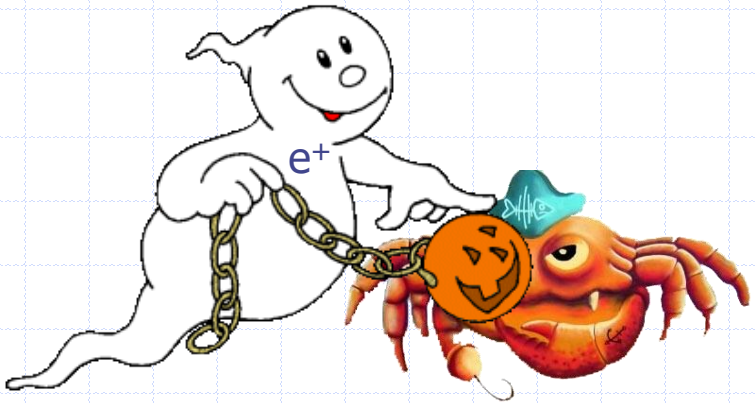
TOMOSCINTIGRAPHIE MYOCARDIQUE DE PERFUSION



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http:\\scinti.edu.umontpellier.fr

PLAN DE LA PRESENTATION

- QUAND REALISER UNE TSM DE PERFUSION ?
- COMMENT REALISER UNE TSM DE PERFUSION ?
  - RADIOTRACEURS, PROTOCOLES (RC), EPREUVE DE STRESS
- QUEL CONTRÔLE DE QUALITE EN TSM DE PERFUSION ?
  - ARTEFACTS (dig, bougé, respiration, centrage, BBG, 3 TRONCS…)
- QUELS RESULTATS EXPLOITER D'UNE TSM DE PERFUSION ?
  - VOLUMES VG MOYENS
  - MOUVEMENT PARIETAL & EPAISSISSEMENT SYSTOLIQUE
  - FONCTION SYSTOLIQUE VG
- VIABILITE MYOCARDIQUE
- RESERVE CORONAIRE

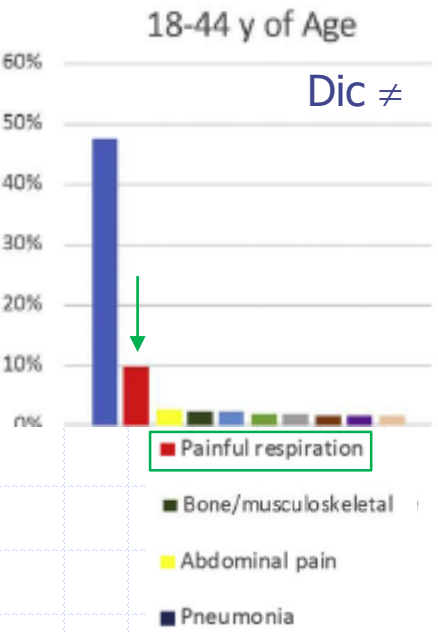
INDICATIONS

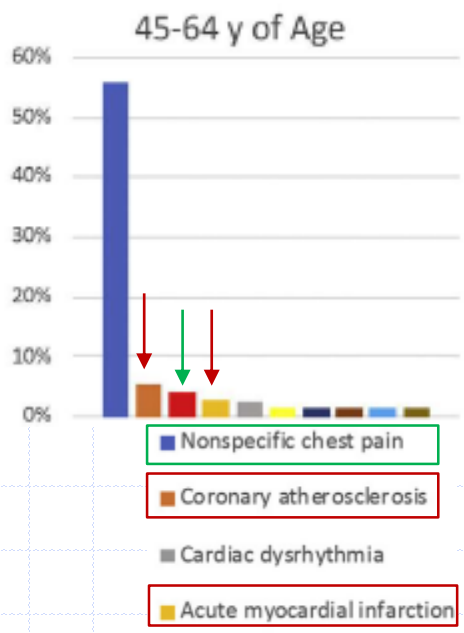
- DIAGNOSTIC, SUIVI, PRONOSTIC DES SYNDROMES CORONARIENS CHRONIQUES (SCC)
  - Coronaropathie chronique / Microcirculation altérée
  - Asymptomatique, angor, dyspnée transitoires → SCA
    - Sténoses d'une coronaire épicardique, athérosclérose diffuse
    - Anomalies congénitales des coronaires, vasospasme (épicardique ou microcirculatoire)
    - Dysfonction microvasculaire coronaire (INOCA)
    - Anémie, tachycardie, ΔTA, CMP hypertrophique, fibrose...
- DEPISTAGE D'UNE ISCHEMIE MYOCARDIQUE SILENCIEUSE
    - FRCV, Préopératoire, DNID, HIV
- DIAGNOSTIC D'UNE MALADIE DE SURCHARGE
    - Sarcoïdose, amyloses cardiaques.

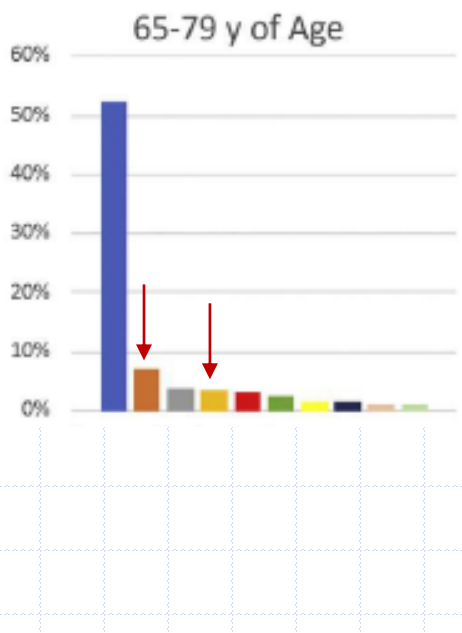
Am Heart J 1999;137(5):949-57 – Am J Cardiol 2002;90:827-832 – Eur Heart J 2004;25:543-550 - Diabetes Care 2004;27:1954-61 - Circulation 2005;112:I311-6 -Diabetes Métab 2004;30 – Diabetes Care 2005; 28(11):2722-7 – Circulation 2002;106:1883-1892 - Eur Heart J 2006;27:713-21 – JACC 2009;53(23):2201-2229

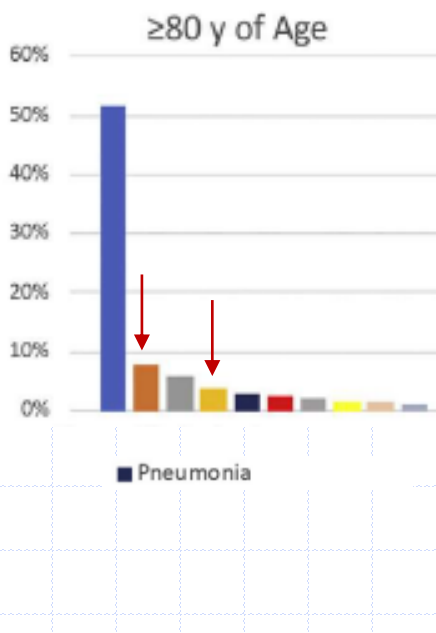
PREVALENCES

- p(DT/vie) = 20-40%, F> H
- SCA < 10% des DT
- Aux urgences, les DT sont surtout non spécifiques









M Gulati et al. 2021 ACC/AHA Guideline for the evaluation and diagnostic of chest pain. J Cardiov Comput Tomo. 2022;16(1):54-122
C Vrints et al. 2024 ESC Guidelines for the management of chronic coronary syndromes. Eur Heart J. 2024; 45:3415-3537

PREVALENCE CLINIQUE DE SCC

Diamond and Forrester model

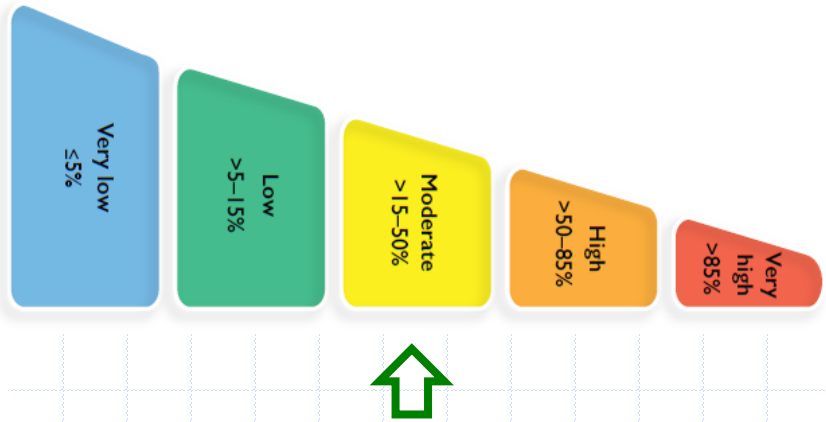
	Typical angina		Atypical angina		Non-anginal pain	
Age	Men	Women	Men	Women	Men	Women
30–39	59	28	29	10	18	5
40–49	69	37	38	14	25	8
50–59	77	47	49	20	34	12
60–69	84	58	59	28	44	17
70–79	89	68	69	37	54	24
>80	93	76	78	47	65	32

- **White boxes**: PTP <15%. No further testing.
- **Blue boxes**: PTP 15-65%. May need Exercise EKG or non-invasive imaging.
- **Orange boxes**: PTP 66-85%. Should have a non-invasive imaging.
- **Red boxes**: PTP>85%. Assume CAD is present.

La prévalence des SCC ↓ depuis 1979

GA Diamond & JS Forrester. Analysis of probability as an aid in the clinical diagnosis of CAD. N Engl J Med 1979;300:1350–8.

