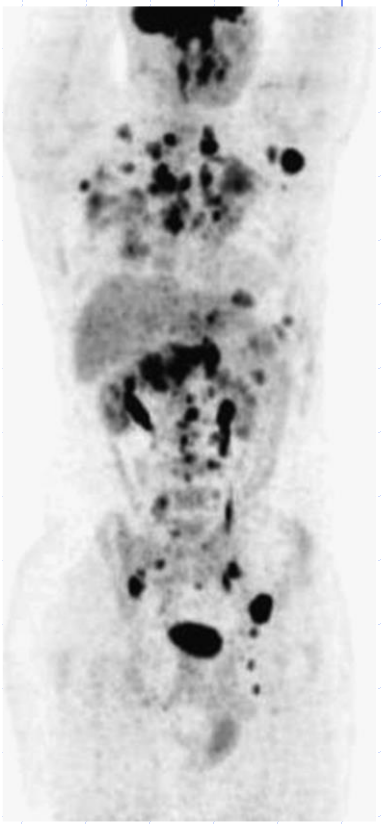
S Dorbala Eur J Nucl Med 2014;41 – Pilebro J Nucl Cardiol 2018;25

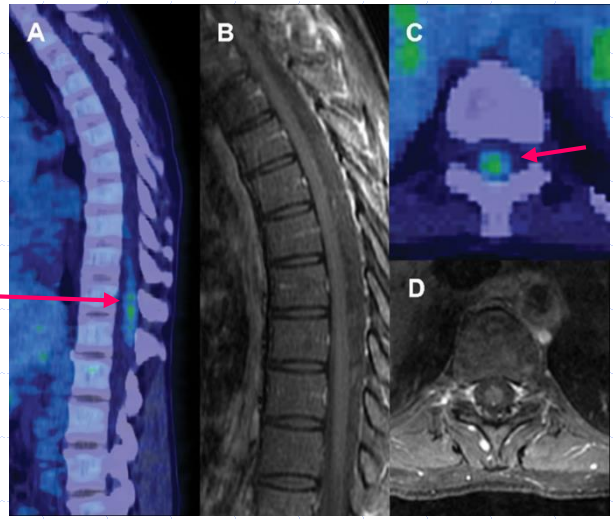
SARCOIDOSE

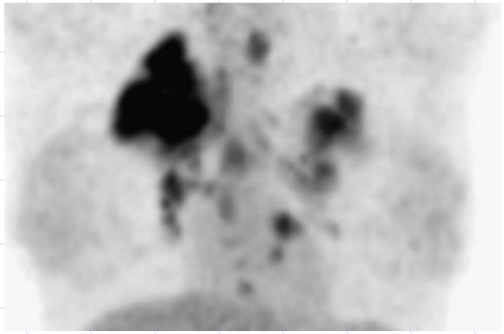
FDG ∝ Macrophages et T activés biopsie, diagnostic, Δ ttt > 2/3
→ médiastin, poumon (> 1/2)
→ peau (1/3), muscles, os & moelle
→ Foie & rate (1/10), digestif (2%),
→ Rétro péritoine (1/4)
→ SN (1/10)
→ Cœur (5%)
Traceurs des SRS (Ga) en évaluation
Limites : Δ ≠ lymphomes / cancers

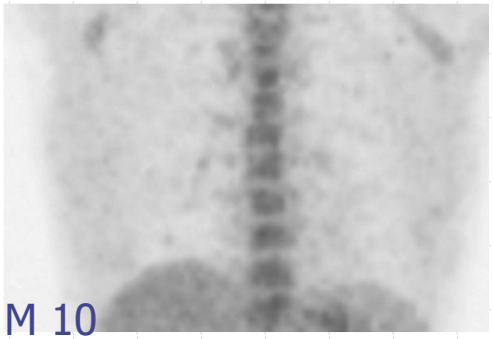






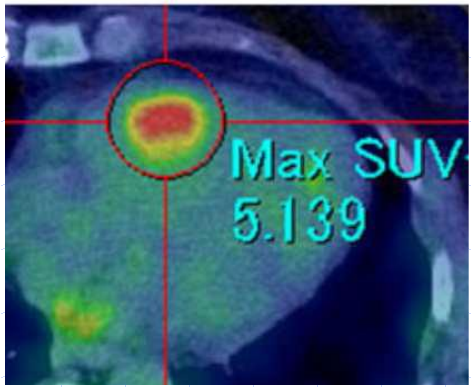






D Sobic-Saranovic Sem Nucl Med 2013 (revue) & JNM 2012

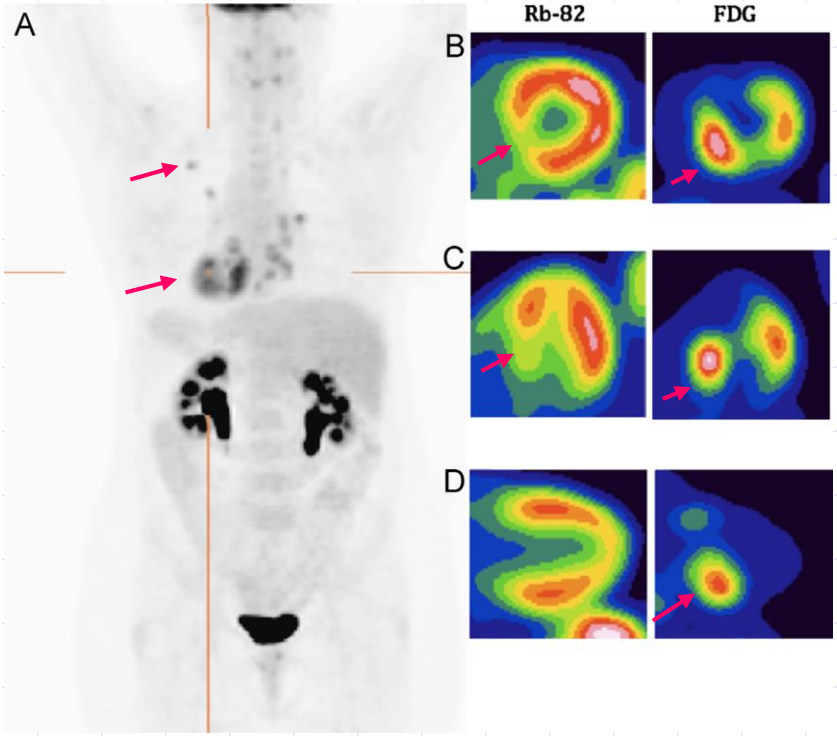
SARCOIDOSE CARDIAQUE



Clinique dans 5% des sarcoïdoses, 25% dans les autopsies
Décès 13-25% (IC, tr. rythme)

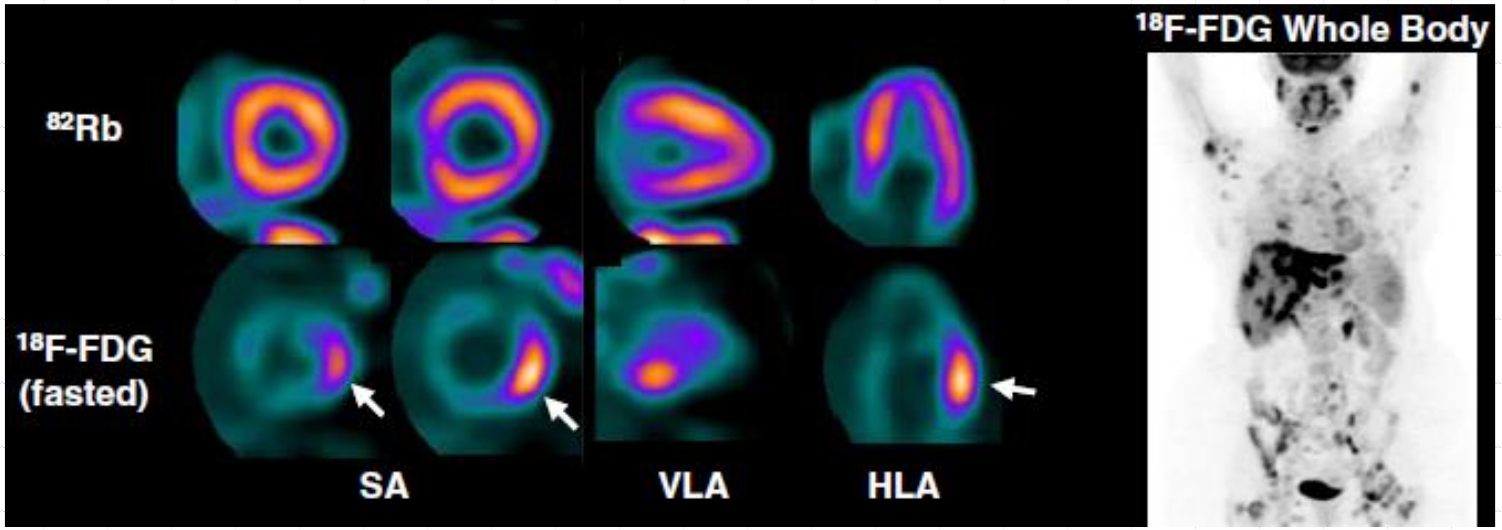
- Inflammation → TEP (Se =89% Sp = 78%), IRM
  TEP/IRM + : 72/100 % chronique 92/67 % aigu
- Vasoconstriction → TSM
- Fibrose → TSM, IRM

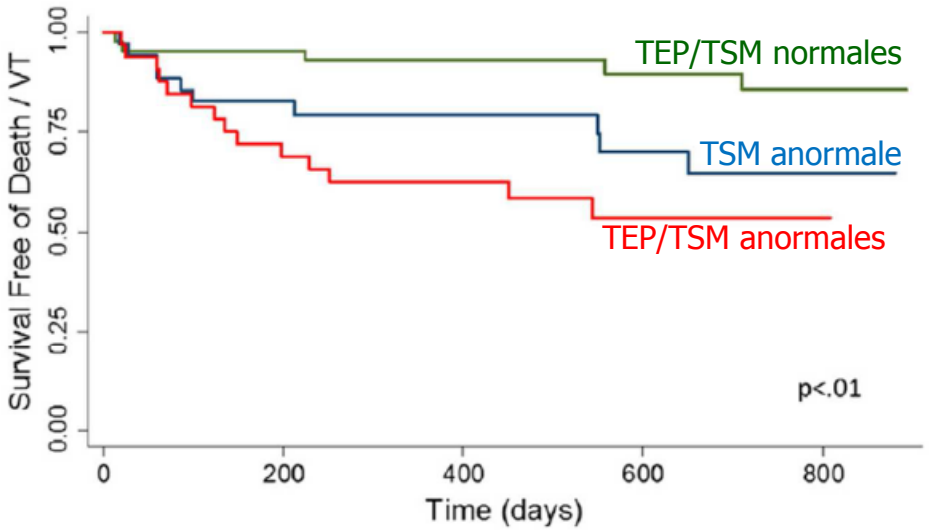
Régime sans hydrate de carbone
la veille puis jeûne



G Youssez J Nucl Med 2012 (méta-analyse) - Ohira Eur J Nucl Med 2011 et 2015 - M Soussan J Nucl Cardiol 2013 - Ahmadian J Nucl Cardiol 2014 - Blankstein JACC 2014 - Osborne J N Cardiol 2014 – Pei Ing J Nucl Cardiol 2016 -

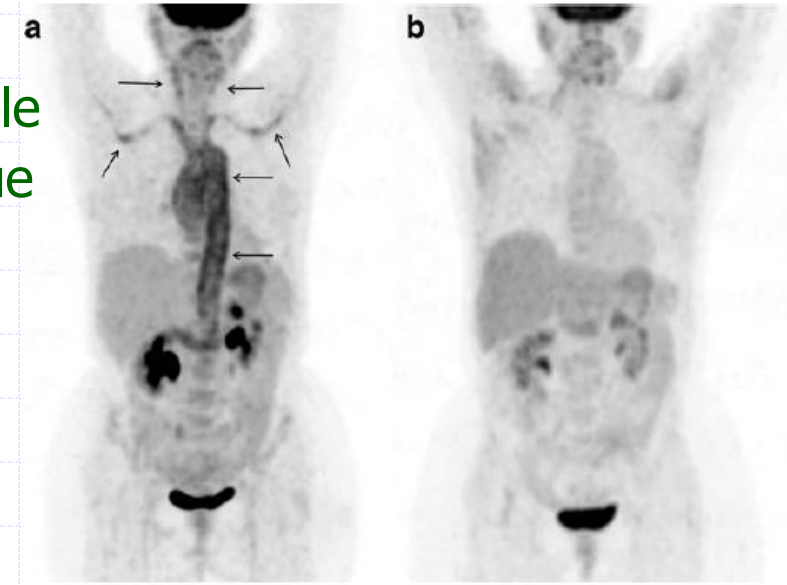
SARCOIDOSE CARDIAQUE



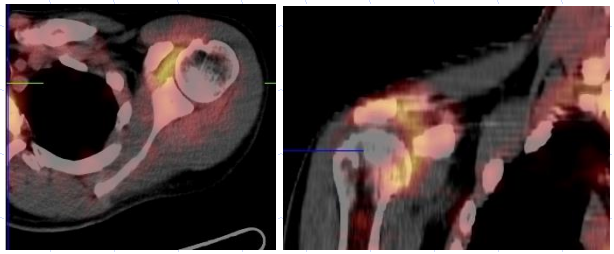


MALADIE DE HORTON

- Diagnostic sur les grosses artères
  - sous clavières, aorte, carotide, ilio-fémorales
  - spécifique (88 ± 10%),
  - sensible sauf cortisone/temporale
  - pronostic pour dilatation aortique
  - ↓ M1-M3 puis ↔ : remodelage
  - non prédictif des récidives



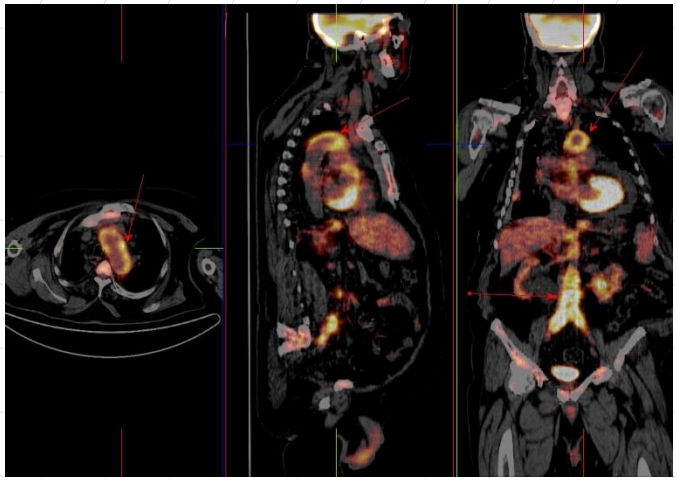
- perisynovite des ceintures (> 90%)
  - 31 % hyper Vx / ψPR « isolées »



D. Blockmans, *Ann. NY Acad. Sci.* 2011, *Rheumatology* 1999/2008, *Am J Med* 2000, Arthritis Rheum 2006* – M. Brodmann, *Rheumatology* 2004.

TAKAYASU & KAWASAKI

- Takayasu: TEP plus précocement positif que l'angio-IRM
  - Se = 77 ± 1% Spe = 76 ± 11%
  - VPP = 78% VPN = 60% (p = 63%)



- Kawasaki
  - pas d'étude en diagnostic
  - scintigraphie de perfusion myocardique
  - évaluation de la réserve coronaire
    - TEP au ^{18}FDG
    - SPECT au ^{201}Tl ou au ^{99m}Tc

KH Lee. *Arthritis Rheum.* 2012 - SG Lee. *Clin Nucl Med* 2009 – Arnaud et al. *Arthritis Rheum* 2009*.

