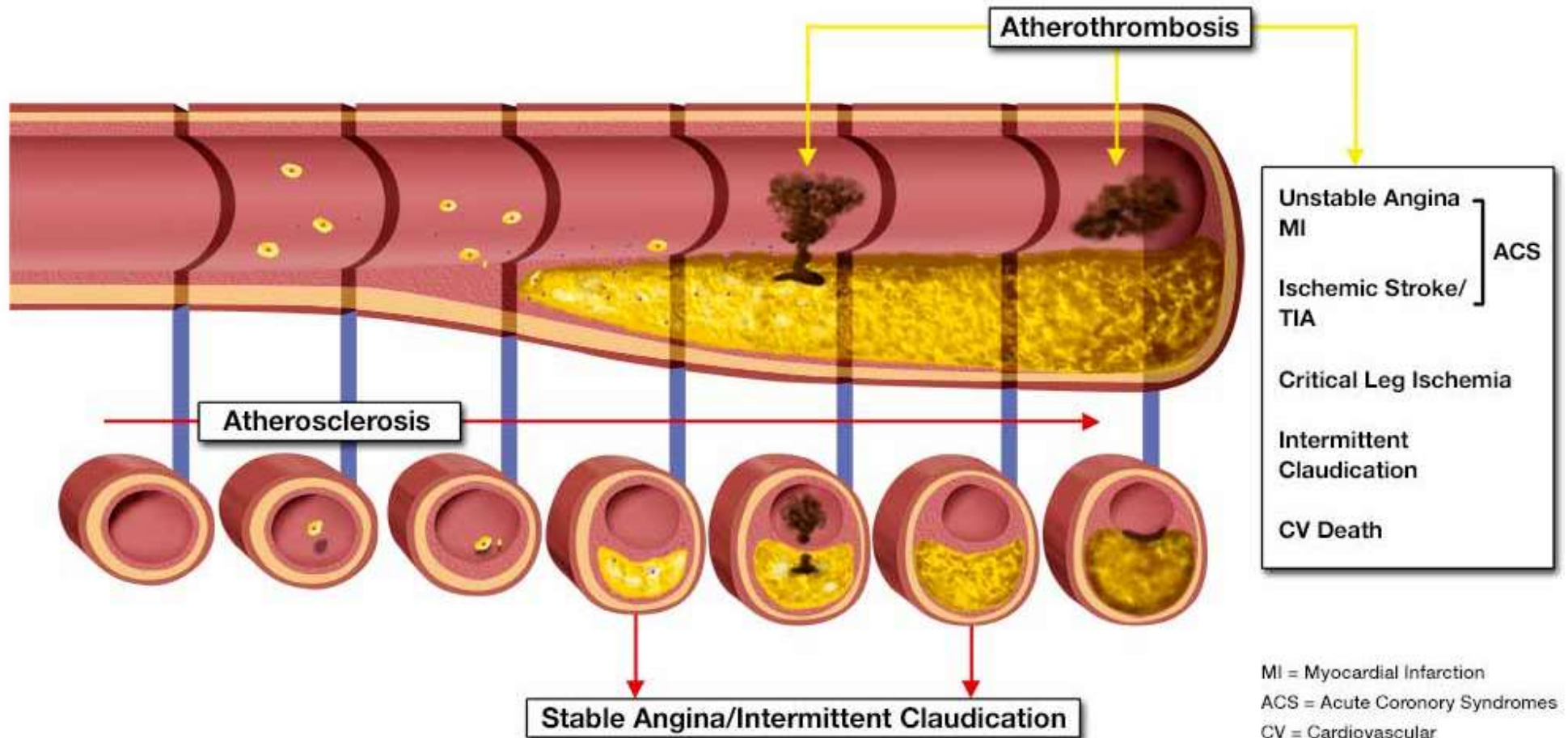


Diagnostic de la maladie coronaire SPECT & TEP

François ROUZET

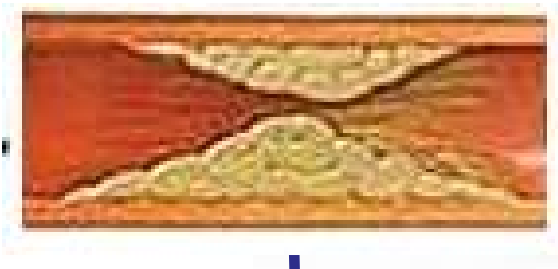
- Service de Médecine Nucléaire, GH Bichat-Claude Bernard, APHP
- Université Paris Diderot
- Inserm U1148 (LVTS)