PREVALENCE CLINIQUE DE SCC



1 Symptom score (0–3 points)

Chest pain characteristics		Symptom score
Type and location	Constricting discomfort located retrosternally or in neck, jaw, shoulder or arm (1 point)	Main symptom either: Chest pain (0–3 points) or Dyspnoea (2 points)
Aggravated by	Physical or emotional stress (1 point)	
Relieved by	Rest or nitrates within 5 min (1 point)	
Dyspnoea characteristics		
Shortness of breath and/or trouble catching breath aggravated by physical exertion (2 points)		

2 Number of risk factors for CAD (0–5):
Family history, smoking, dyslipidaemia, hypertension and diabetes

3 Estimate the Risk Factor-weighted Clinical Likelihood (RF-CL) of obstructive CAD

Number of risk factors	Symptom score: 0–1 point				Symptom score: 2 points				Symptom score: 3 points			
	Women		Men		Women		Men		Women		Men	
	0–1	2–3	4–5	0–1	2–3	4–5	0–1	2–3	4–5	0–1	2–3	4–5	0–1	2–3	4–5	0–1	2–3	4–5
Age 30–39	0	1	2	1	2	5	0	1	3	2	4	8	2	5	10	9	14	22
Age 40–49	1	1	3	2	4	8	1	2	5	3	6	12	4	7	12	14	20	27
Age 50–59	1	2	5	4	7	12	2	3	7	6	11	17	6	10	15	21	27	33
Age 60–69	2	4	7	8	12	17	3	6	11	12	17	25	10	14	19	32	35	39
Age 70–80	4	7	11	15	19	24	6	10	16	22	27	34	16	19	23	44	44	45

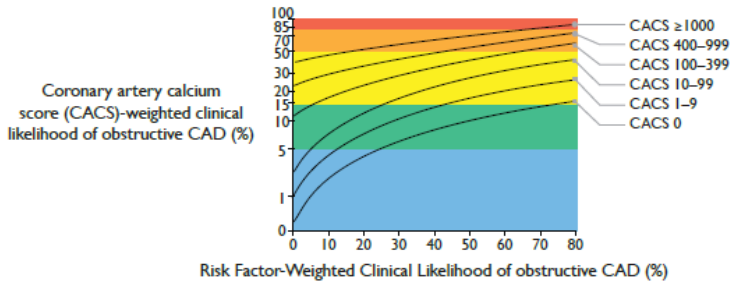
Clinical likelihood: Very low · Low · Moderate

ESC

4 Adjust clinical likelihood based on abnormal clinical findings (Class I)

- Resting ECG changes (Q-wave or ST-segment/T-wave changes)
- Exercise ECG with abnormal findings
- LV dysfunction (severe or segmental)
- Ventricular arrhythmia
- Peripheral artery disease
- Coronary calcification on pre-existing chest CT

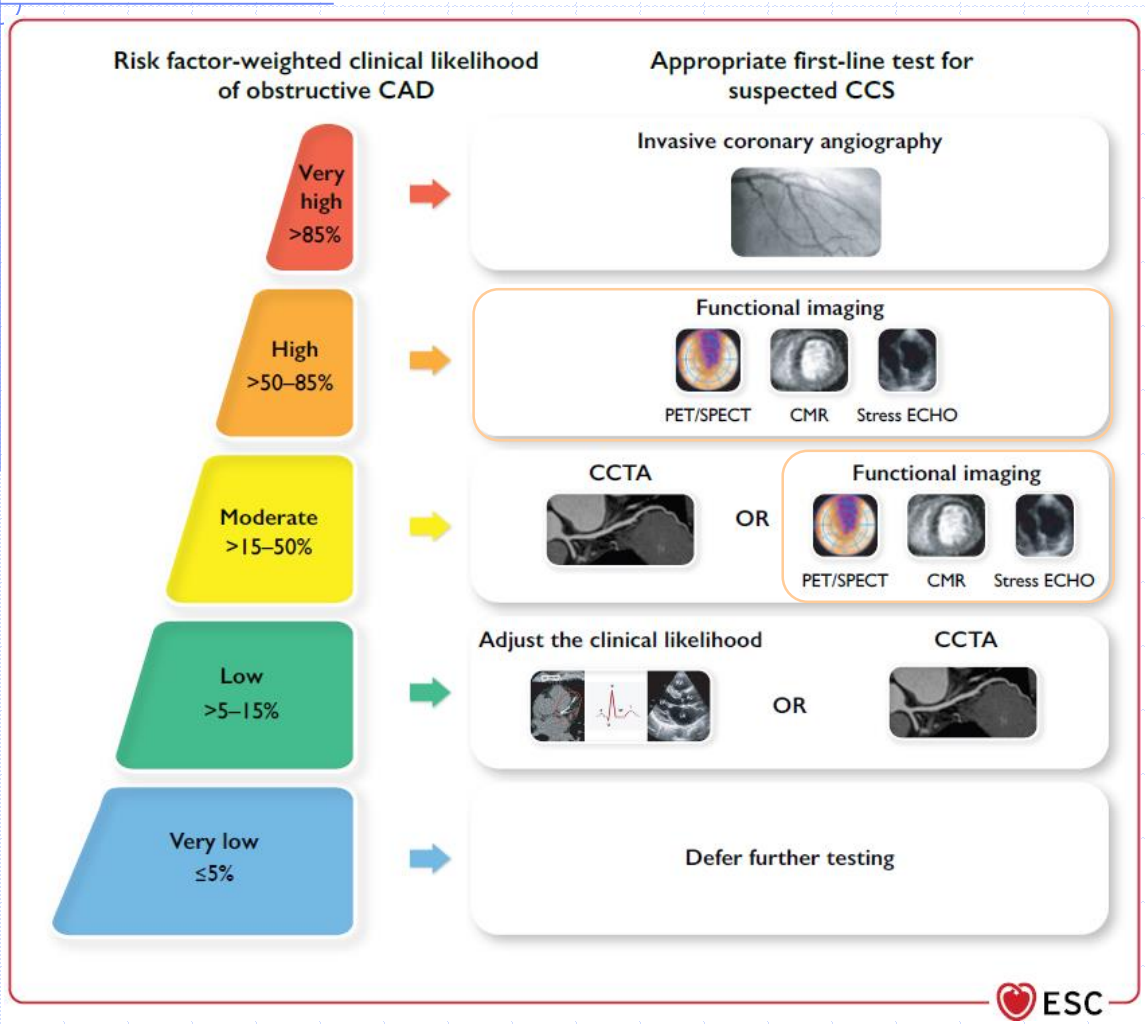
5 Consider reclassification of low RF-CL (>5–15%) using CACS to identify very low (≤5%) CACS-CL (Class IIa)



ESC

C Vrints et al. 2024 ESC Guidelines for the management of chronic coronary syndromes. Eur Heart J. 2024; 45:3415-3537
S Winther et al. Incorporating coronary calcification into pre-test assessment of the likelihood of CAD. JACC 2020;76:2421-32

DIAGNOSTIC D'UN SCC



Pour les SCC, pas de coronarographie sans test fonctionnel positif (ou FFR) *

Revascularisation
⇑
mais sténose ≠⇒ ischémie

☺ CCTA ⇒ sténose, plaques à haut risque, SC
Dic ≠ (péricardite, dissection Ao, Ep, pneumopathie…).
☹ tachy-arythmie, iode, dosimétrie aux seins.

C Vrints et al. 2024 ESC Guidelines for the management of chronic coronary syndromes. Eur Heart J. 2024; 45:3415-3537
S Winther et al. Incorporating coronary calcification into pre-test assessment of the likelihood of CAD. JACC 2020;76:2421-32
* R Hachamovitch et al. Circulation 2003; 107(23): 2900-2907 - SD Fihn et al JACC 2012;60(24): e44-e164 - J Knuuti et al. Eur Heart J 2020; 41(3):407-477.

ISCHEMIE ⇒ OBSTRUCTION ?

Etude	Année	Inclusions	Effectifs	Absence de maladie coronaire obstructive
Registre ACC 2004-2008	2010	Registre (33 / 37% angor typique / atypique)⇒ Coro	397954	39% de coro normales (sténoses<20%) 62% de sténoses >70% (ou > 50% pour le TC)
FAME2	2014	Lésions sur coro traitables par PCI	1220	27% (332) FFR > 0,80
PROMISE	2015	74% angor (12% typiques)/ 14% dyspnée ⇒ 4686 CTCA ⇒ 609 coro	609	28% (170) non obstructif
CorMica	2018	angor probable/certaine selon Rose ⇒ Coro	391	39% (151) coro N améliorés à M6 si TTT médical sur FFR/RC/IMR/ACh (spasme, microvx)
ORBITA	2018	1 sténose ≥ 70% ⇒ coro	200	29% (57) FFR > 0,80

Ischémie ou Angor ⇔ sténose coronaire

Intérêt des tests fonctionnels de dépistage de l'ischémie

M Patel et al. N Engl J Med 2010;362:886-95 - B De Bruyne et al. N Engl J Med 2014;371:1208-17 - P Douglas et al. N Eng J Med 2015; 372:1291-300 - T Ford et al. JACC 2018;72(25):2841-55 – R Al-Lamee et al. Lancet 2018;391:31-40