MYOPATHIES INFLAMMATOIRES

Diagnostic clinique + myométrie, biologie (inflammation, Ac, CK), biopsie

Intérêt et place de la TEP FDG:

- Sensible, corps-entier ($\neq$ IRM)
- SUV corrélé au grade histologique d'infiltration inflammatoire cellulaire

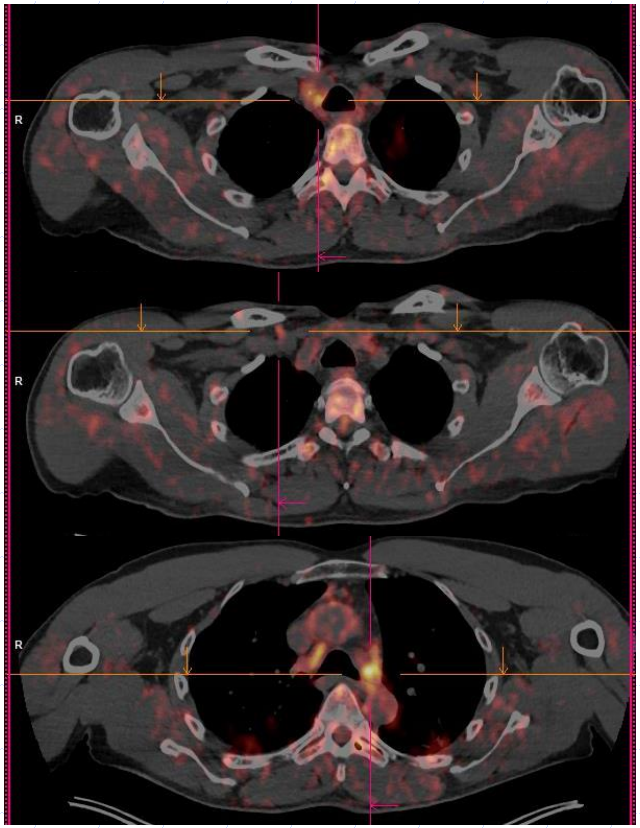
- Au diagnostic: identification d'un site de biopsie,
- Bilan d'extension: peau, poumon, œsophage, cœur, autre connectivite,
- Efficacité thérapeutique

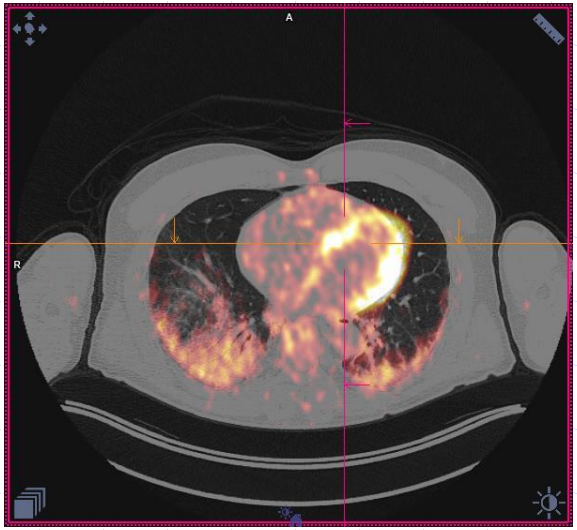
- Recherche et surveillance de néoplasie (lymphome, poumon, colon, sein, ovaire) associée (dermato M surtout, polymyosite si pas d'anti p155)

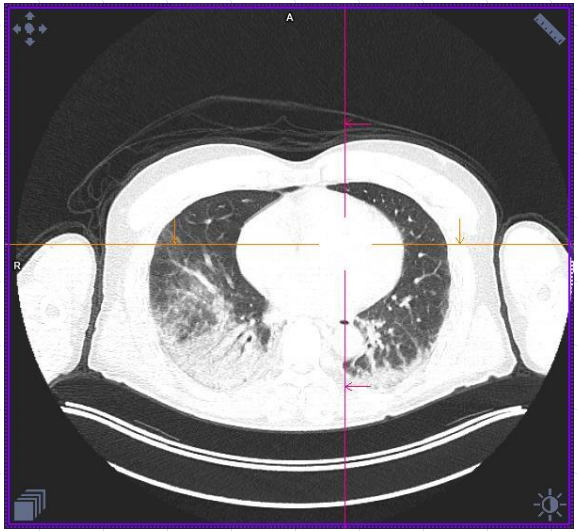
    - peut remplacer tous les autres tests (O'Callaghan 2010).
    - Se / Sp= 100 / 87 % dans une population de « MI idiopathiques » (Li 2017)

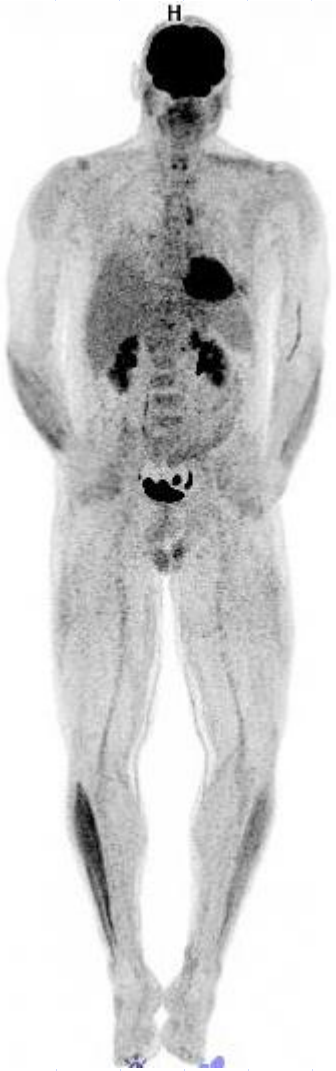
A Al Nahhas Ann NY Acad Sci 2011–S O'Callaghan Am J Med 2010–Y Li Clin Rheumatol 2017–M Tateyama BMJ Open 2014 – S Tanaka Rheumatology 2013

MYOPATHIES INFLAMMATOIRES









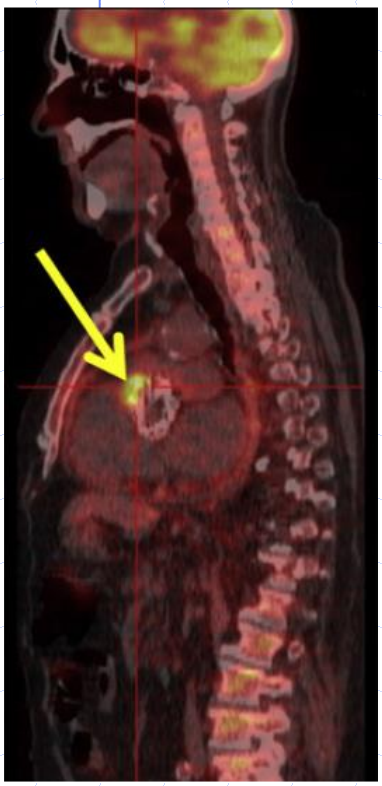
Syndrome des anti-synthétases:

- Sd intersticiel pulmonaire
- Polymyosite (tibial antérieur +)
- Adénopathies IV, sus claviculaire, 4R, 5

ENDOCARDITES ET INFECTIONS

Positron Emission Tomography/Computed Tomography for Diagnosis of Prosthetic Valve Endocarditis

Increased Valvular ^{18}F-Fluorodeoxyglucose Uptake as a Novel Major Criterion



	Final Diagnosis		
	Definite PVE	*Possible* PVE	*Rejected* PVE
Duke			
Definite PVE	21 (70)	0 (0)	0 (0)
Possible PVE	8 (27)	22 (100)	10 (50)
Rejected PVE	1 (3)	0 (0)	10 (50)
Duke-PET/CT			
Definite PVE	29 (97)	10 (45)	2 (10)
Possible PVE	1 (3)	12 (55)	10 (50)
Rejected PVE	0	0	8 (40)

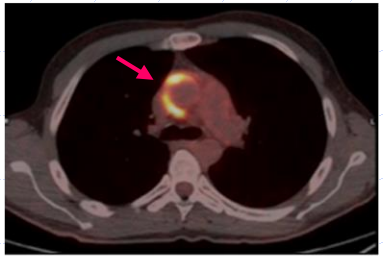
TW Scholtens JACC 2014; 63

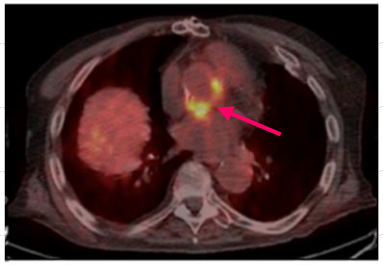
ENDOCARDITES

Sur prothèses valvulaires
(peu sensible sur les végétations des valves natives < écho)

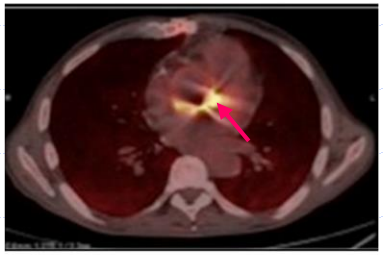
Foyer de SUV > 5
PN marqués en cas de doute

Prothèse biologique aortique infectée

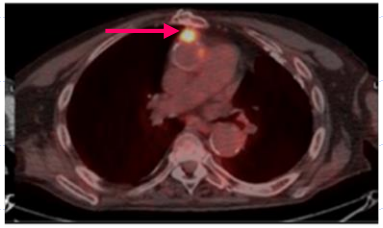




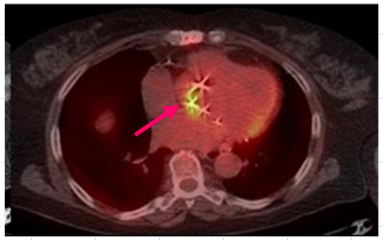
Prothèse aortique infectée sur la valve aortique



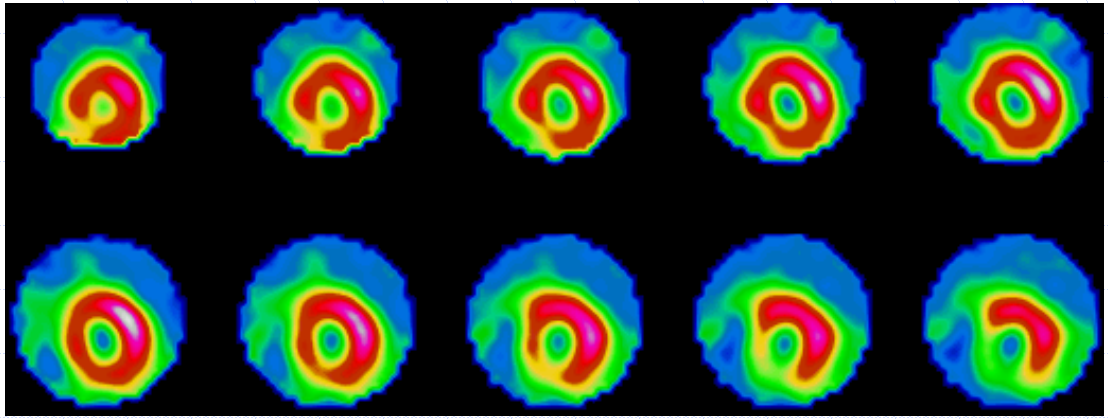
Abcès sur prothèse aortique

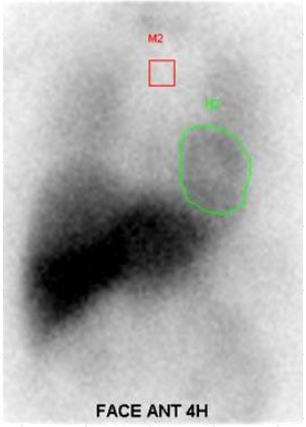


Valve mitrale infectée



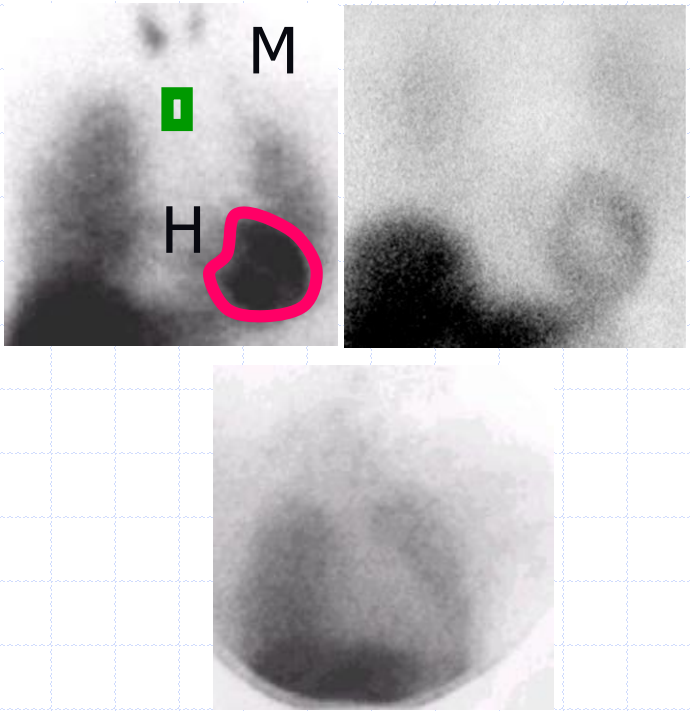
FONCTION SYMPATHIQUE

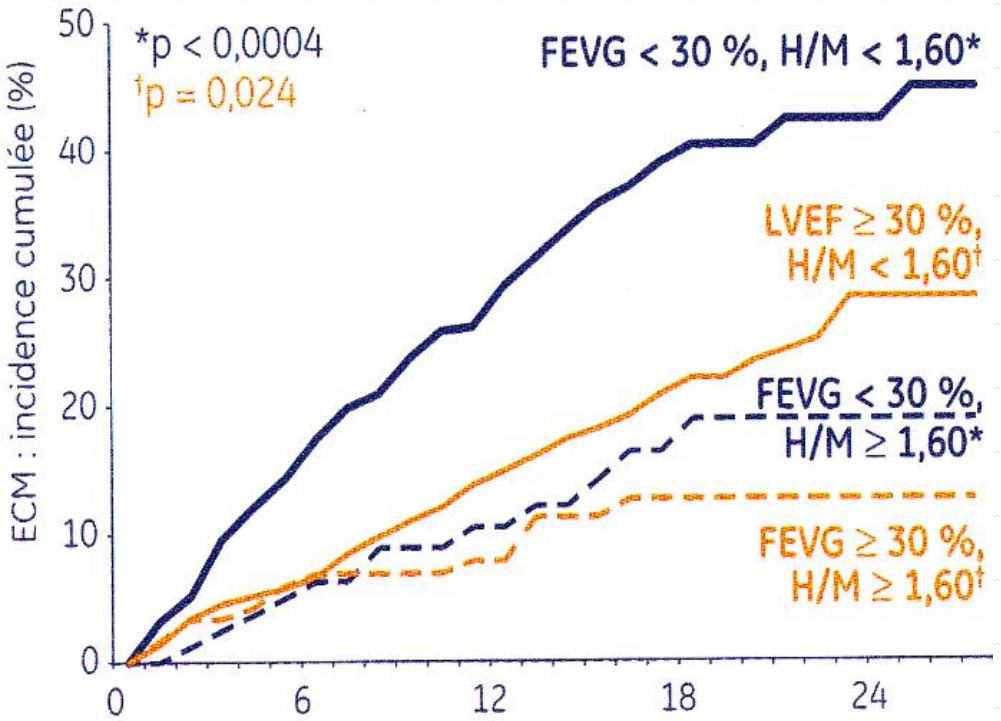




INDICATIONS

Pronostic des insuffisances cardiaques NYHA 4

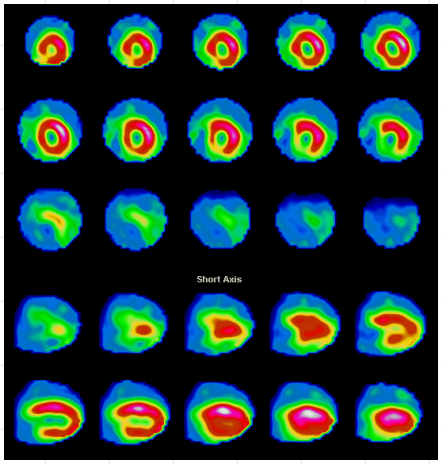


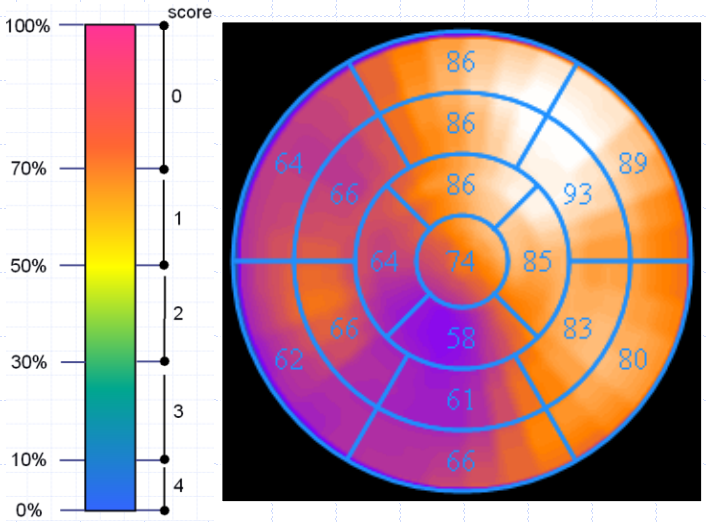


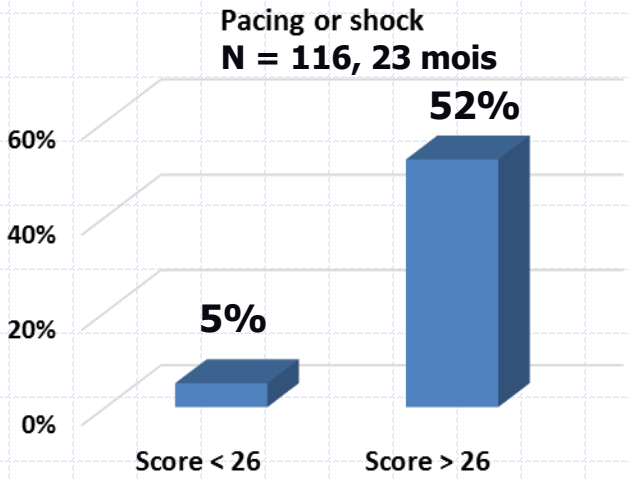
Idem avec progression IC, Evts rythmiques, Mort