Athérothrombose



Athérothrombose

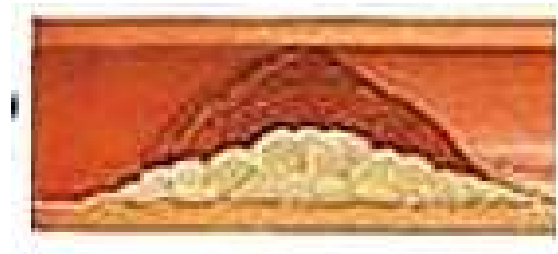
Insuffisance coronaire stable



↓
Sténose (chronique)

↓
Traitement médical
±
Angioplastie programmée

Syndrome coronaire aigu

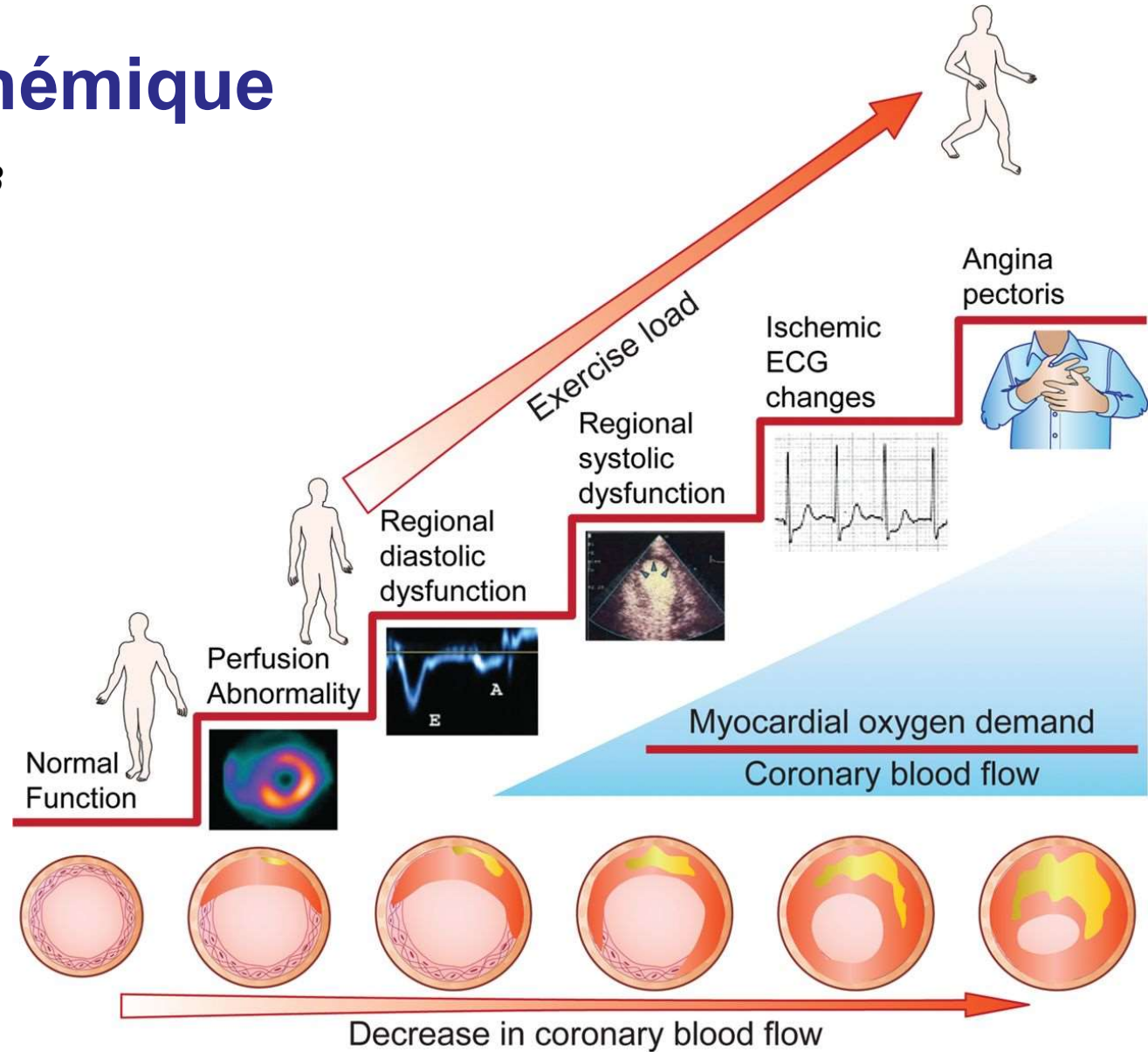


↓
Occlusion (aiguë)