INDICATIONS

	Main imaging target(s) in CCS	Requirements	Limitations
Anatomical imaging			
CCTA	Atherosclerosis (obstructive and non-obstructive) in epicardial coronary arteries	Iodinated contrast Radiation E = 0,5 à 7 mSv CE Premedication: • Beta-blockers or ivabradine for heart rate control • Nitroglycerine for adequate vasodilation	Severely impaired kidney function[a] Documented allergy to iodinated contrast Tachyarrhythmia refractory to beta-blockade Irradiation (especially young women) H(seins) = 80 mSv (2007) → 8-16 ?
SPECT/CT **PET/CT**	Atherosclerosis coronary artery calcium score	Radiation	Irradiation (especially young women)
Functional imaging			
Stress Echo	LVEF and volumes		Poor Echo windows
	Wall motion abnormalities Myocardial perfusion Coronary velocity flow reserve	Performed with exercise, dobutamine and vasodilators Echo contrast to improve image quality and assess perfusion	Poor Echo windows Contraindications to stressor
CMR	LVEF and volumes		Non-CMR-compatible metal devices Severe claustrophobia
	MI (scar)	Paramagnetic contrast	Non-CMR-compatible metal devices Severe claustrophobia Haemodialysis
	Ischaemia/blood flow	Vasodilator stress + paramagnetic contrast	Non-CMR-compatible metal devices Severe claustrophobia Contraindications to stressor Haemodialysis
	Wall motion abnormalities	Inotropic stress (dobutamine)	Non-CMR-compatible metal devices Severe claustrophobia Contraindication to stressor
SPECT	LVEF and volumes Wall motion abnormalities Ischaemia/viability/MI	Vasodilator or exercise stress Radioactive tracer E = 4 mSv CE @ 185/555 MBq	Contraindication to stressor H(seins) < 3 mSv Irradiation (especially young women)
PET	LVEF Ischaemia/blood flow Viability	Vasodilator stress Radioactive tracer (^{13}N-ammonia, ^{15}O-water, ^{82}Rb) E = 2 à 5 mSv CE	Contraindication to stressor Irradiation (especially young women)

C Vrints et al. 2024 ESC Guidelines for the management of CCS. Eur Heart J. 2024; 45:3415-3537 - A Einstein et al. Estimating risk of cancer associated with radiation exposure from 64-slice CTCA. JAMA. 2007;298(3): 317-323 – H Verberne et al. Eur J Nucl Med Mol Imag 2015 42:1929–1940

GAMMA-CAMERAS

		AVANTAGES	INCONVENIENTS
ANGER GRAND CHAMP		CT pour CA (ou SC) Artefacts de mouvement / Sinogramme Polyvalence en MN.	Sensibilité diminuée, SPECT en 10 min
CZT DEDIEES		Sensibilité x 10 : RC SPECT en 3 min Résolution en E (Tl,Tc) Dosimétrie	Pas de CT pour CA (ou SC) Artefacts de mouvement ? Centrage rigoureux FOV elliptique réduit

La résolution n'est pas un enjeu majeur en SPECT myocardique : une FWHM en mode tomographique de l'ordre de celle des caméras de Anger est souhaitable (15 mm)

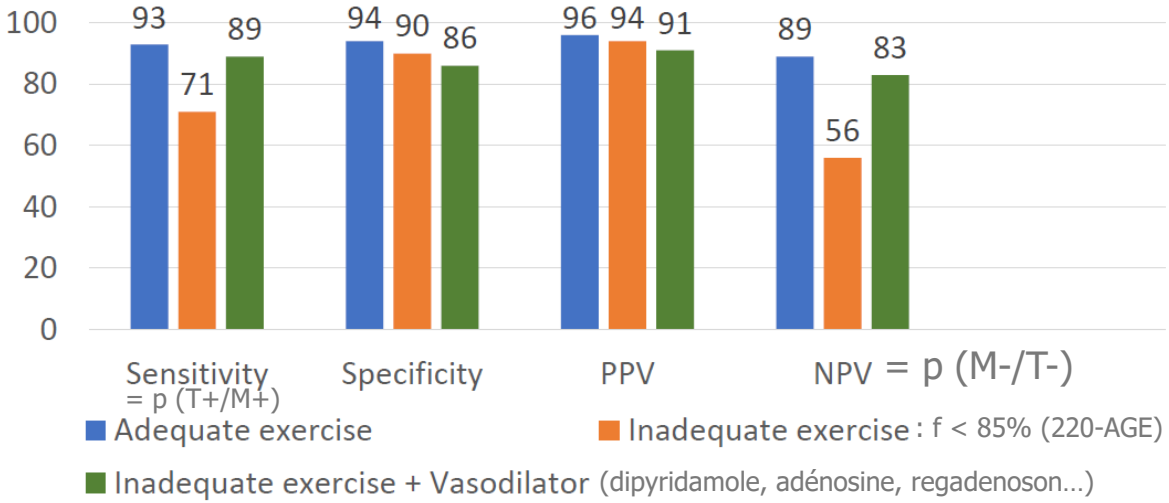
PROTOCOLES

	Fixation vs. Perfusion	Digestif	Atténuations	Cardiologue	Patient	Comparaison S/R	V(VG) S/R	Fct VG : S/R	Dosimétrie	Coût
Tc REPOS → EFFORT 1 jour				Synchro/R	3/4 h (CZT) - 2h	R à bas coups				
Tc EFFORT → REPOS 1 jour					4 à 5 h	S à bas coups				
Tc EFFORT sans REPOS 1 jour					1/2 h (CZT) - 1h					
Tl REPOS → Tc STRESS 1 jour	S	S	R	Synchro/R	3/4 h (CZT) - 2h	R vs S	R vs S	R vs S		
Tl REPOS → Tl STRESS 1 jour				Synchro/R	3/4 h (CZT) - 2h	R à bas coups				
Tl STRESS → REDISTRIBUTION 4h → REPOS, 1 jour			S	Synchro/γ	6 h					
Tc R/E (ou E/R) 2 jours					2 JOURS					

E DePuey et al. Patient-centered imaging. J Nucl Cardiol 2012; 19(2):185-215

EE MIXTE

Pas de café, thé, chicorée, cola, chocolat, banane 24h avant l'examen

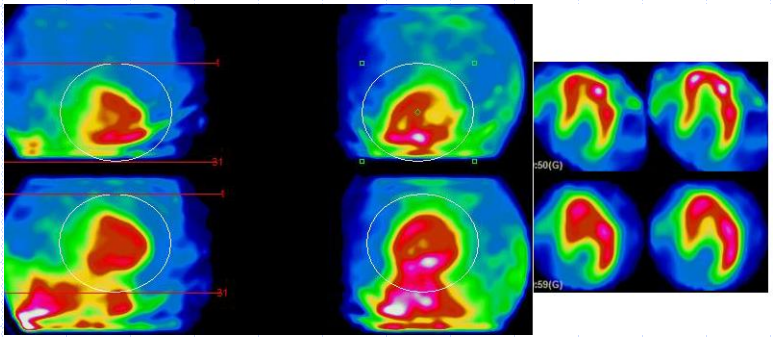


Modified from Candell-Riera J et al, J Am Coll Cardiol 1997

Candell-Riera et al. J Am Coll Cardiol 1997

CONTRÔLE DE QUALITE

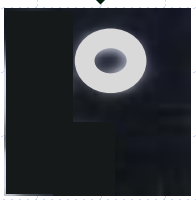
- De la γ-caméra
- Centrage
  - myocarde dans le FOV,
  - centré en CZT



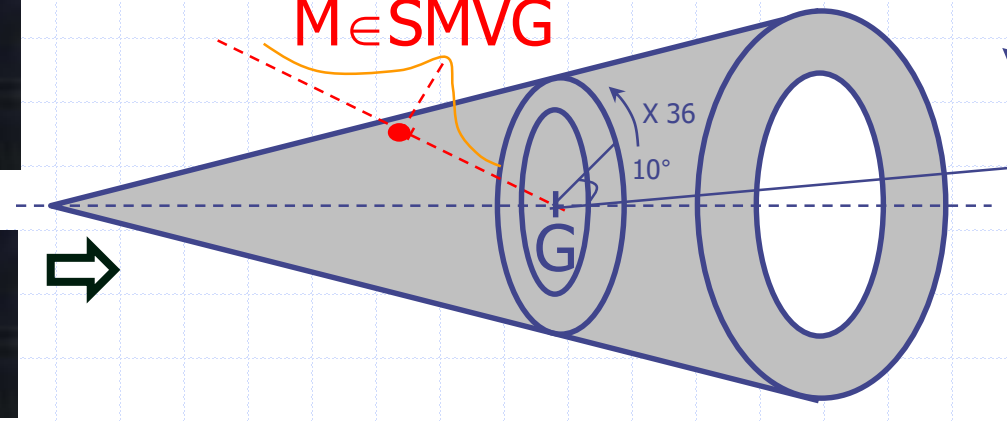
- Mouvements (sinogramme ou artefact sur CZT GE)

- Activité digestive
- Paramètres de reconstruction (fc)
- Atténuations
- ECG et synchronisation