Admire HF (N=961) AF Jacobson et al. JACC 2010; 55(20):2212-21

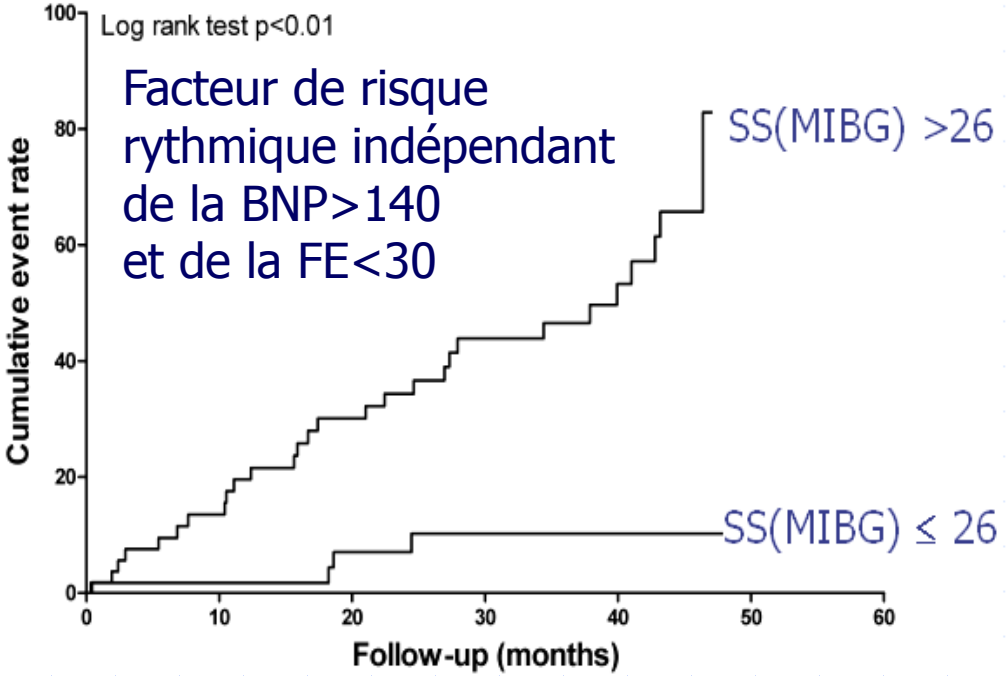
INDICATION DAI







Facteur de risque rythmique indépendant de la BNP>140 et de la FE<30

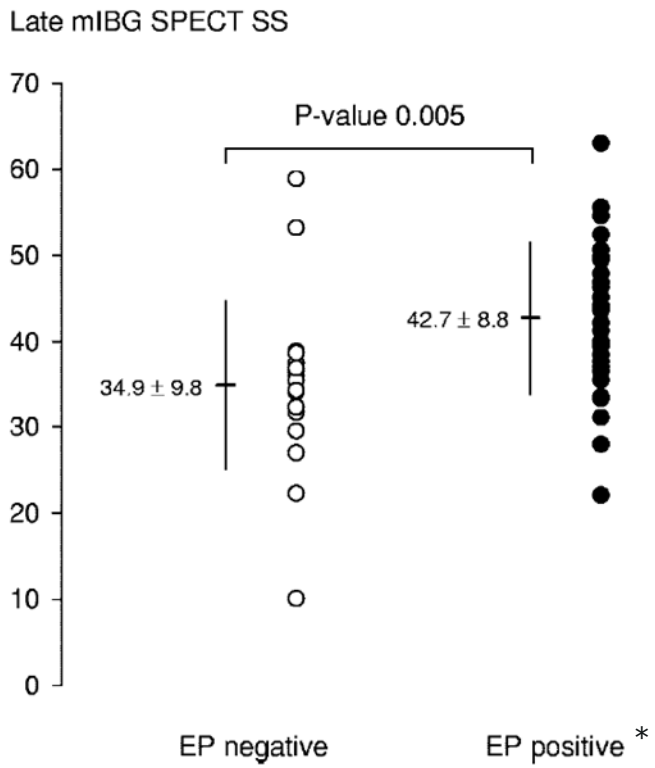


AF Jacobson et al. JACC 2010; 55(20):2212-2221 - MJ Boogers et al. JACC 2010; 55(24):2769-2777

TACHYCARDIE VENTRICULAIRE

SS seuil = 37%
Se = 77%
Sp = 75%

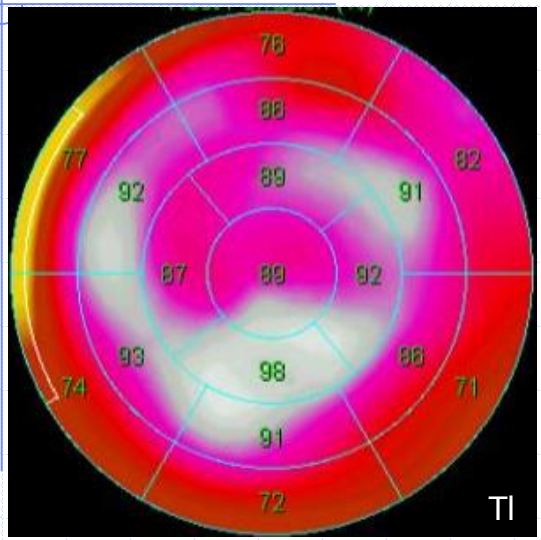
extent score 44
severity score 50

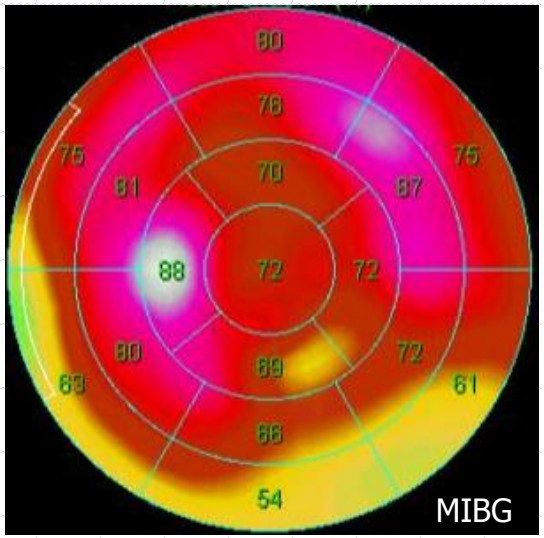


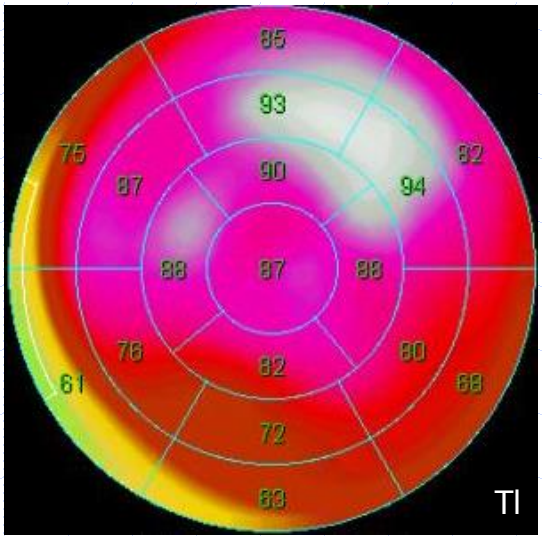
* tachyarythmie inductible en exploration électro-physiologique

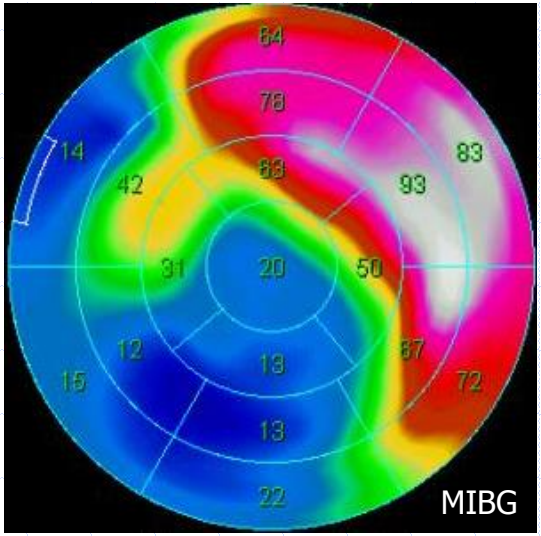
Bax et al. Circ Cardiovasc Imaging 2008

GACHETTES POST SCA ST+ PEC à 3h

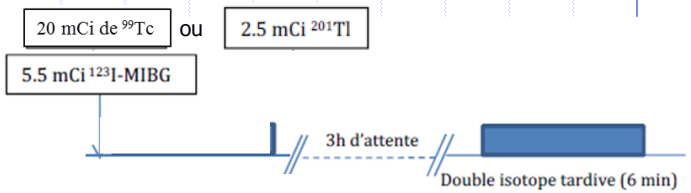








CZT Tl/c/MIBG



CD3 suboccluse
↳stent H3
80% / IVA2 + Mg1
↳ stents J3

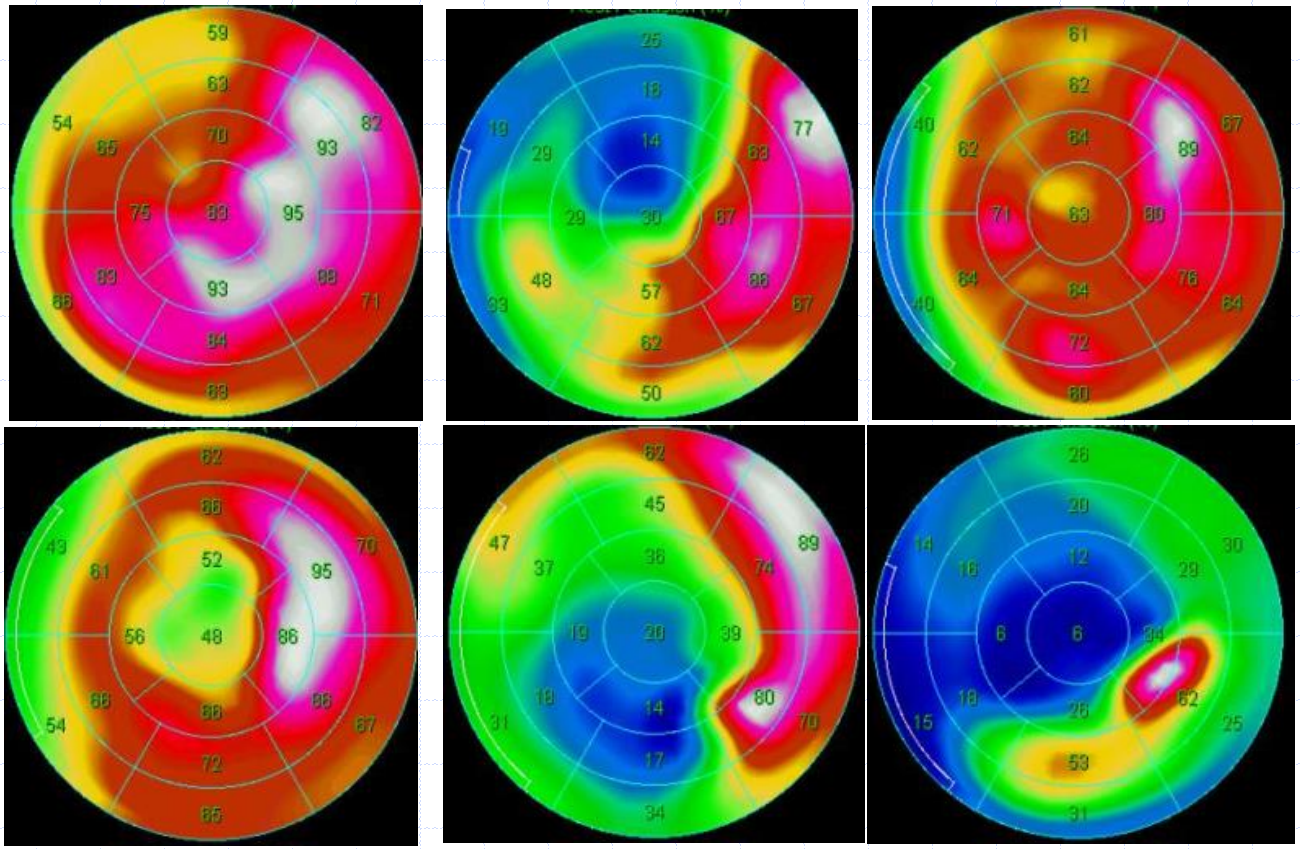
IVA2 serrée
↳ Stent H3

Gâchettes ± systématiques, corrélées au pic de troponine, à la ↓ FEVG et ↑ NYHA à un an

E d'Estanques et al. J Nucl Cardiol 2017;24
C. Hédon, Nucl Med Comm 2018;26

GACHETTES POST SCA ST+ PEC à 3h

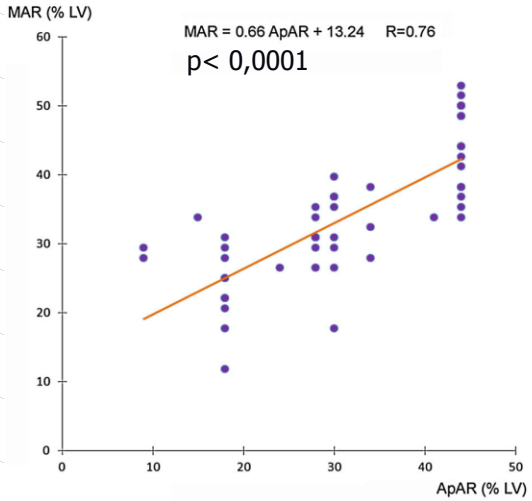
Suivi des zones gâchettes post SCA ST+:
Stabilité et lien avec les évènements cardiovasculaires

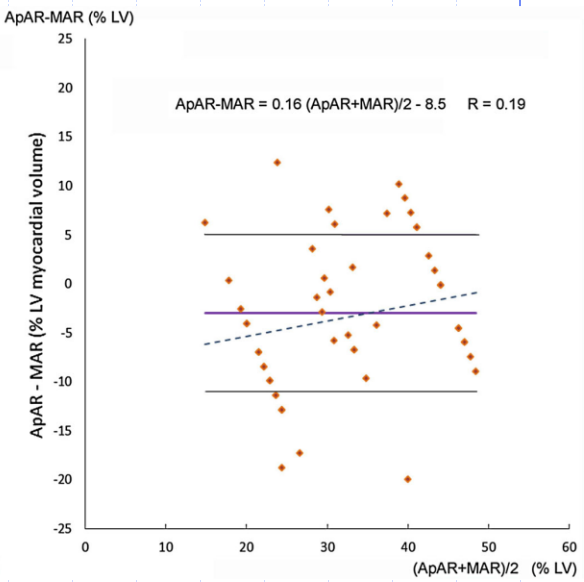


VIABILITE MIBG POST SCA MIBG A 1 AN

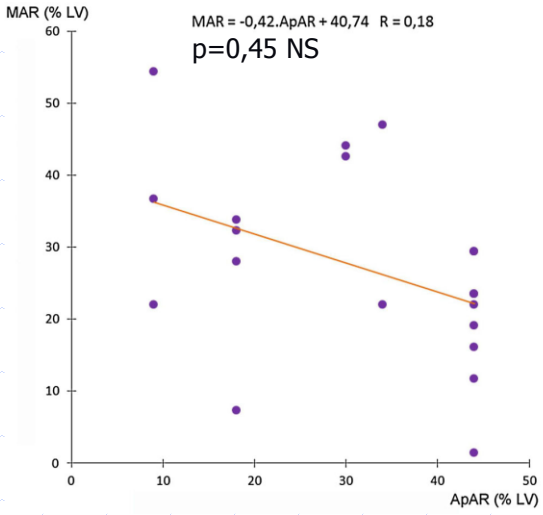
ZONE A RISQUE APRES SCA ST+

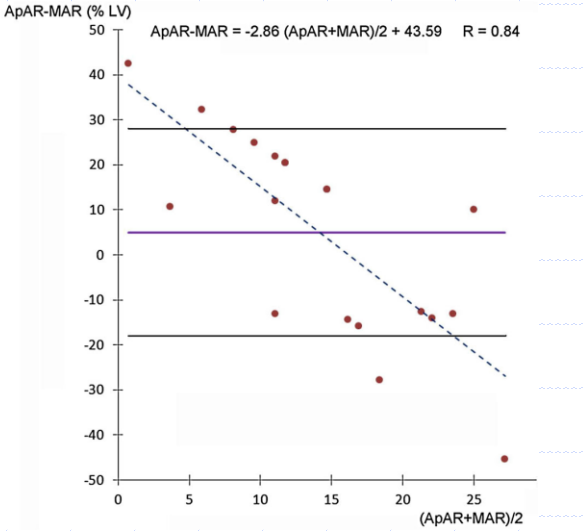
Occlusions complètes





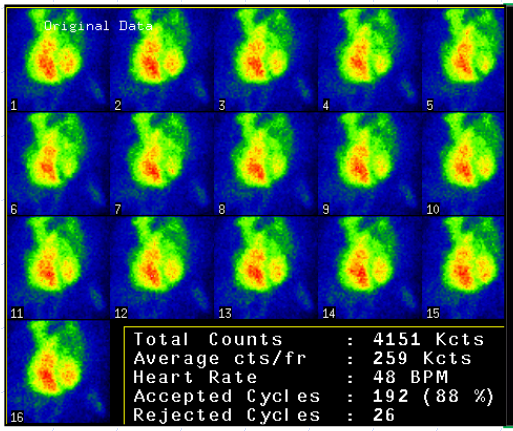
Occlusions partielles

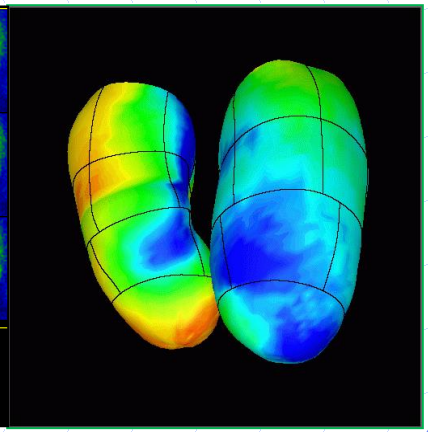


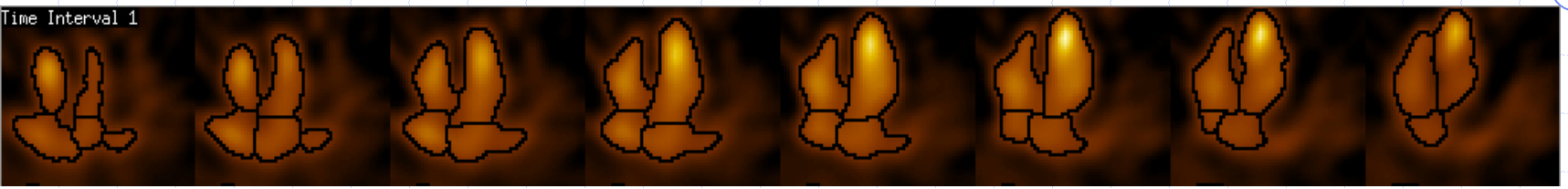


F Vauchot J Nucl Cardiol 2018;25
JT Ortiz-Perez Eur Heart J 2007;28

VENTRICULOGRAPHIE

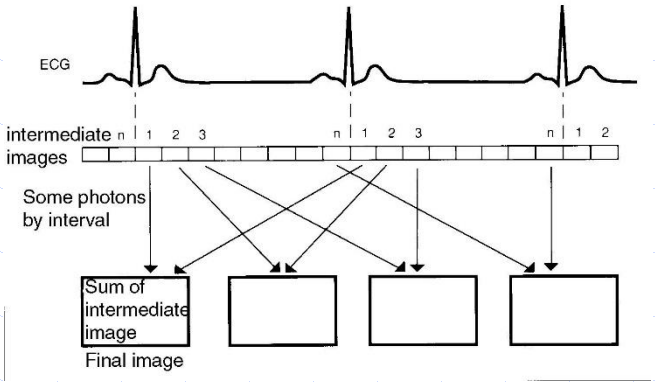


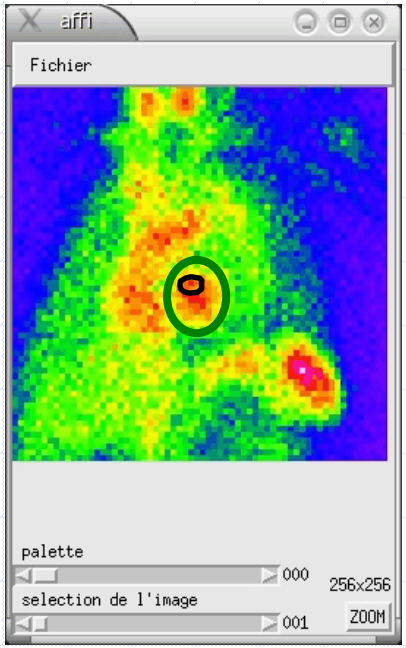


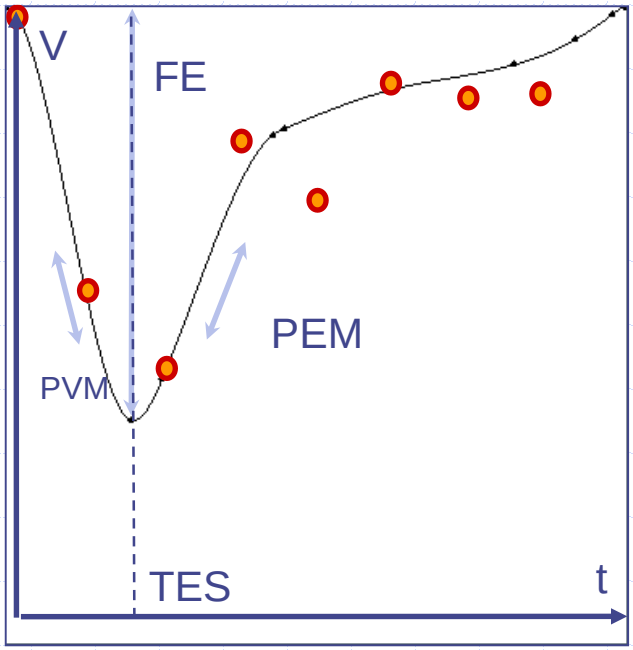


VENTRICULOGRAPHIE ISOTOPIQUE

- Marquage des GR au ^{99m}Tc : Contraste
- Synchronisation ECG

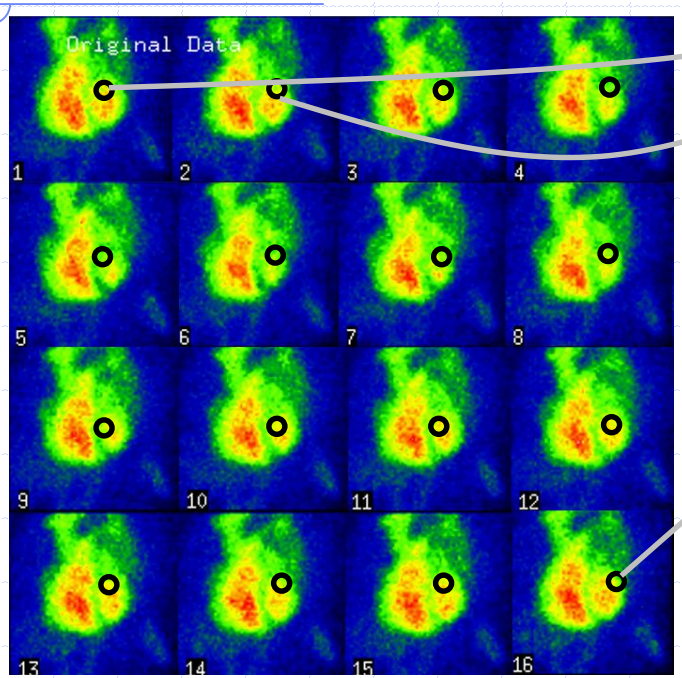


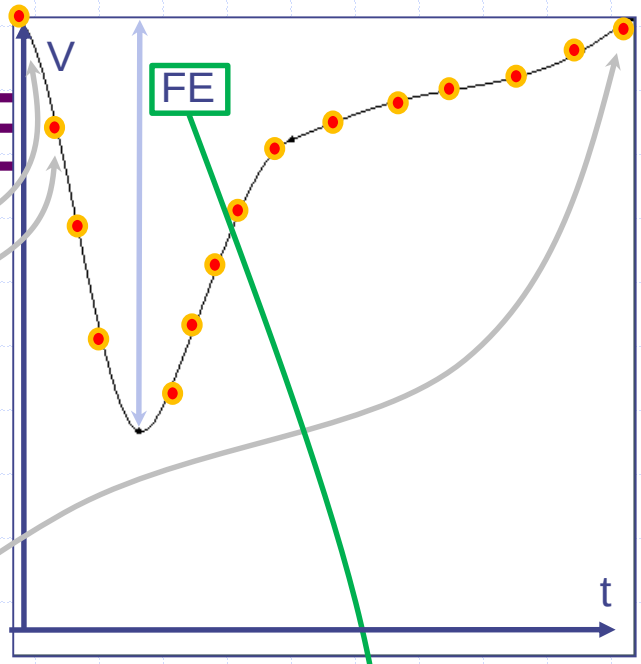


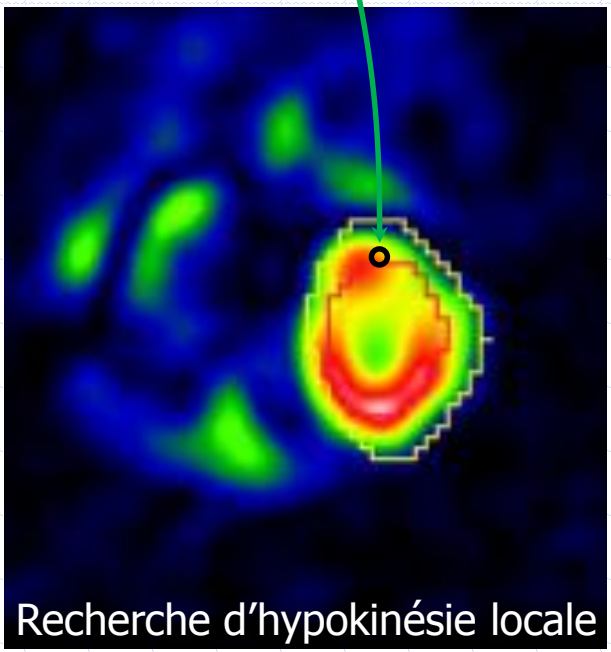


- Analyse de CTA
  - Activité $\propto$ Volume
  - Globale ou locale

IMAGE D'AMPLITUDE

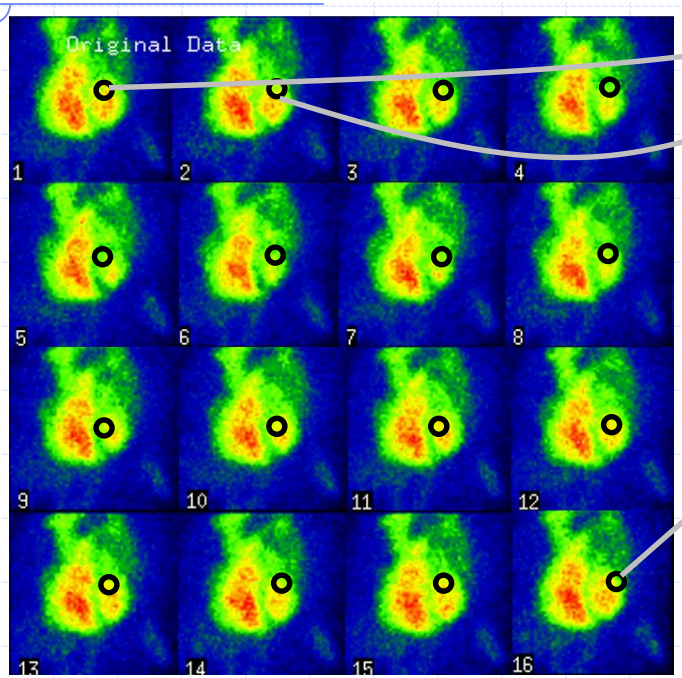


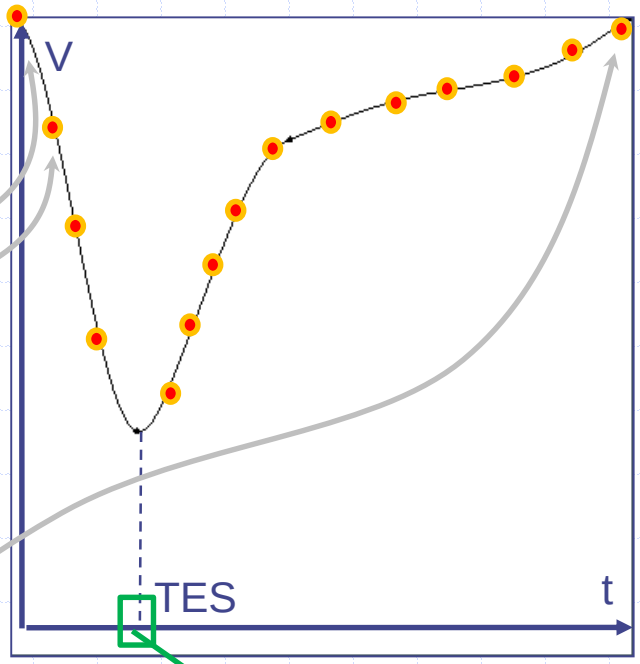