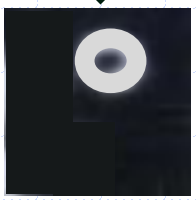
QPS



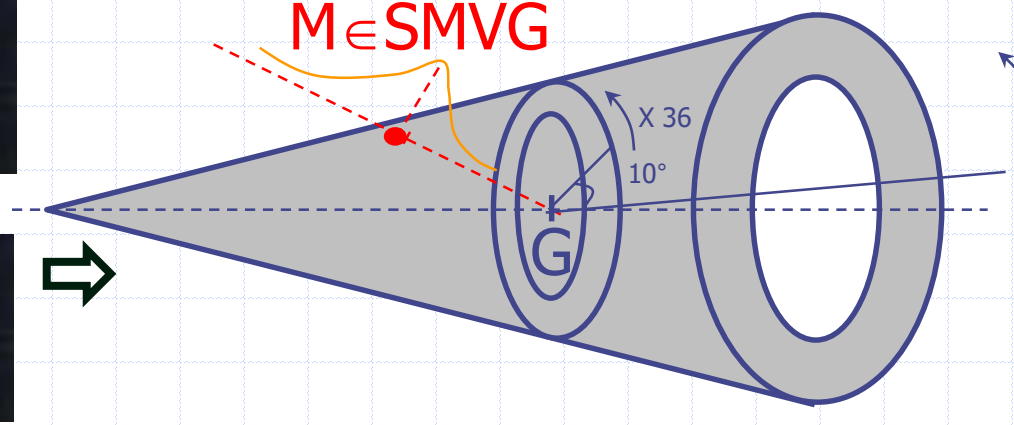
Masque VG

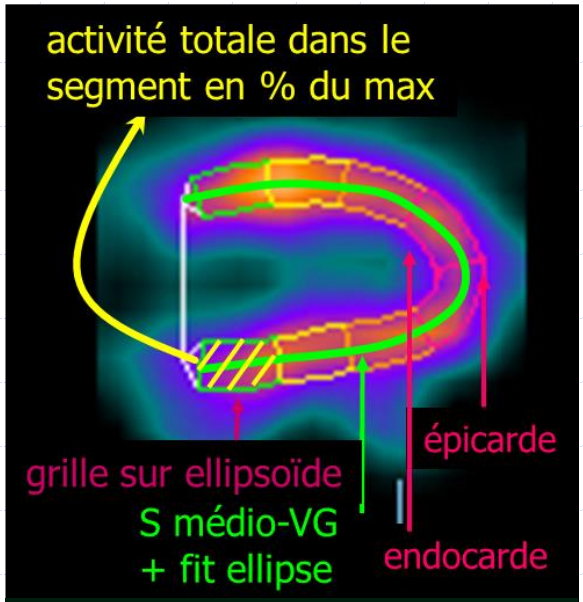


QPS

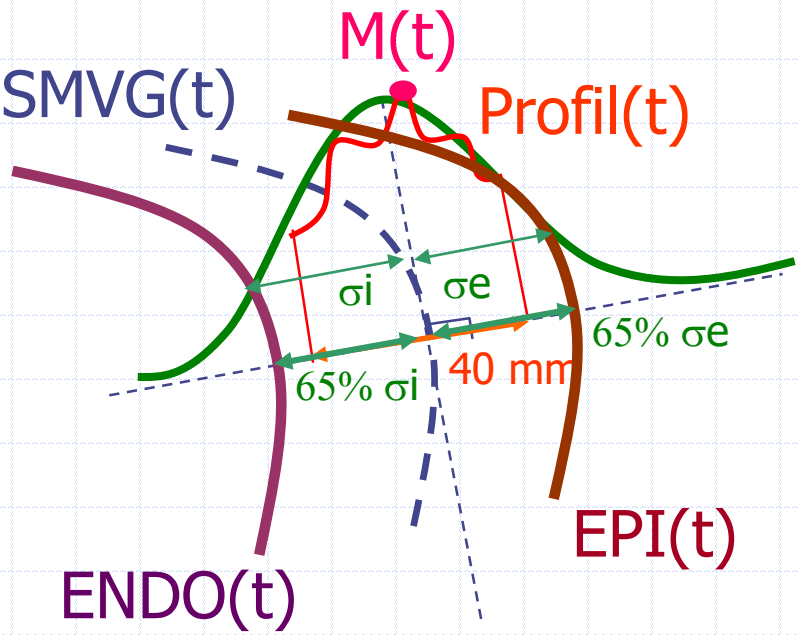


Masque VG





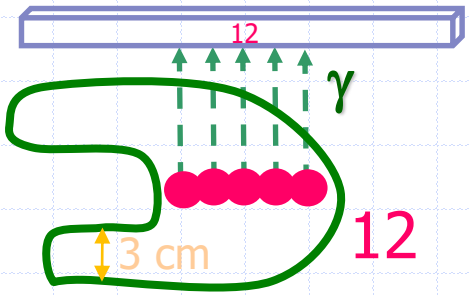
En moyenne, en TD et en TS



EPAISSISSEMENT SYSTOLIQUE

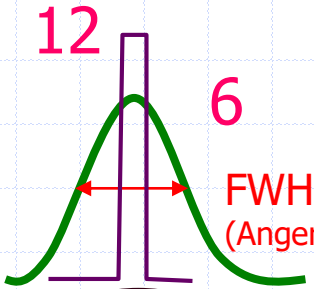
3 9 12 12 12 9 3

3 6 3
3 6 3
3 6 3
3 6 3
3 6 3

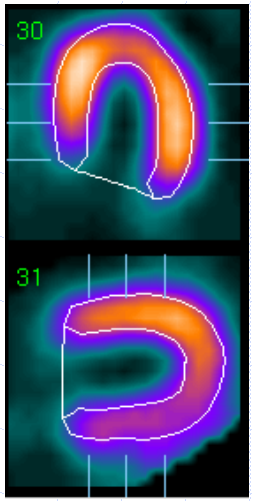


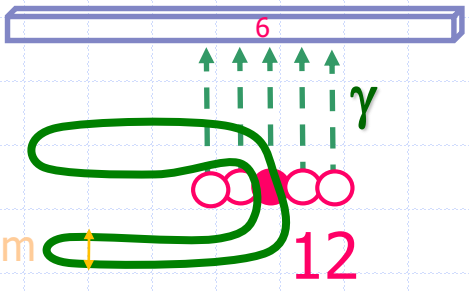
Épaississement systolique E/R ⇒ ni nécrose, ni hibernation, ni sidération

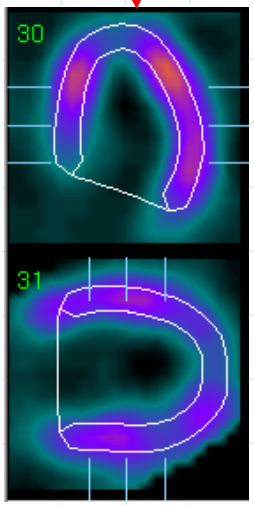
Sous-estimation
au centre des parois
d'épaisseur
e < 2.FWMH
e < 3 cm
(Anger ou CZT filtrée)



3 6 3





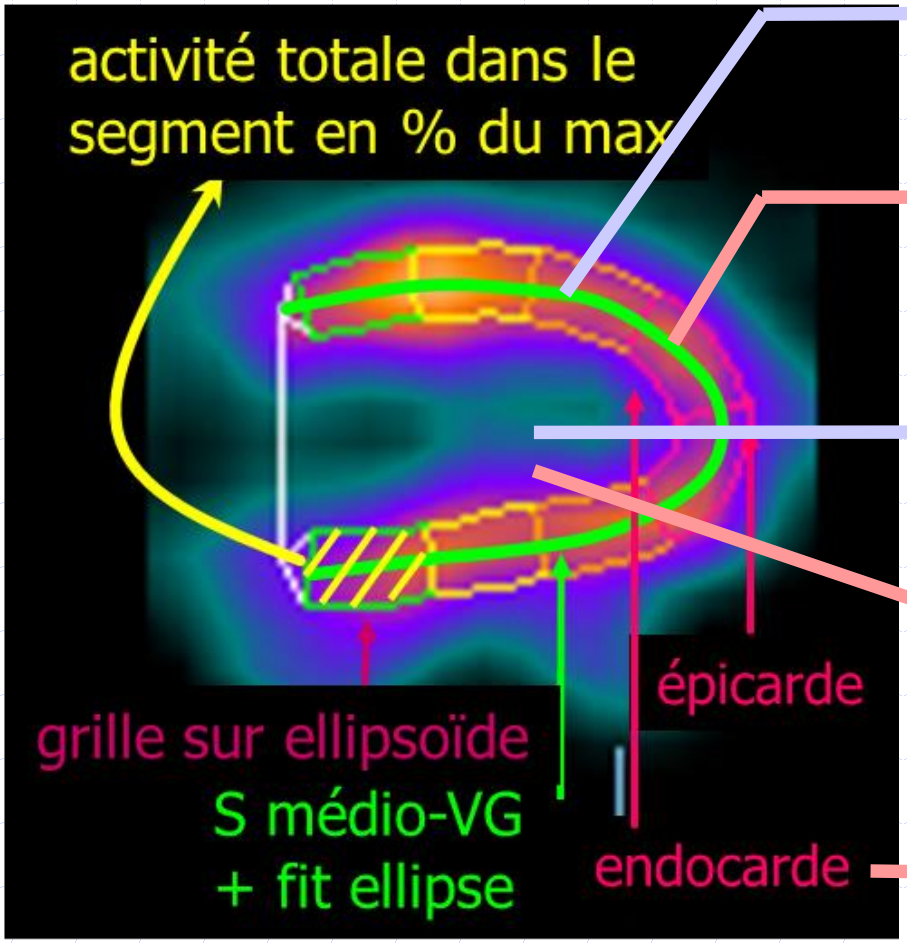


TS en fin d'éjection systolique

TD en fin de remplissage diastolique

$$d_{pixel} = \frac{FWHM}{2} \Longrightarrow d_{pixel} = 7\ mm \Longrightarrow 64\text{x}64 \text{ si FOV} = 45\text{x}45\text{cm}$$

QPS-QGS



Activité/17 segments % maxi
Perfusion de stress & de repos
⇒ ischémie ou *nécrose*

Δ(activité) entre TS et TD
Epaississement systolique
⇒ sidération ou hibernation
Cinétique ≡ Echo de stress