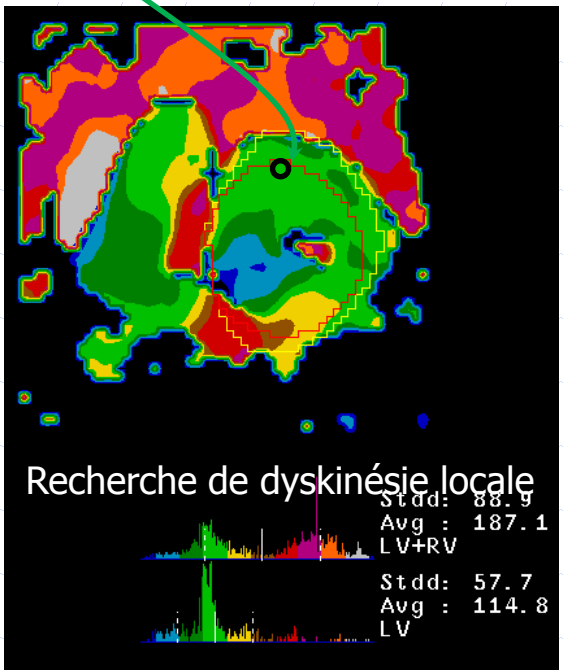


Recherche d'hypokinésie locale

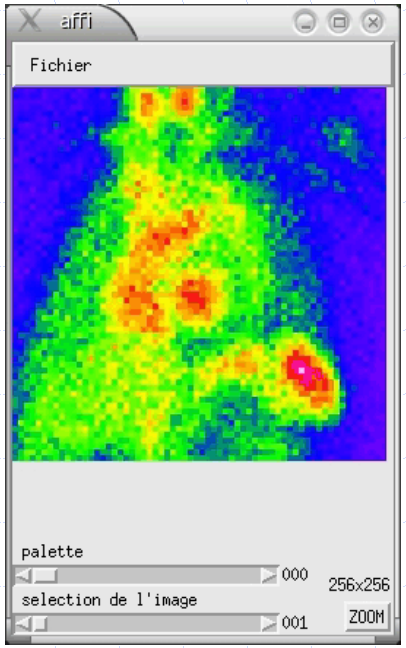
IMAGE DE PHASE







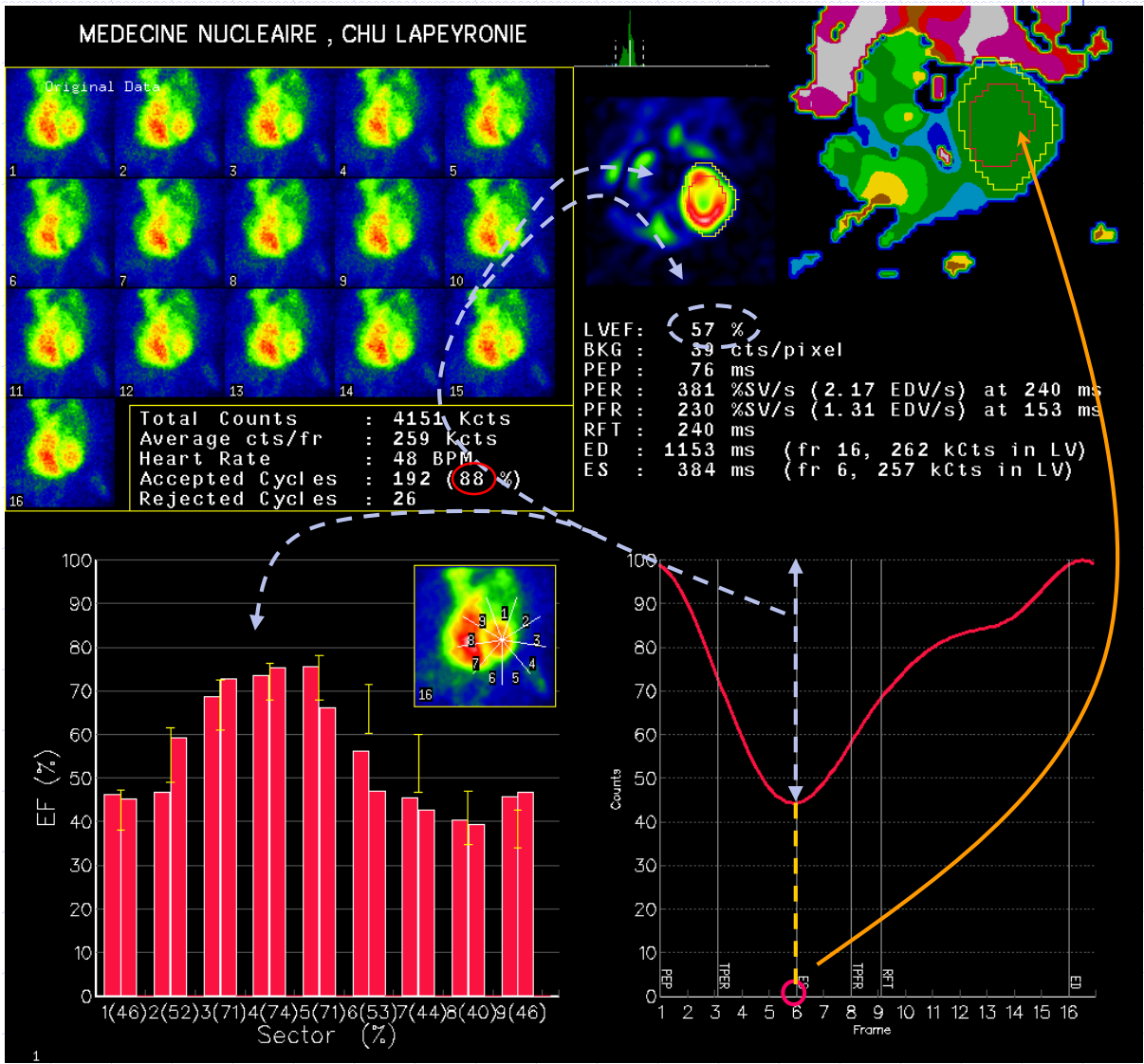
VENTRICULOGRAPHIE 2D



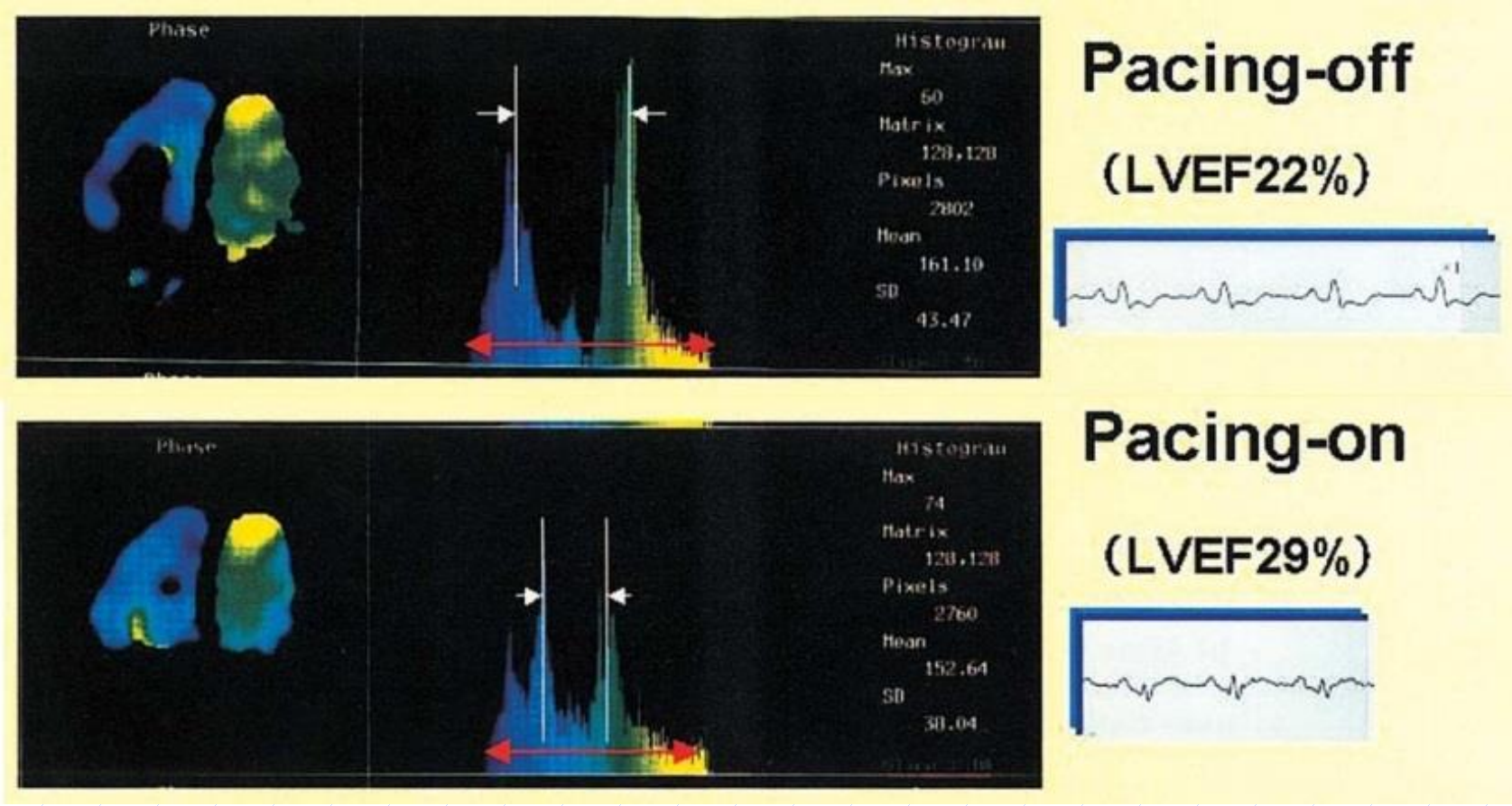
SD < 3%

⇓

Suivi FEVG



RESYNCHRONISATION



Muramatsu et al. Circ J 2005

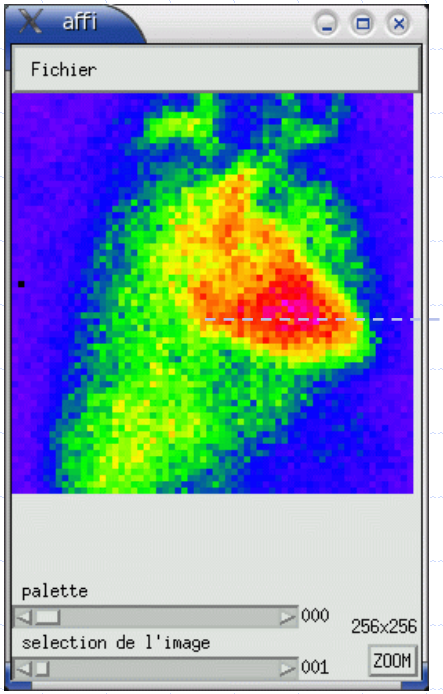
VENTRICULOGRAPHIE 2D: LIMITES

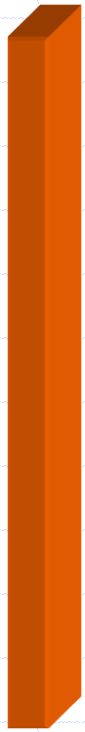
Superposition des plans :

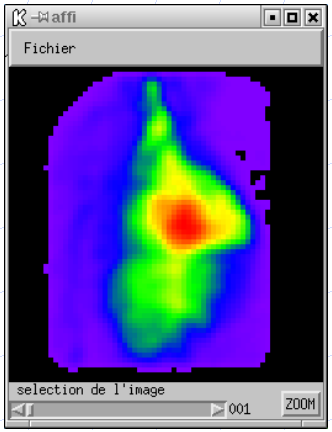
- FEVD planaire au 1° passage, Pb bolus
- FEVG planaire sous estimée
- Superposition ampli/Phase
- Ni volumes ni débits ?

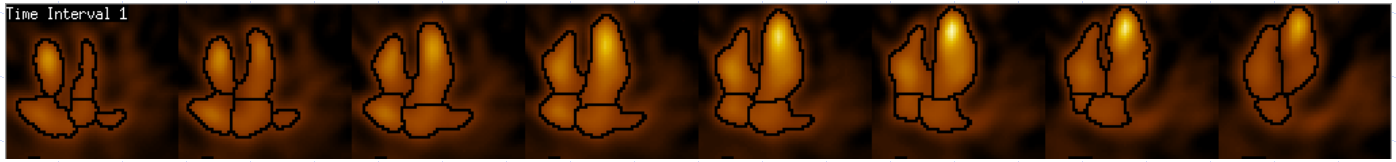
↳Mode tomographique:

QBS, BP-SPECT,
QBE, TOMPOOL…





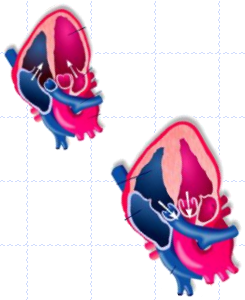


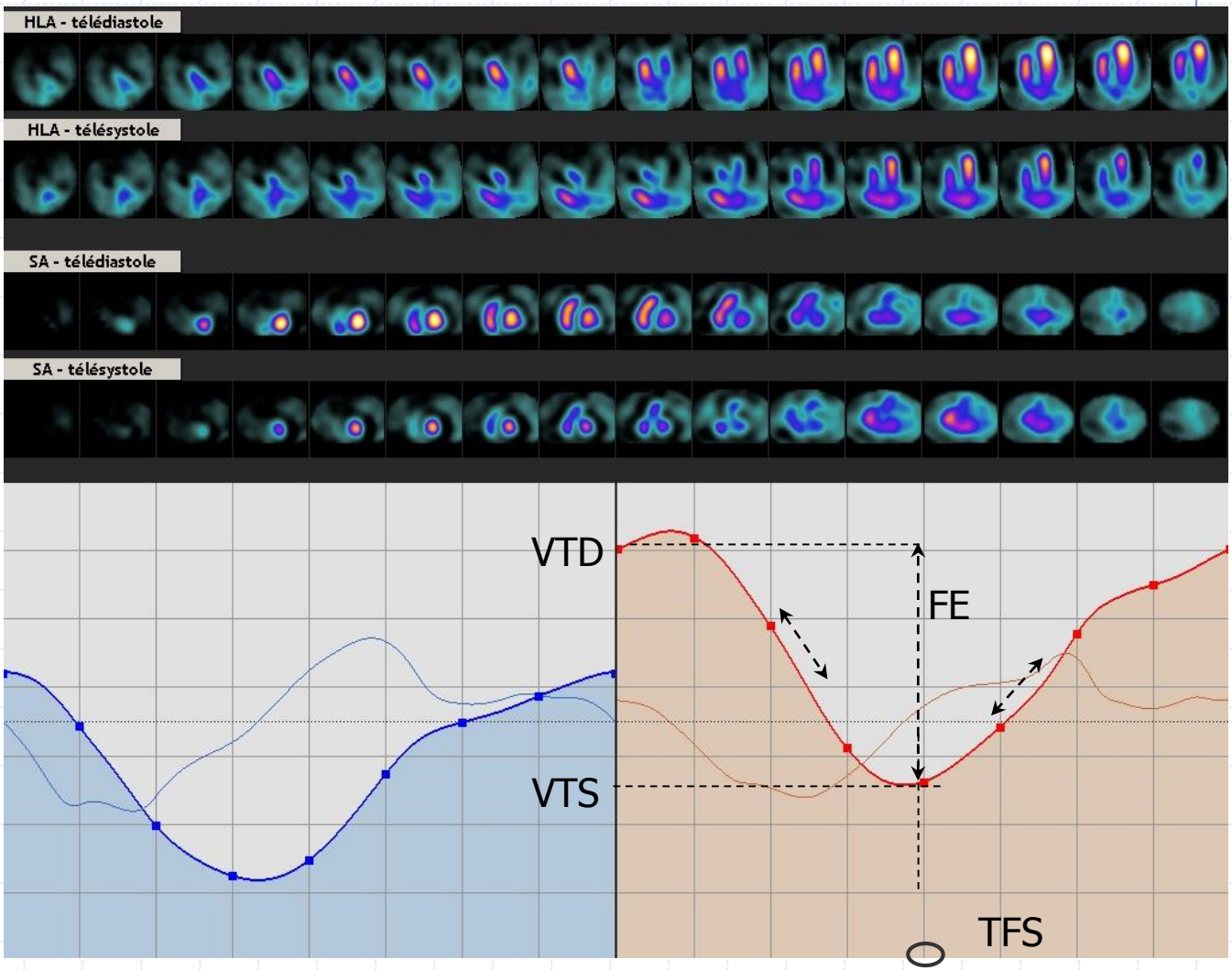


Bergmann, Nichols, Franken,

Mariano-Goulart et al.EJNM 1998;22 et EJNM 2001;28- Daou et al. JNM 2001;42

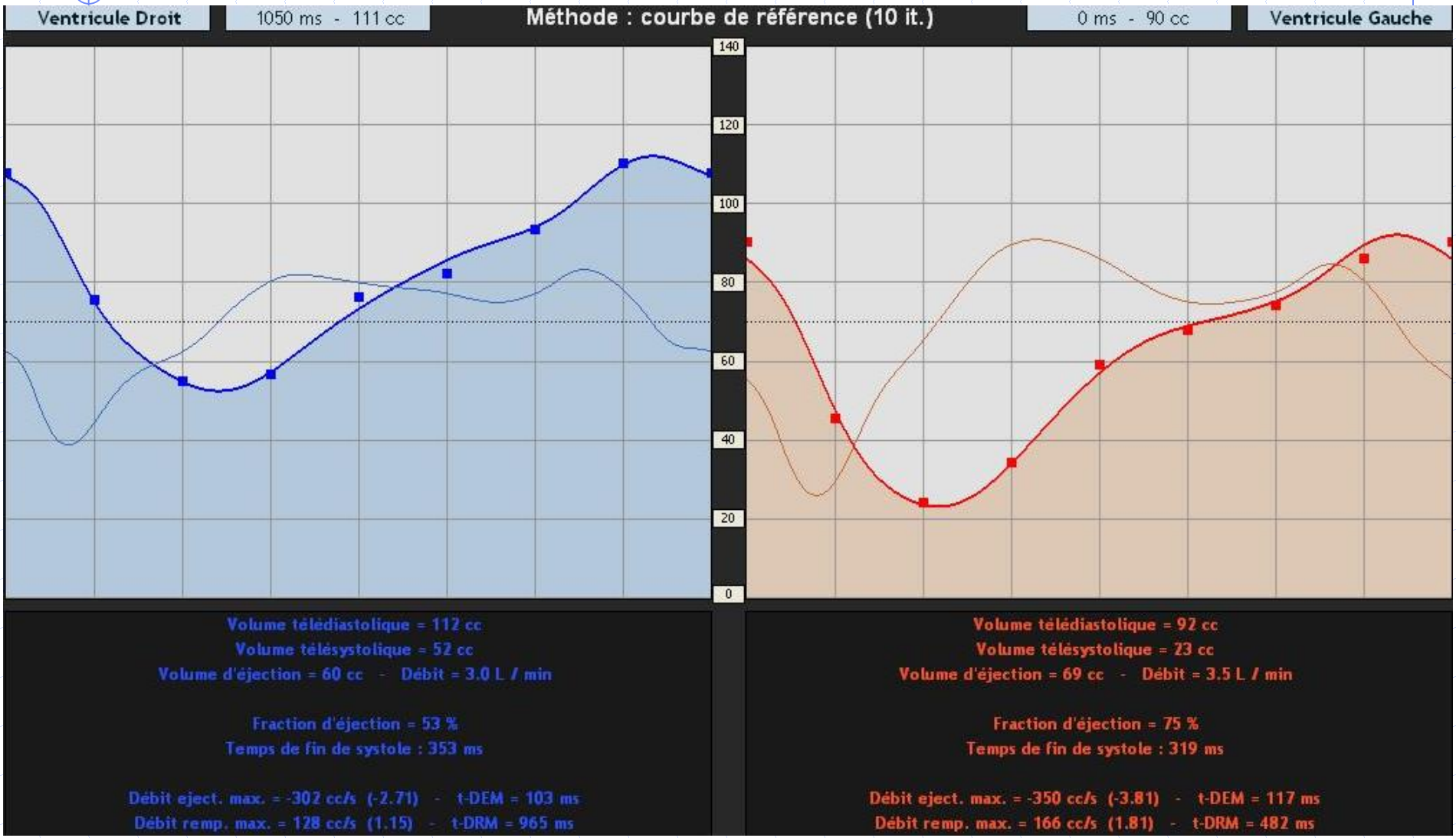
TOMO-VENTRICULOGRAPHIE (3D)





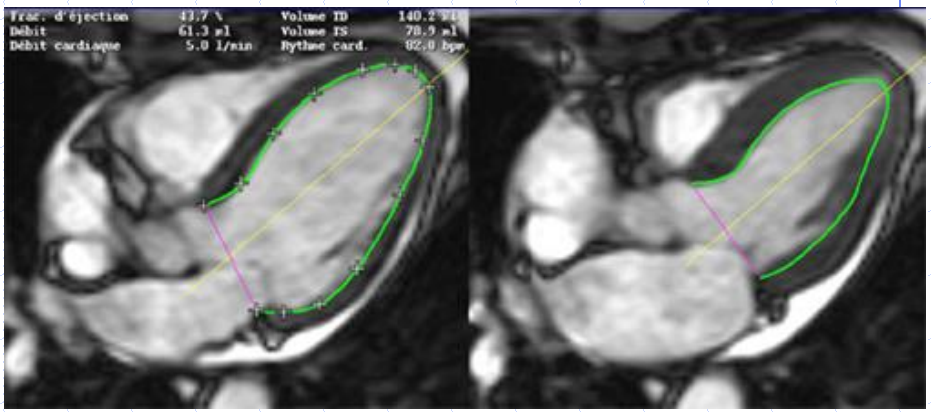
Mariano-Goulart et al.EJNM 1998;22 et EJNM 2001;28- Daou et al. JNM 2001;42

FONCTION VENTRICULAIRE D & G

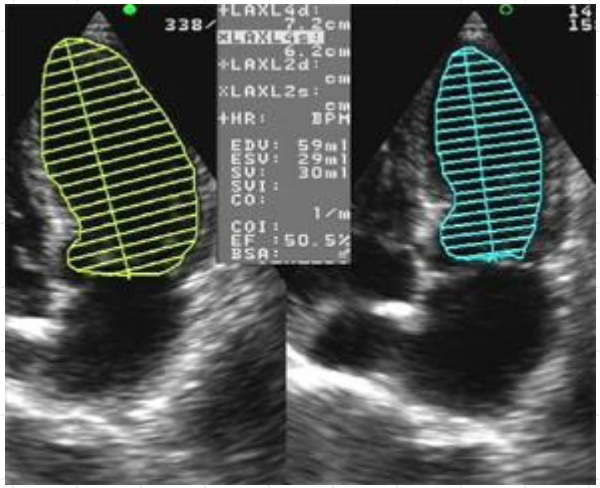


ETT & IRM ?

Référence mais
- contre-indications
- accessibilité
- durée
- traitement manuel

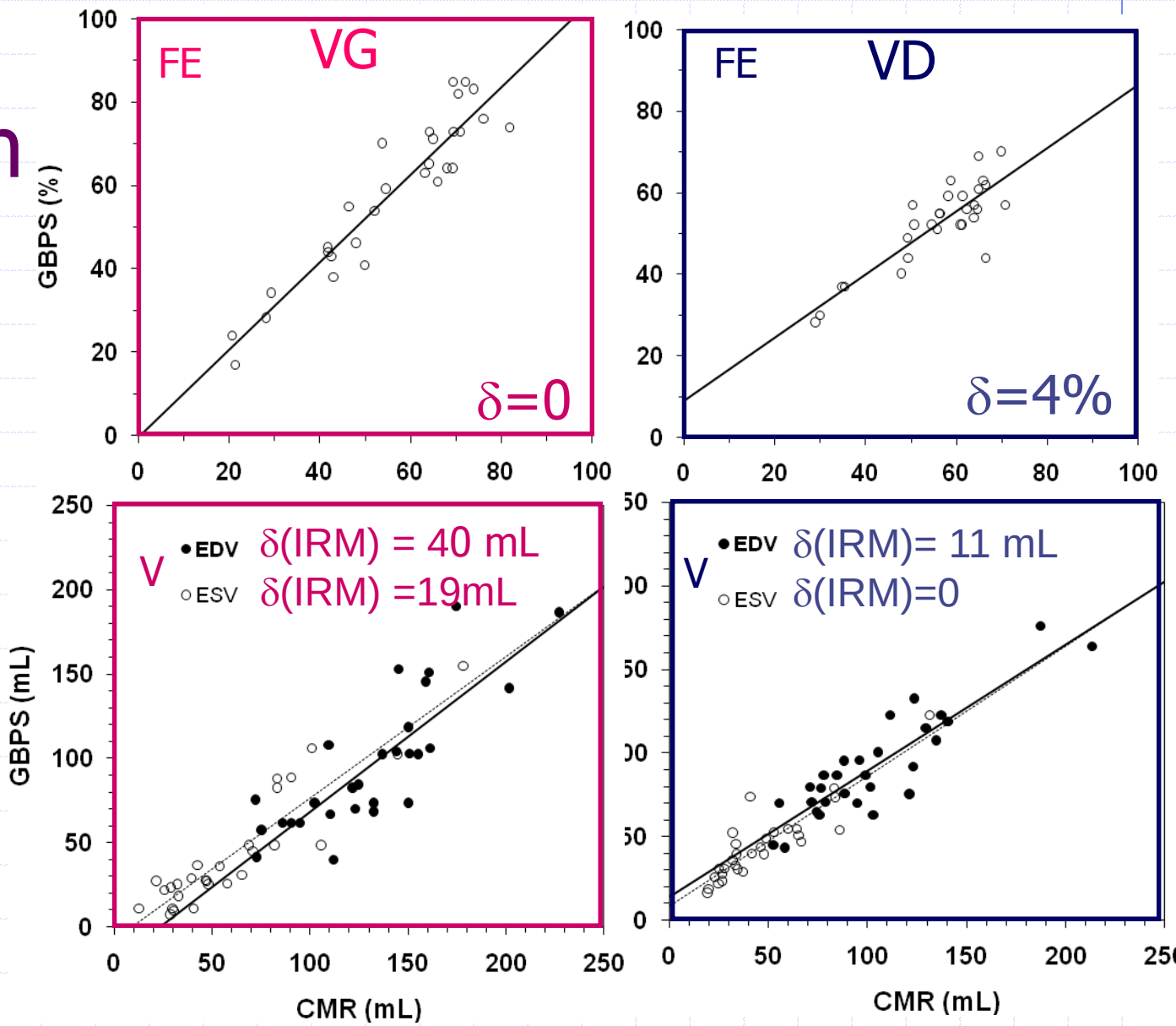


ETT
- reproductibilité
- Hypothèses géométriques
- VD



Validation

TVI versus IRM

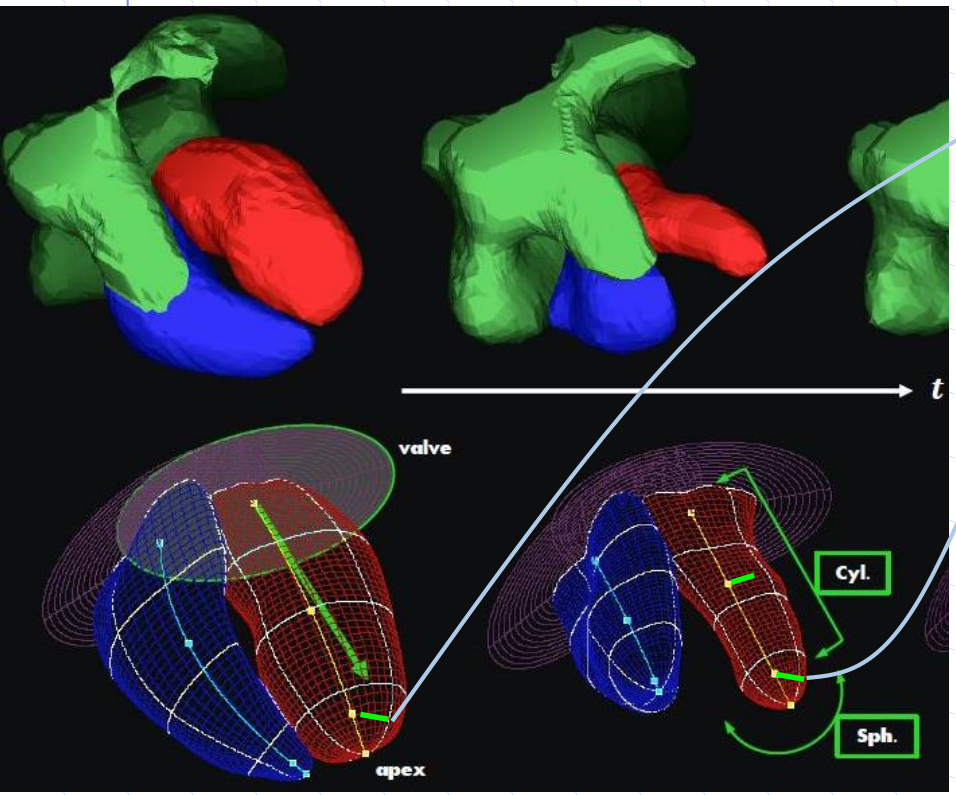


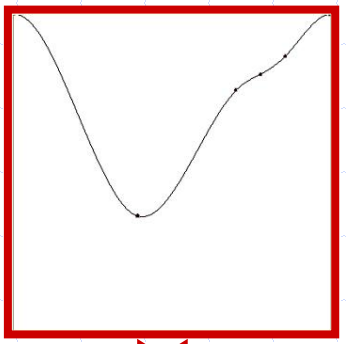
VES(G-D): 9±14 (GBPS) versus 18±13 (IRM)

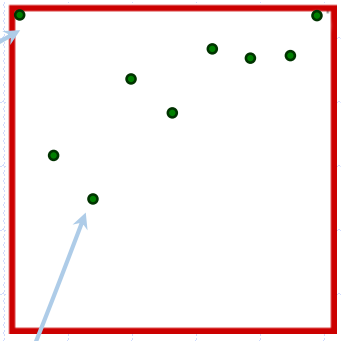
D. Mariano-Goulart et al. Eur J Nucl Med 1998 & 2001, Eur J Heart Fail. 2003, IEEE-TMI 2004, J Nucl Med 2001 & 2007, **Nucl. Med Commun 2010**, J Nucl Cardiol 2011

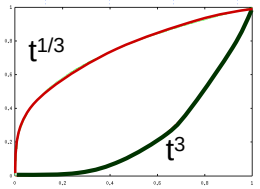
ANALYSE LOCALE

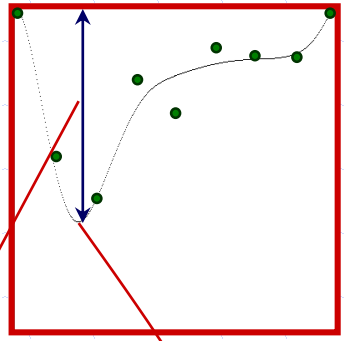
(Tompool®)

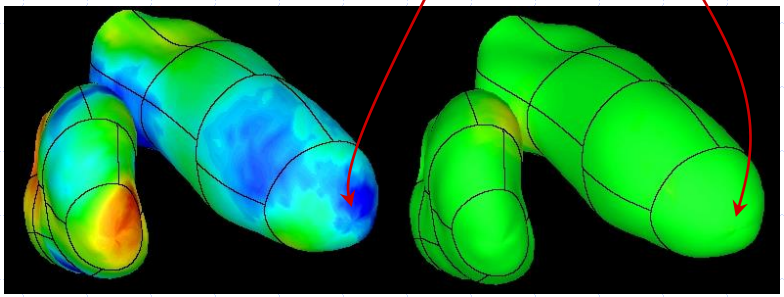






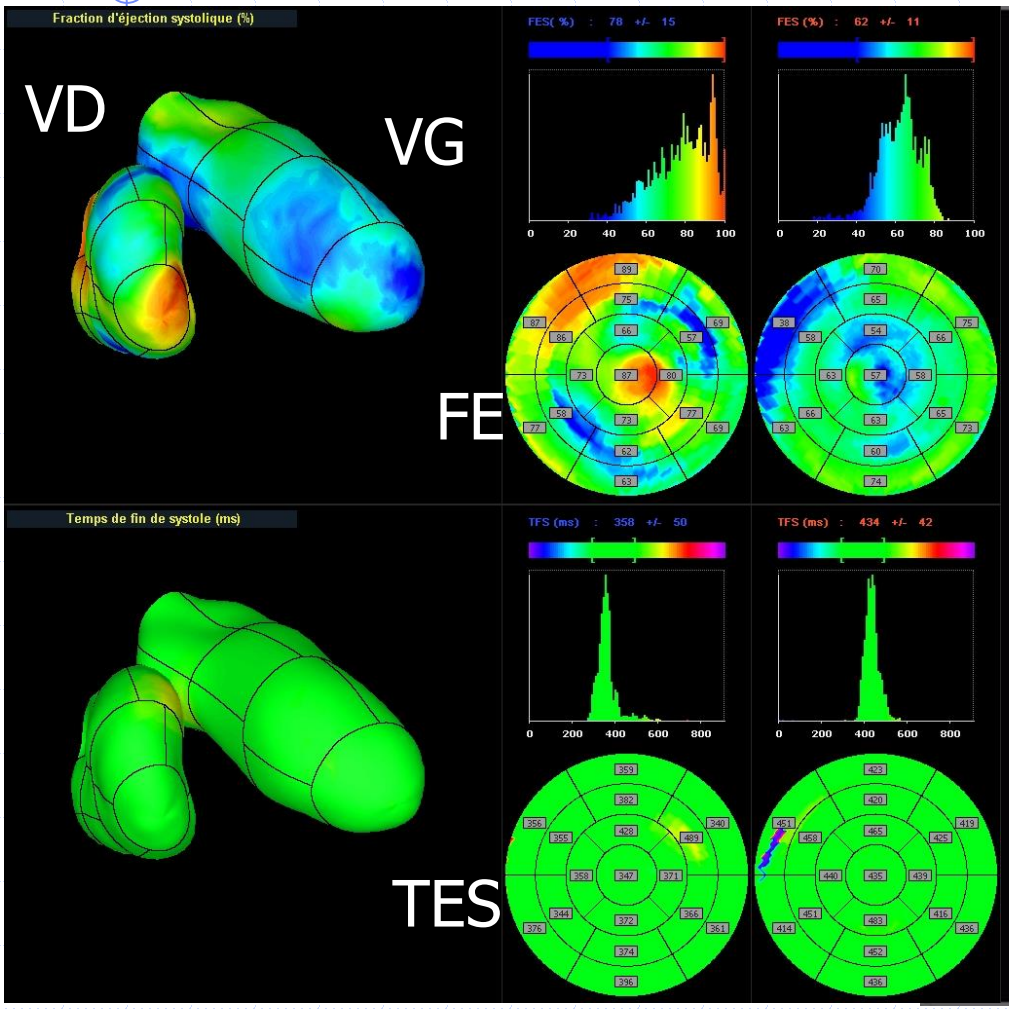


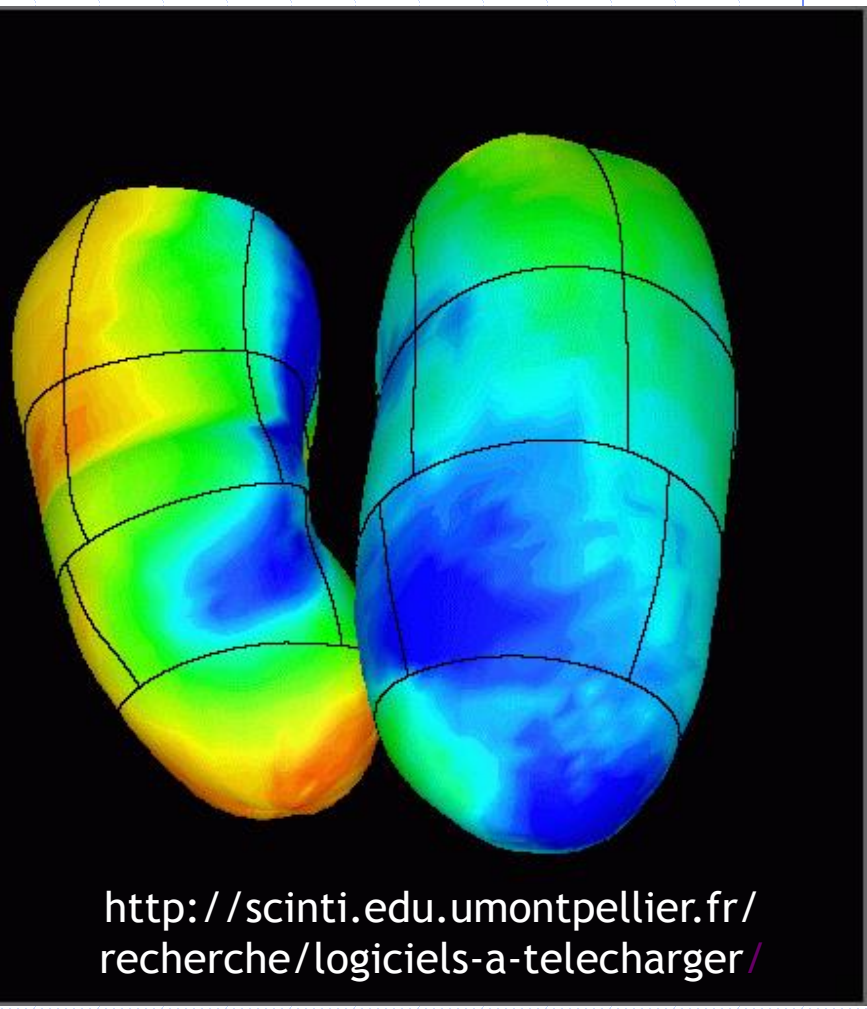




Vilain, J Nucl Cardiol 01- Caderas de Kerleau et Mariano-Goulart, IEEE TRANS MED IMAGING 2004