Volume VG moyen au S/R
⇒ ischémie sous endocardique diffuse si $V_S/V_R > 1,4$

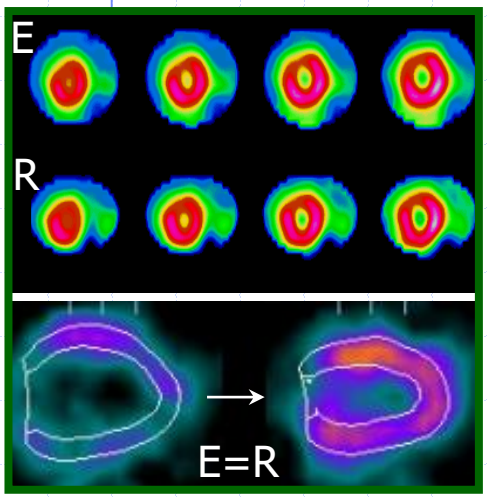
VTD, VTS ≤ 27 (F) et 39 (H) mL/m²
FE ≥ 51% (F) & 43% (H)
⇒ fonction systolique au S/R
Pronostic ≡ Echo de stress

Mouvement de l'endocarde
⇒ dyskinésie

T Sharir J Nucl Cardiol 2018;25:738-741 – M Alama J Nucl Cardiol 2018;25:724-37 - T. Sharir et al. Circulation 1999;100:1035-42 et J Nucl cardiol 2006;13(4):495-506

EXEMPLES

NORMAL



DIASTOLE SYSTOLE

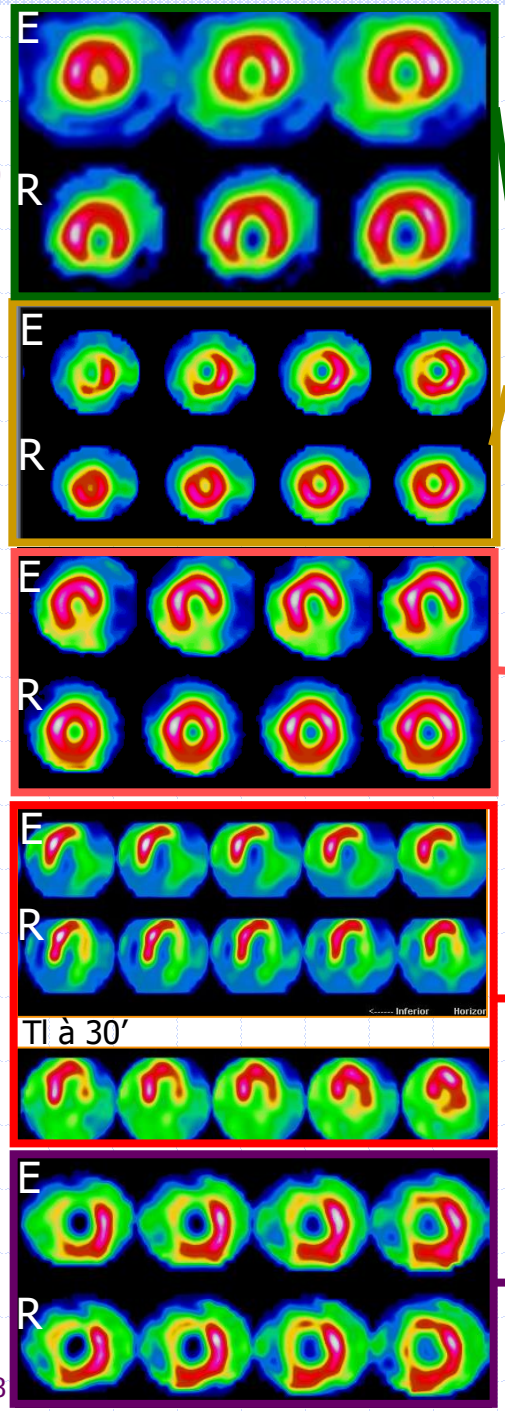
NORMAL (ARTEFACT)

ISCHEMIE 50%<∅<79%

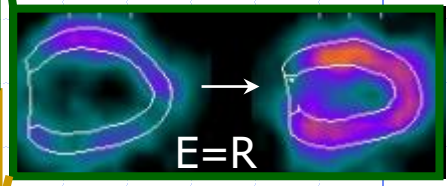
SIDERATION D'EFFORT ∅ < 80%

ISCHEMIE E/R VIABLE (HIBERNATION)

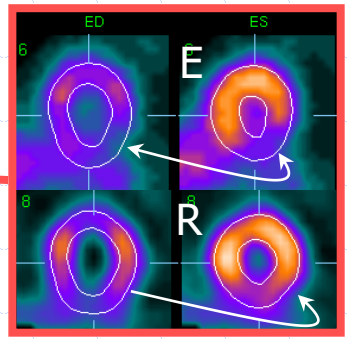
NECROSE

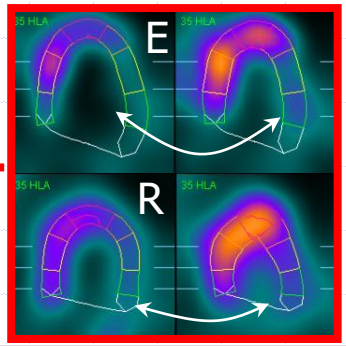


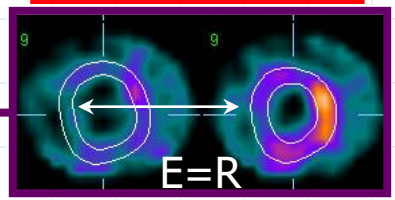
DIASTOLE SYSTOLE



DIASTOLE SYSTOLE

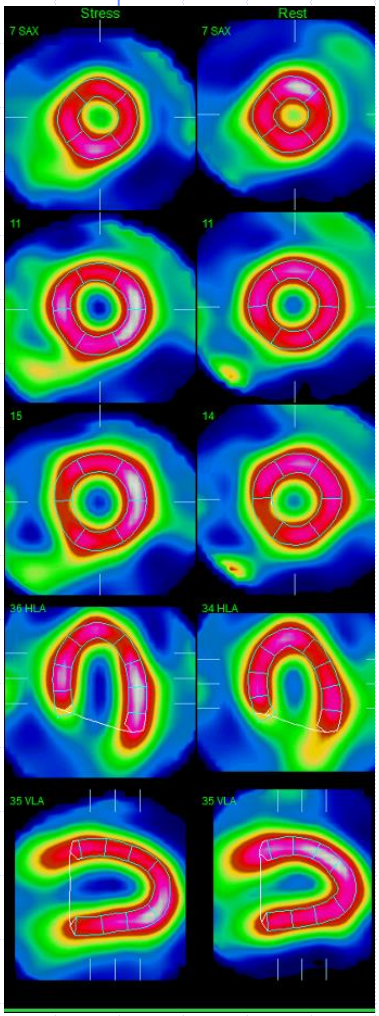






T. Sharir. - J Nucl cardiol 2006;13(4):495-506- L Emmet JACC 2002;39:991-8

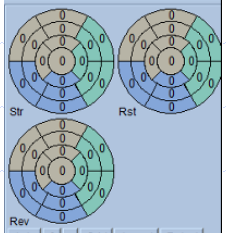
EXEMPLES



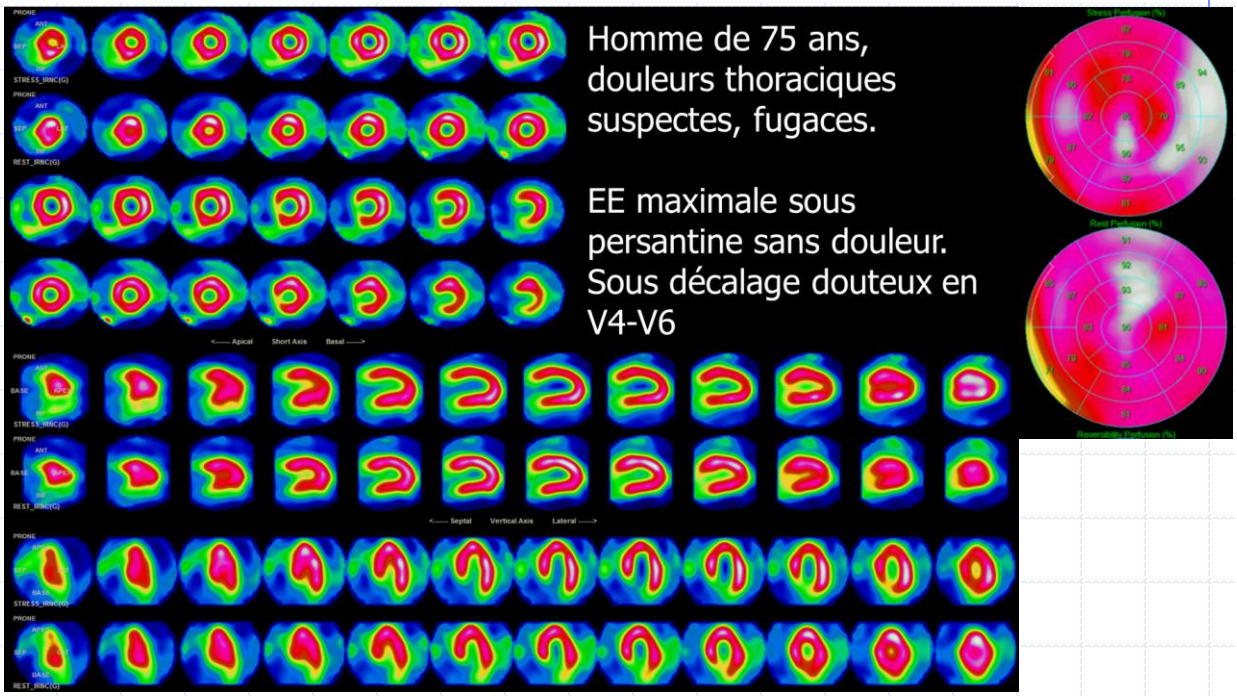
Name	THIEBAULT GEORGES
Pat ID	003607187
Sex	MALE
Limits	--
SSS 0	SRS 0 SDS 0
SS% 0	SR% 0 SD% 0