AMPLITUDE ET PHASE 3D

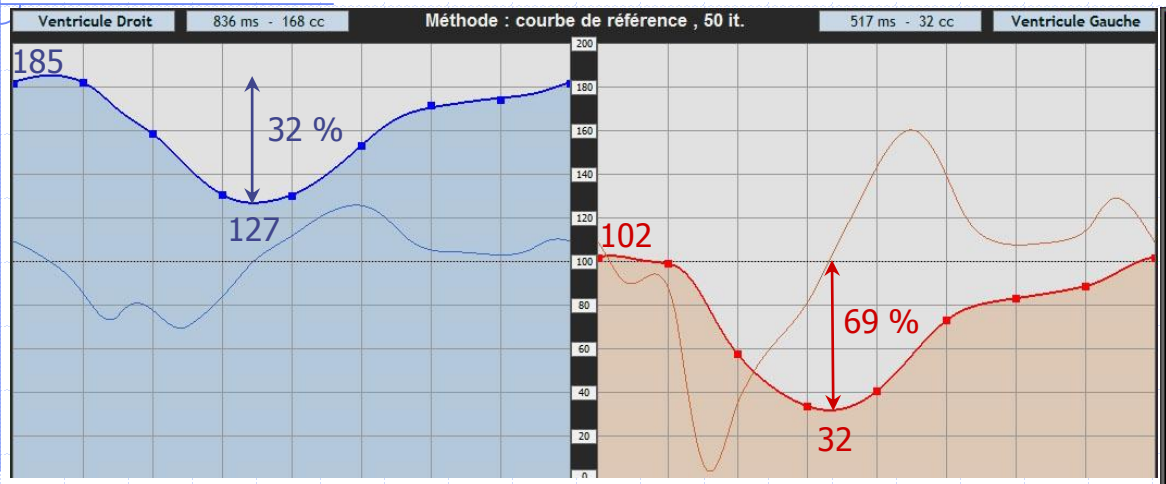


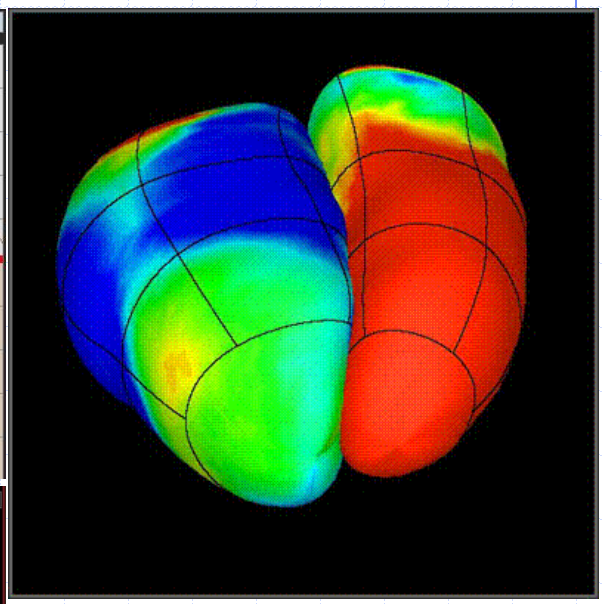


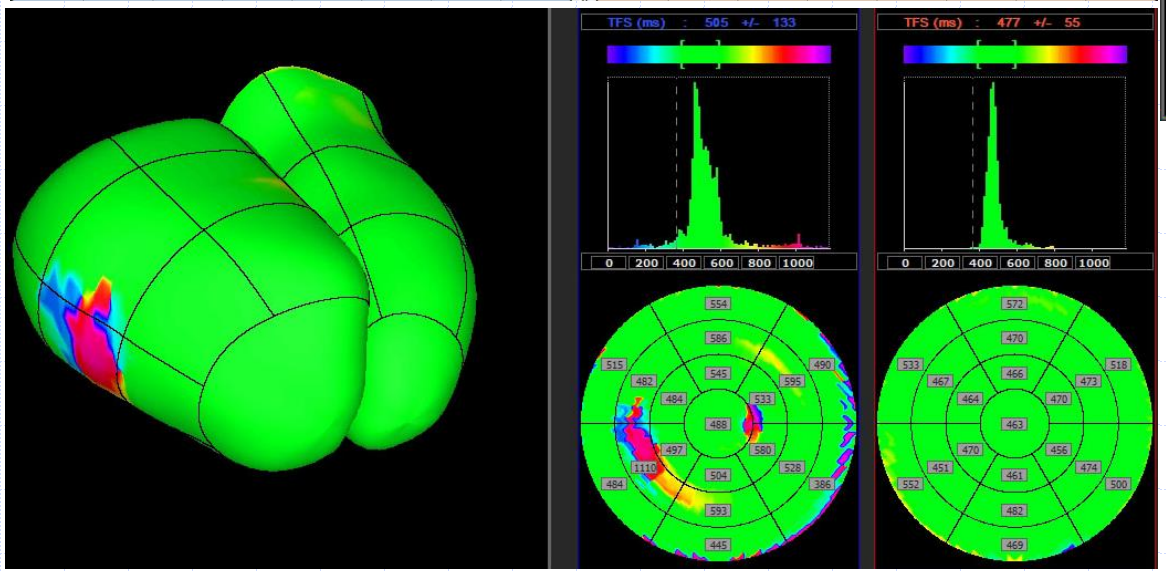
http://scinti.edu.umontpellier.fr/recherche/logiciels-a-telecharger/

Applications: IVG, IVD, HTAP, DVDA, DYSKINESIES, HYPOKINESIES…

CAS CLINIQUE: DVDA







DVDA locales:

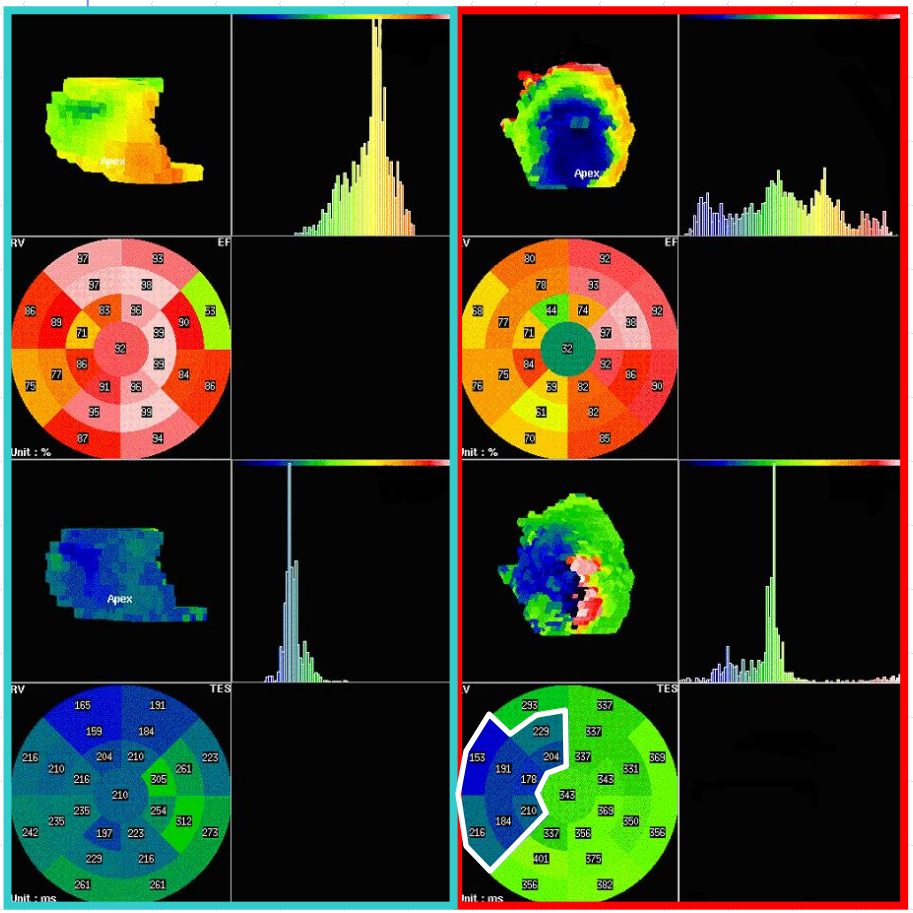
σ_{TES} > 80 ms

Se = VPN = 100%

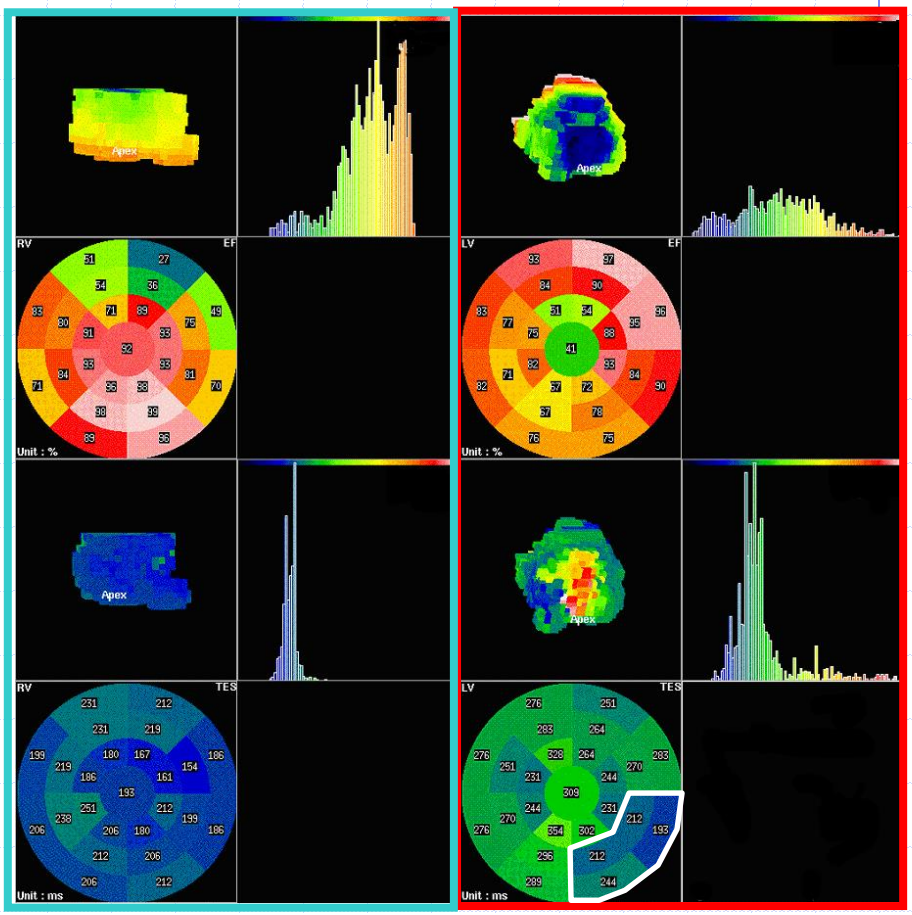
Sp = VPP = 80%

D. Mariano-Goulart et al. JNM 2007;48

CAS CLINIQUE: PMK multi sites

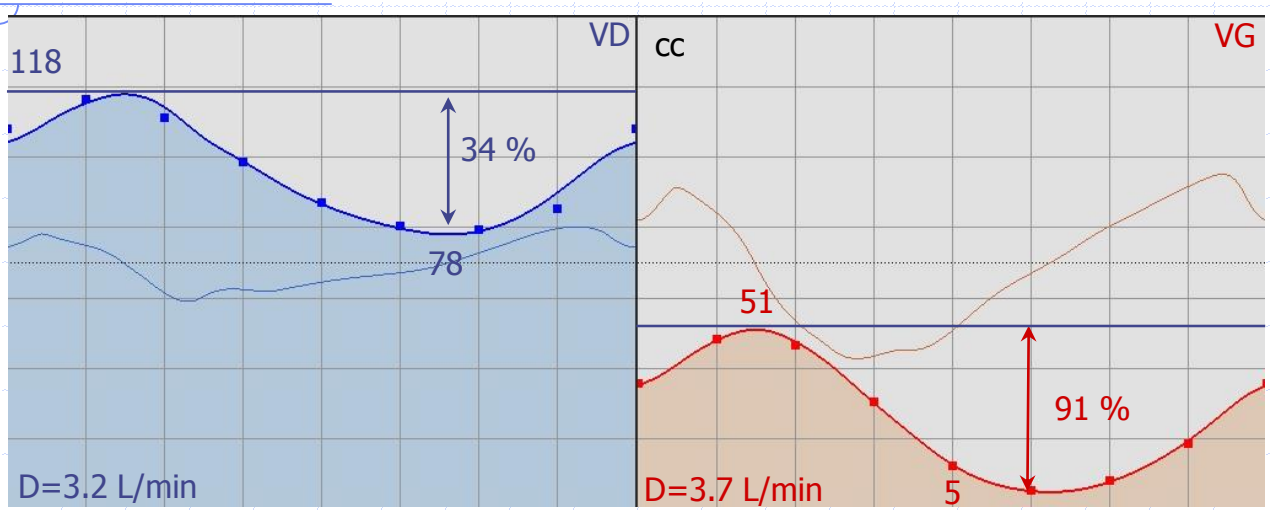


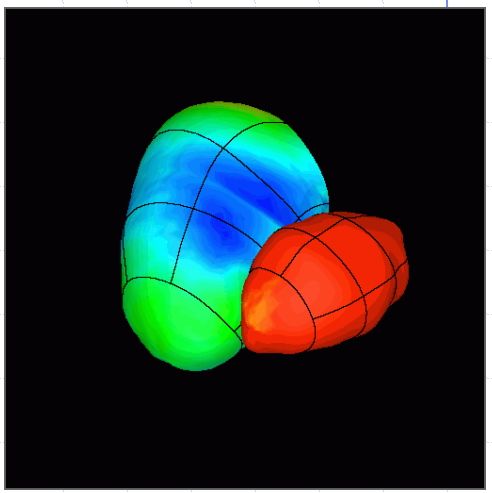
Non stimulé

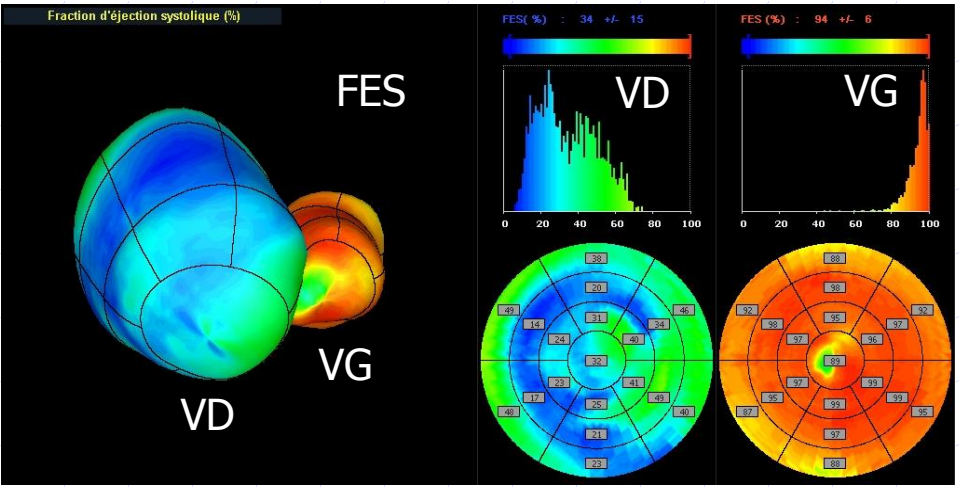


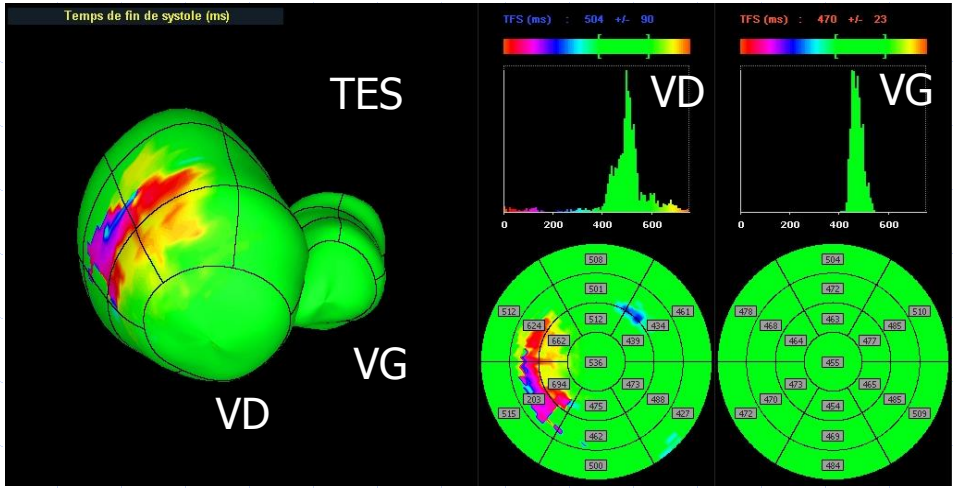
Stimulé

CAS CLINIQUE: HTAP

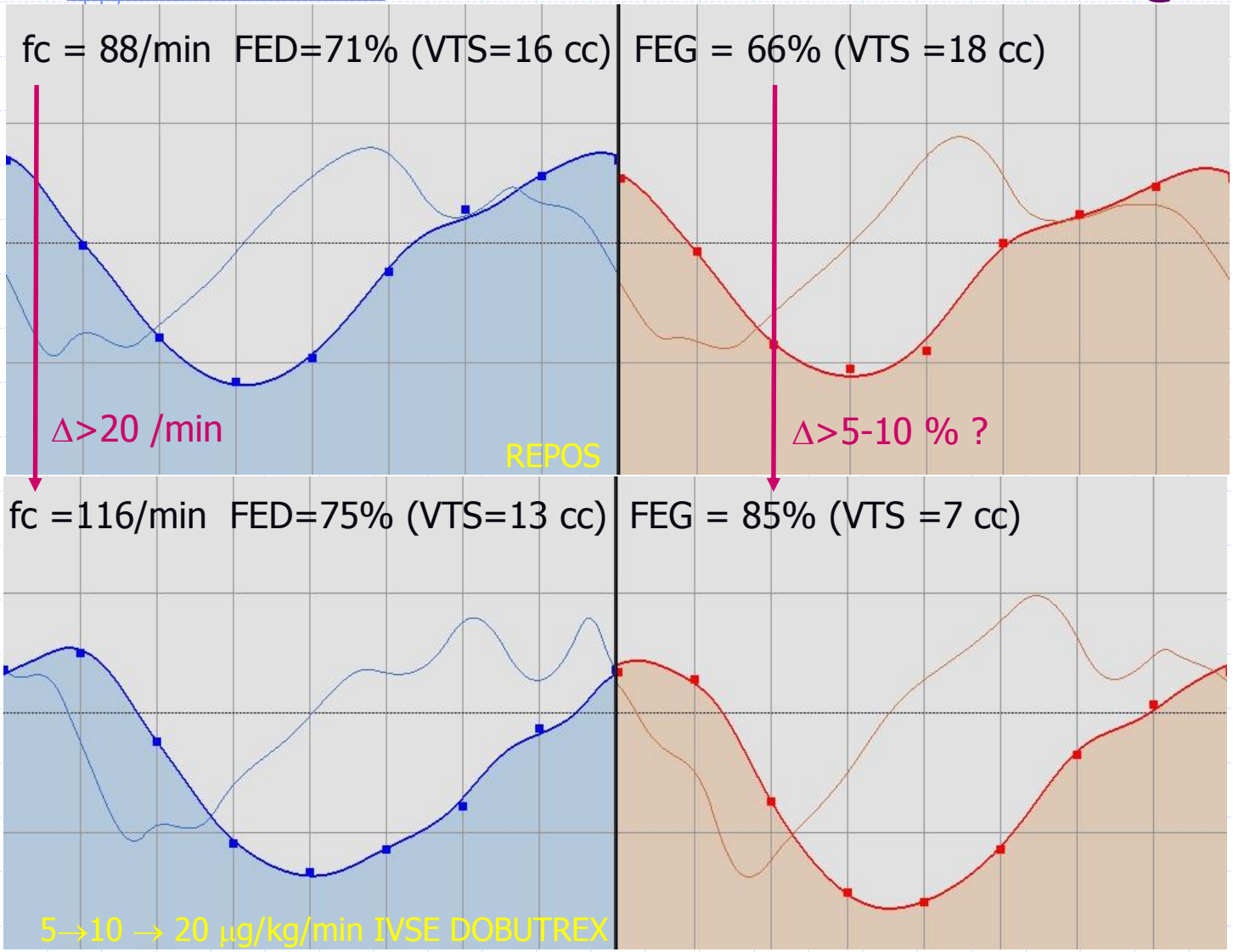


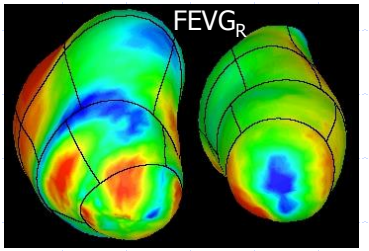


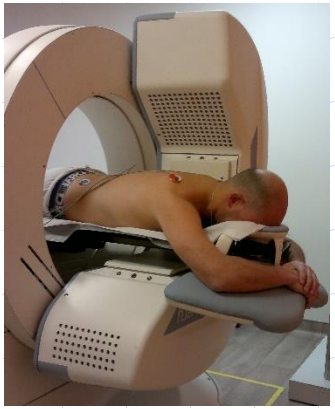


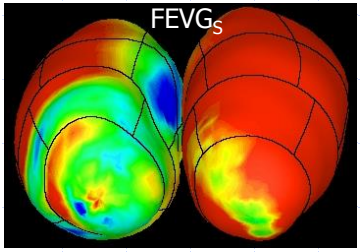


CC RESERVE SYSTOLIQUE VG





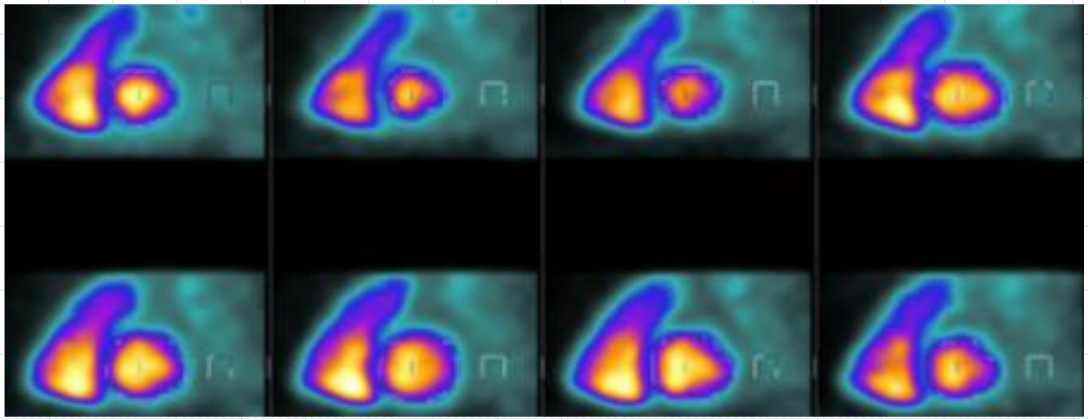


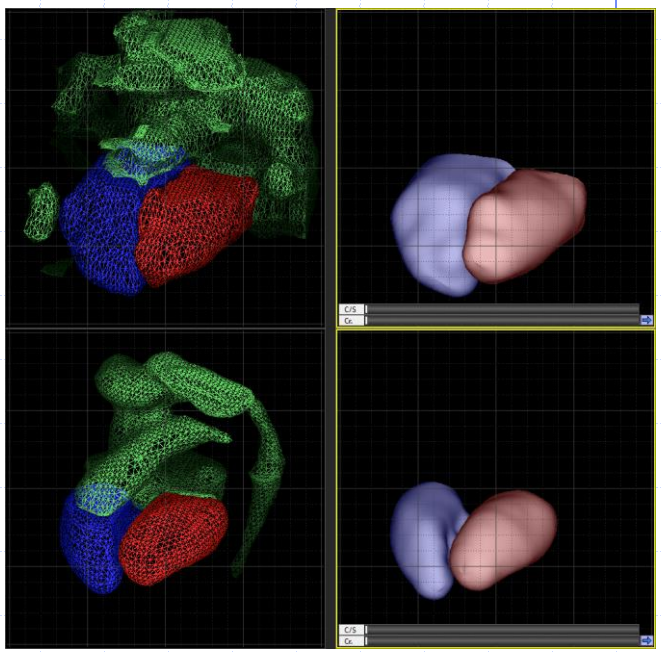


Bilans préopératoires de scolioses dans la myopathie de Duchenne

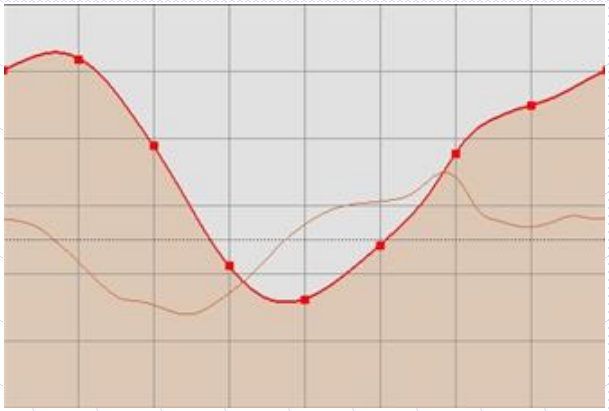
PMUGA ou TMUGA EN TEP 1’

Patients adressés en PET ^{18}FDG pour un suivi de cancer sous chimiothérapie.
Acquisition synchronisée à l’ECG pendant la première minute post FDG IV





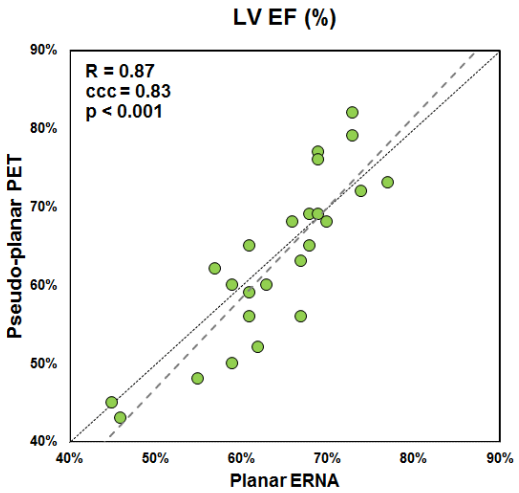
Logiciel ERNA commercialisé



TOMPOOL ou QBS

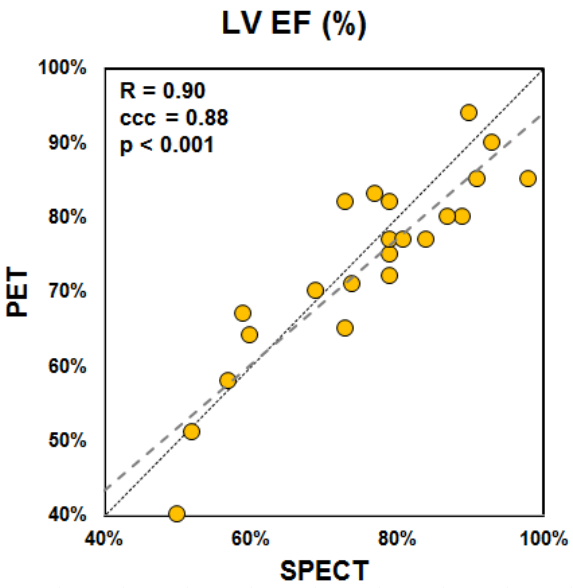
Fayçal Ben Bouallègue et al. Travail en cours de soumission

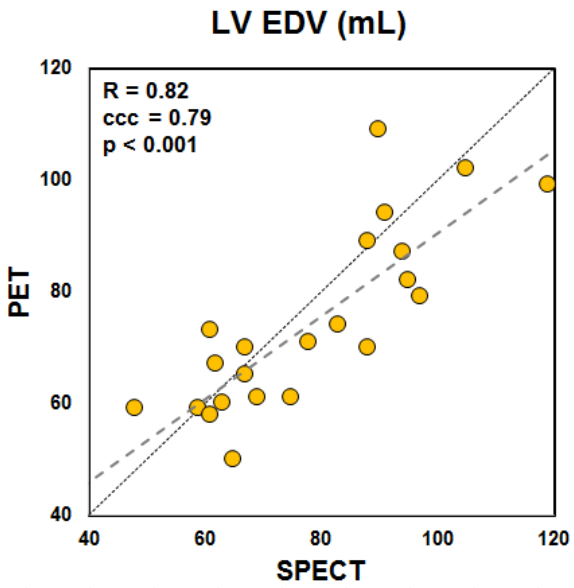
RECONSTRUCTION PMUGA EN TEP

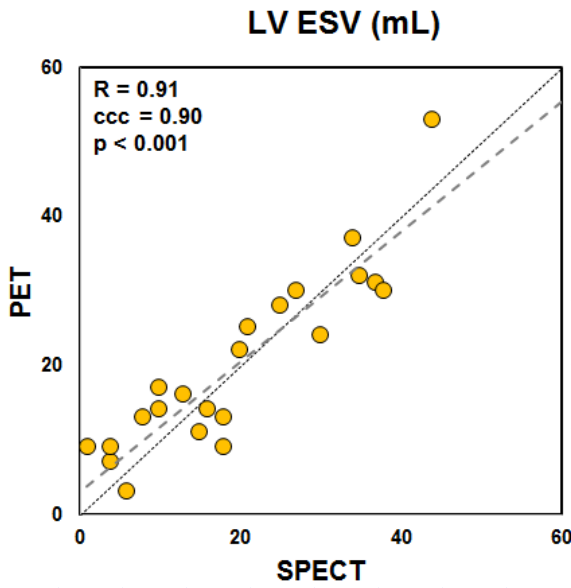


Pas de différence entre :

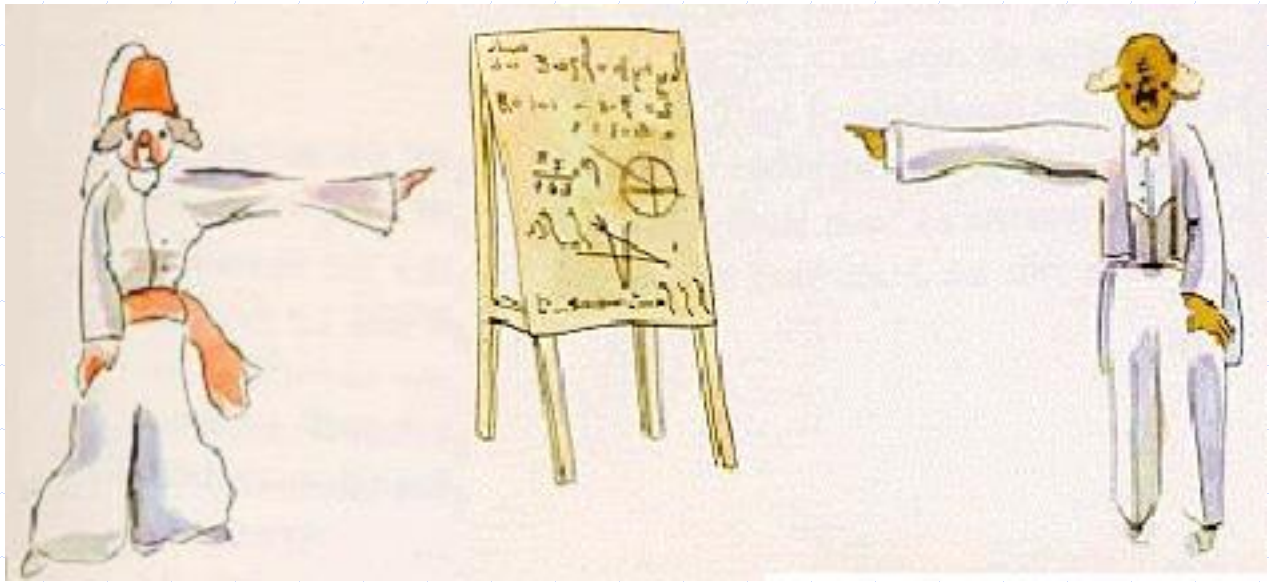
1- PMUGA TEP 1’ et PMUGA par ERNA
2- TMUGA TEP 1’ et TMUGA par tompool







Fayçal Ben Bouallègue et al. Travail en cours de soumission



Merci pour votre attention…

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