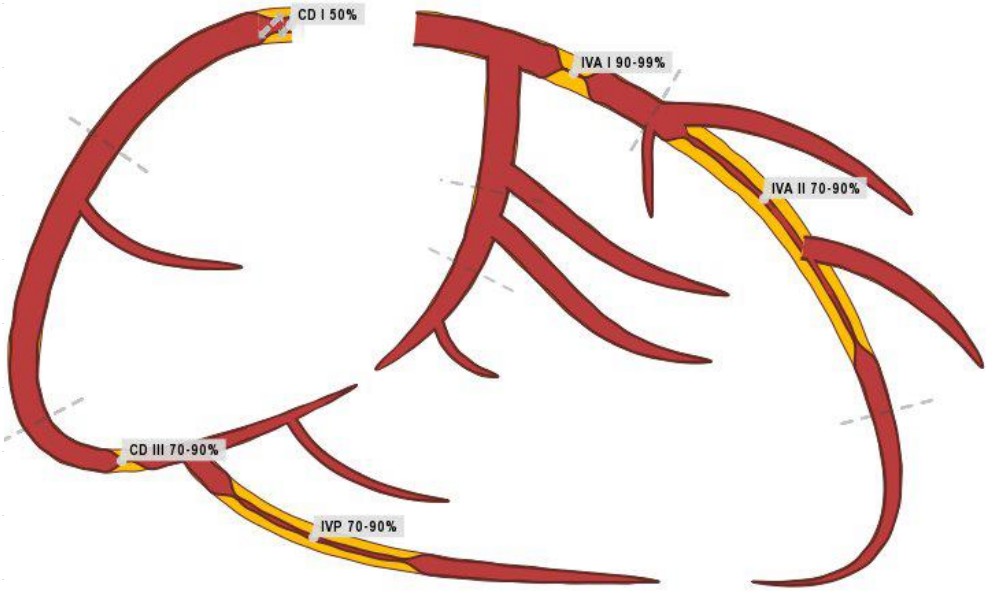
Study	MED-NUC-LAP-MIBI 1 JOUR
Dataset	STRESS_IRNC
Date	2022-09-14 09:58:15
Database	MaleProneStressMB
Volume	41ml
Area	74cm²
Defect	8cm²
Extent	11%
TPD	11%
Eccentricity	0.84

Study	MED-NUC-LAP-MIBI 1 JOUR
Dataset	REST_IRNC
Date	2022-09-14 08:29:31
Database	<No Matches>
Volume	31ml
Area	66cm²
Defect	--
Extent	--
TPD	--
Eccentricity	0.80

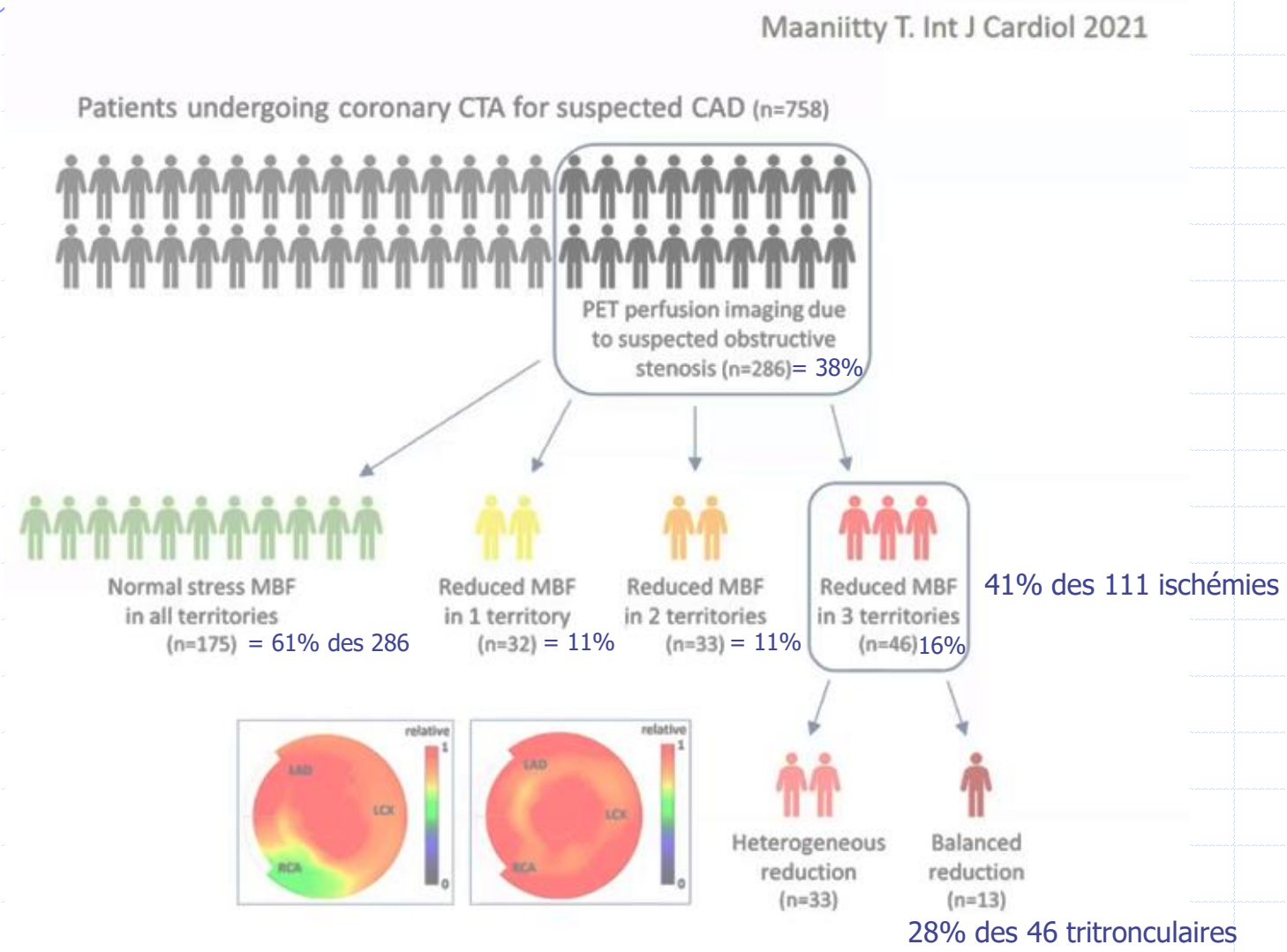


41/31 = 1,32

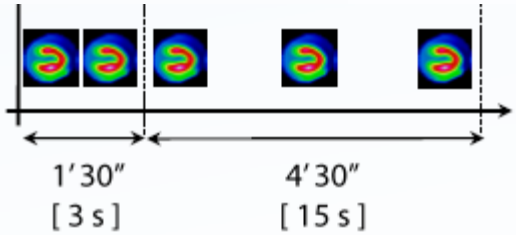


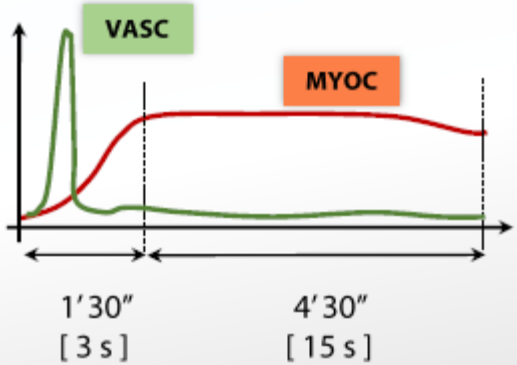


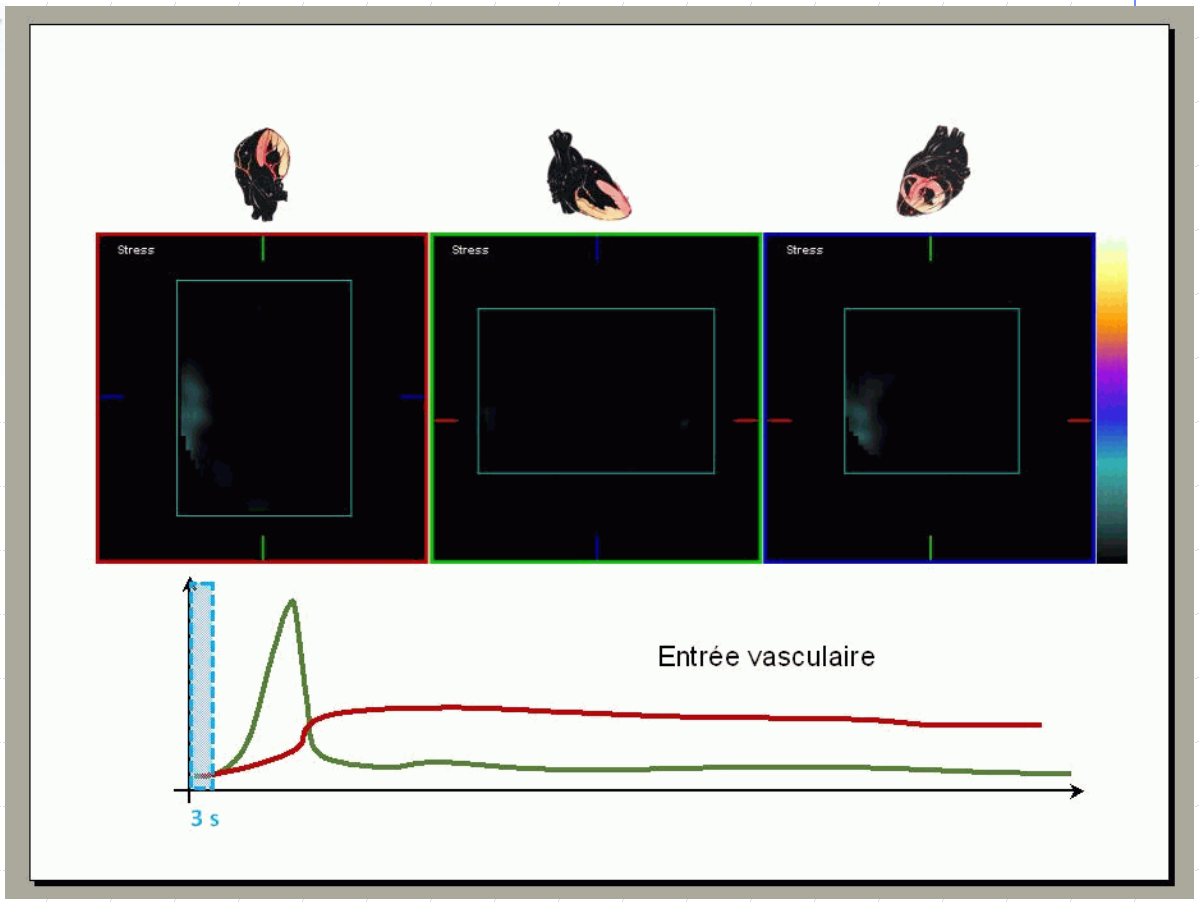
ISCHEMIE EQUILIBREE ?



SPECT DYNAMIQUE (LIST MODE)



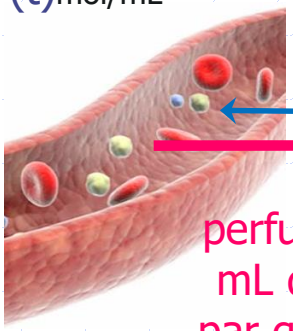




1 mCi Tc-TF centrage — 5 mCi Tc-TF Repos List 5' — 0,56 mg/kg DIP 4' — 18 mCi Tc-TF Stress List 5'

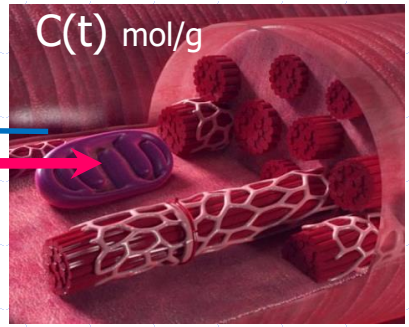
RESERVE CORONAIRE

P(t)mol/mL



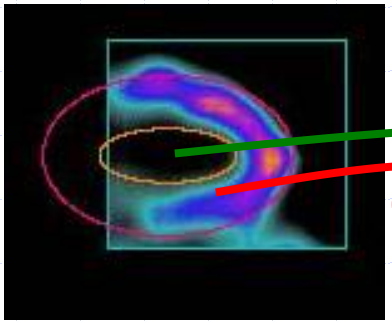
$k_2 \approx 0$

K_1 perfusion en mL de sang par g de tissu et par minute



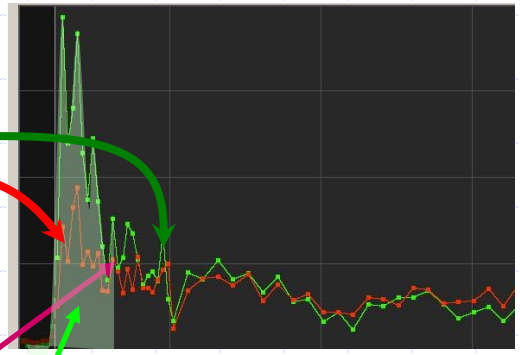
$$\frac{dC(t)}{dt} = K_1.P(t) \Rightarrow \int_0^t \frac{dC(t)}{dt}\,dt = K_1.\int_0^t P(t)dt$$

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

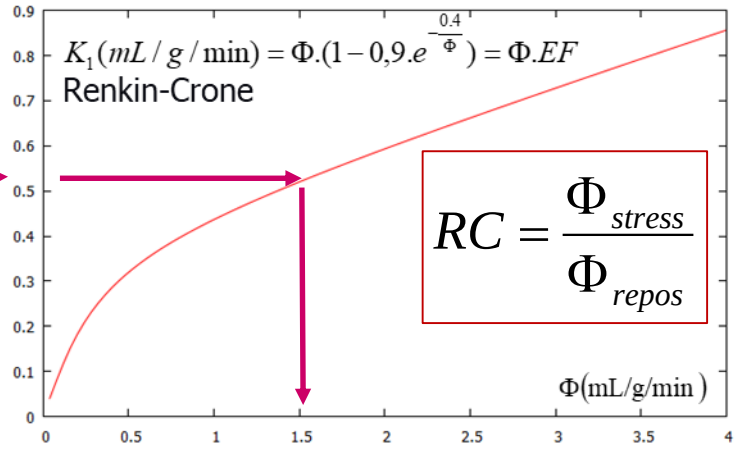


P(t)

C(t)



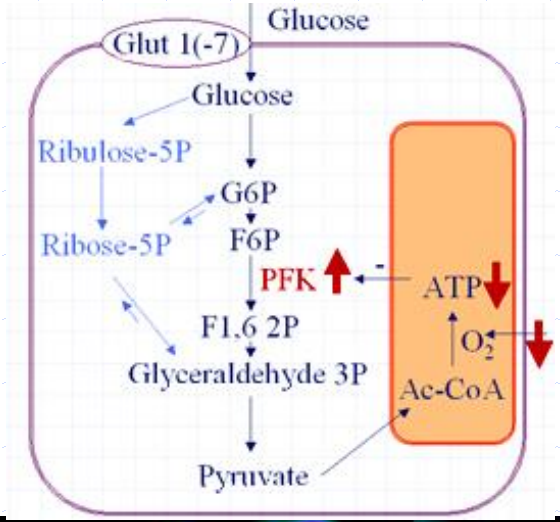
$$K_1 = \frac{C(t)}{ASC(t)} \approx \frac{\overline{C}_{Myoc\ plateau}}{ASC_{Pic\ vascu}}$$

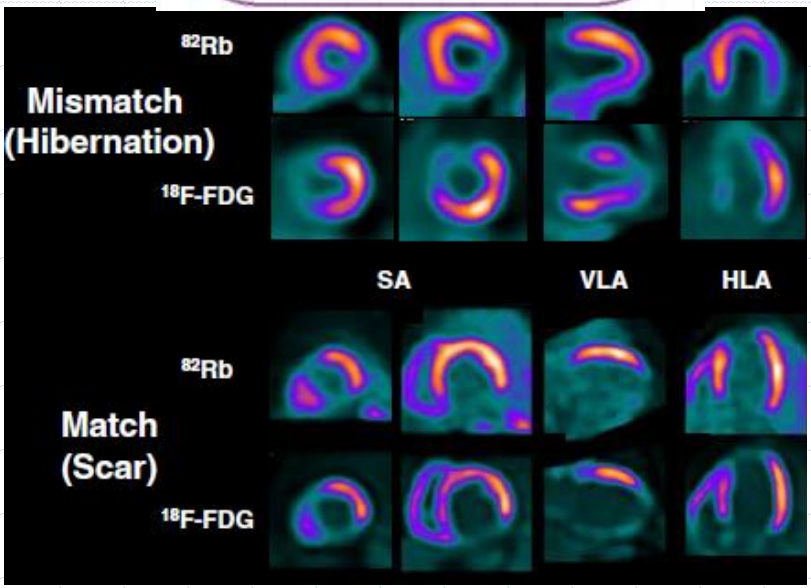


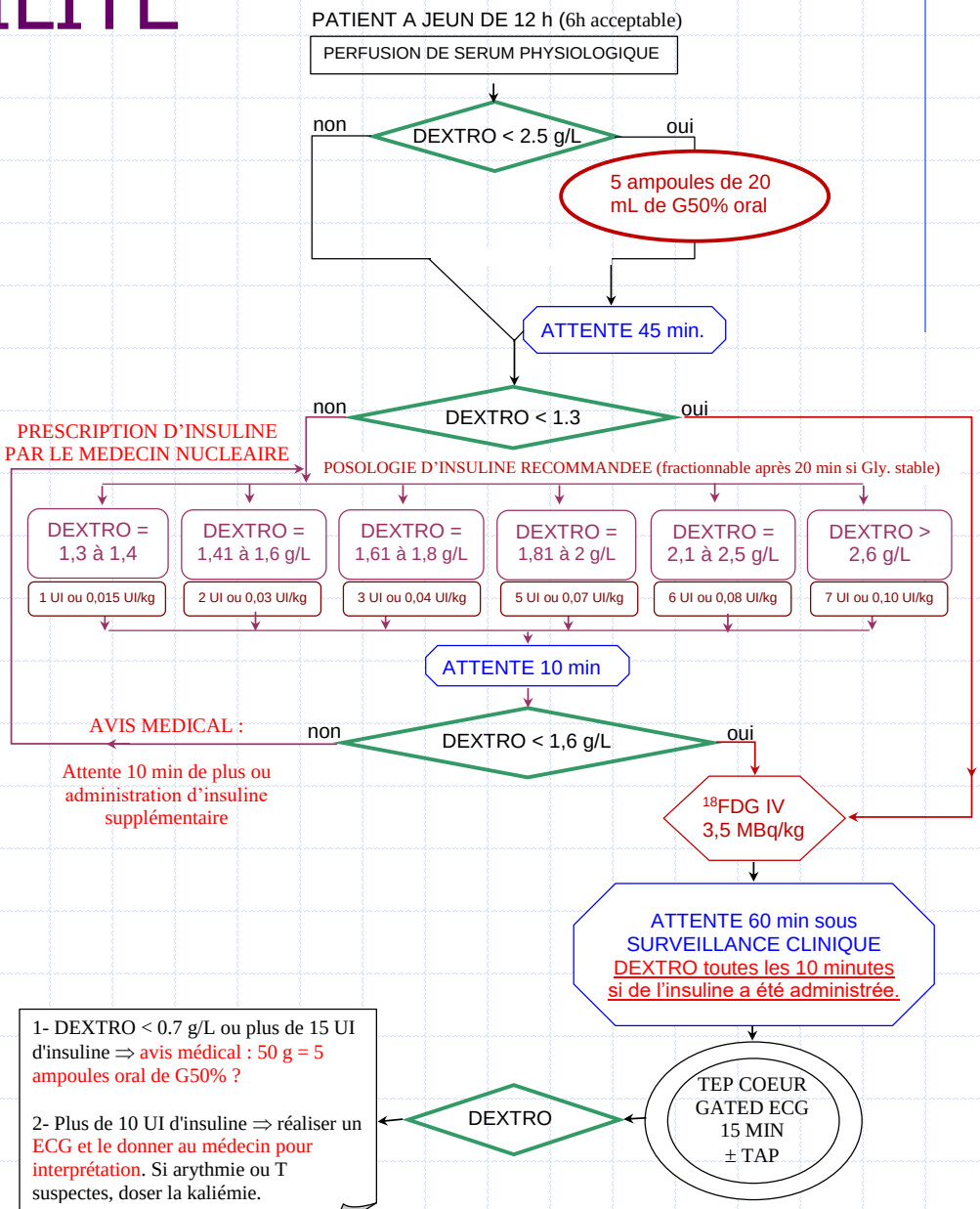
(correction EVP et contamination P→C)

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

TEP ^{18}FDG DE VIABILITE MYOCARDIQUE

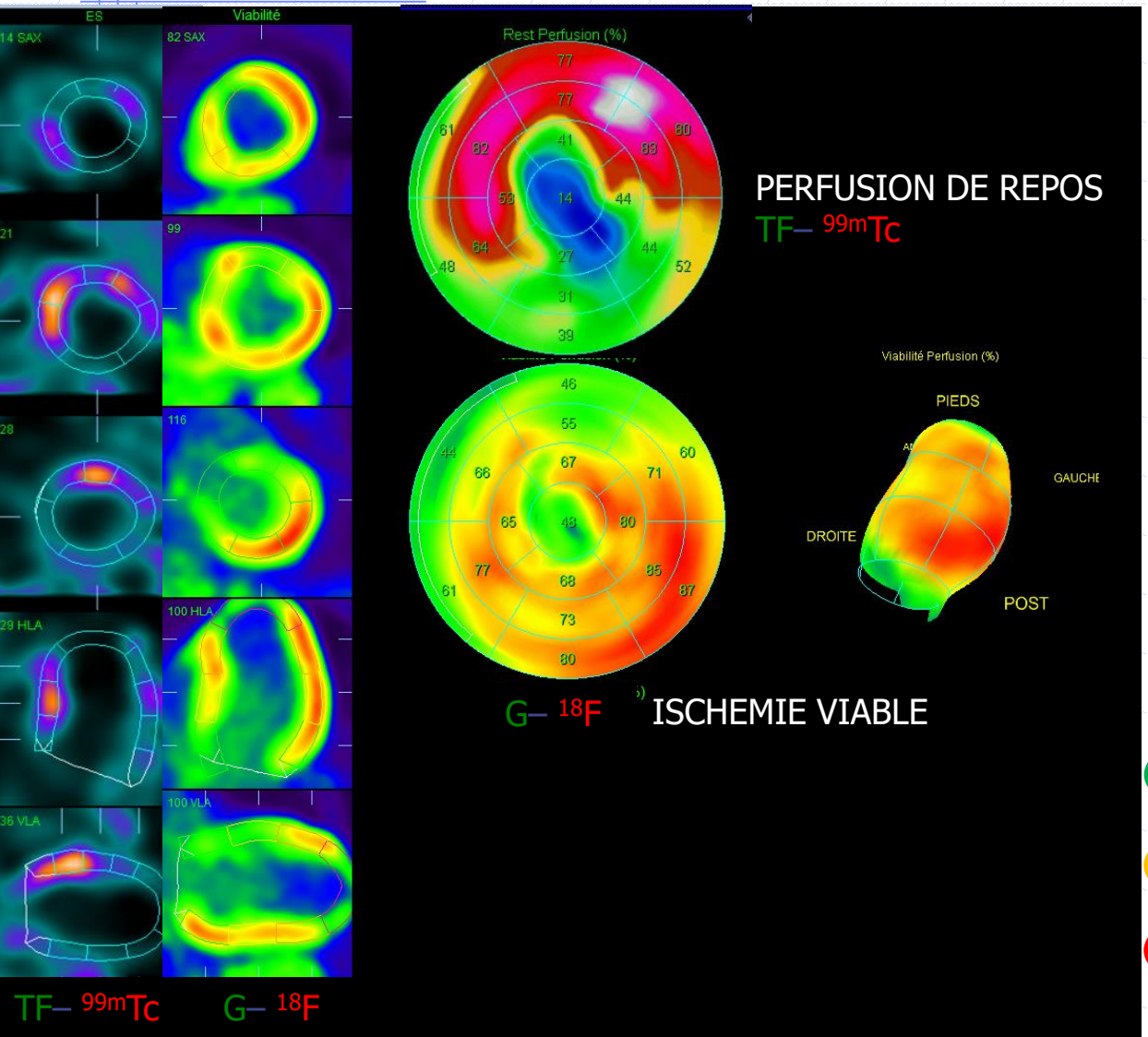


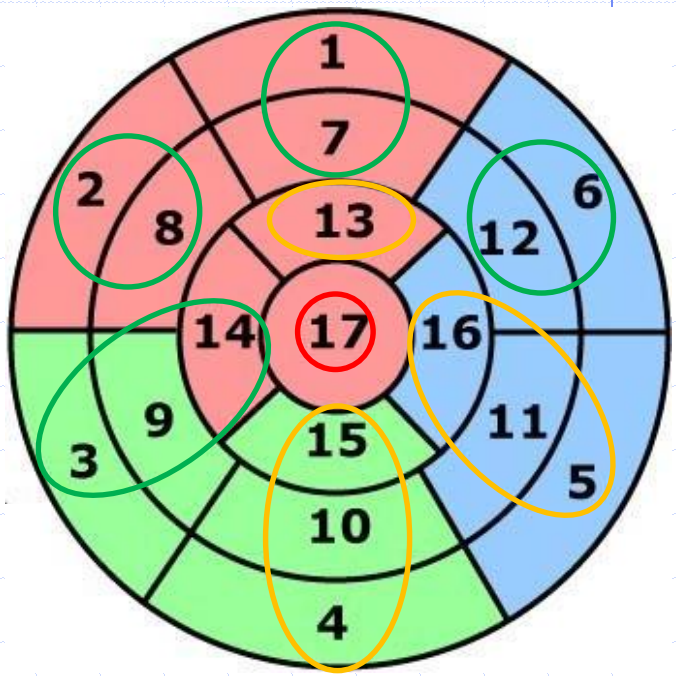




D. Mariano-Goulart. 30/11/2020. Réf. J Nucl Med 2013; 54(8): 1485-1507 et avis du Pr E Renard.

Homme 49 ans tri-tronculaire. Sténoses Mg1, D1 Occlusions chroniques IVA2, Cx1, CD1. Lésion TC



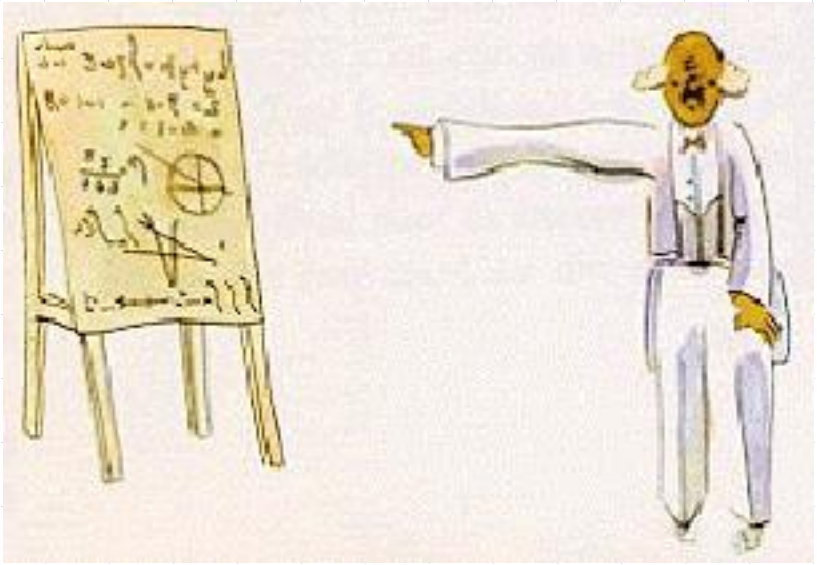


normal au repos

hibernation

nécrose

MERCI POUR VOTRE ATTENTION



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