↓
Angioplastie primaire
+
Traitement médical

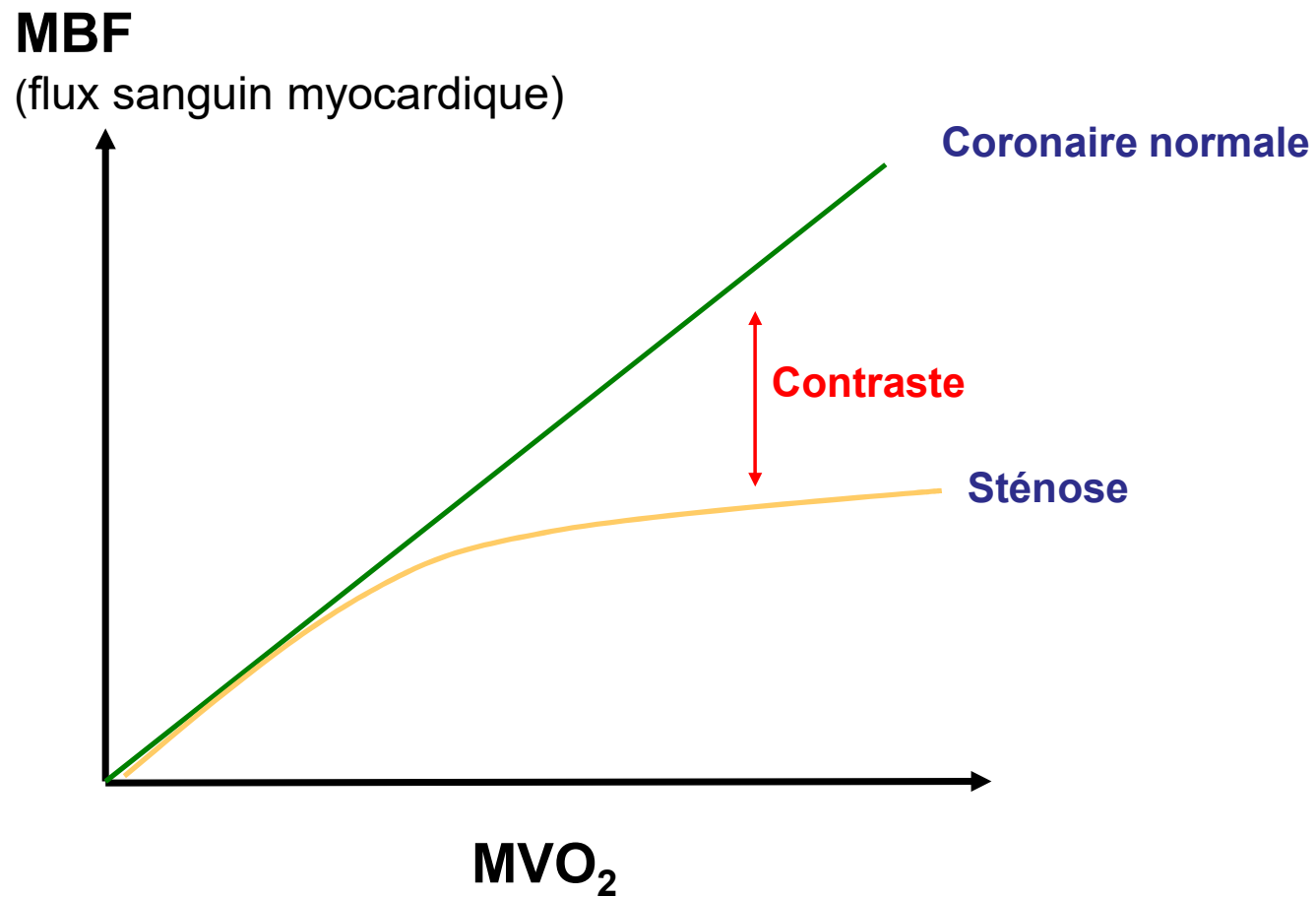
La cascade ischémique

Gaemperli et al, Eur Heart J 2013



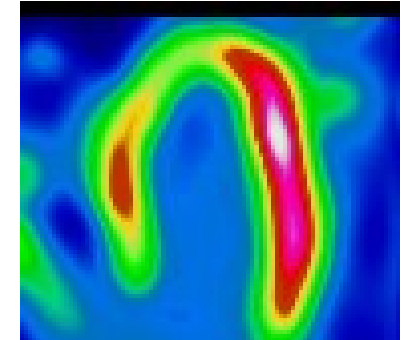
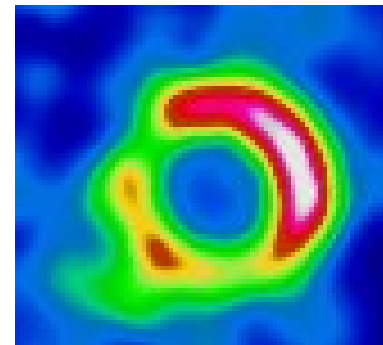
Ischémie myocardique

Déséquilibre entre la demande en O_2 et les apports



Anatomie vs. hémodynamique

Pourquoi a-t-on besoin d'évaluer la perfusion myocardique alors que la coronarographie permet de connaître l'anatomie des coronaires ?

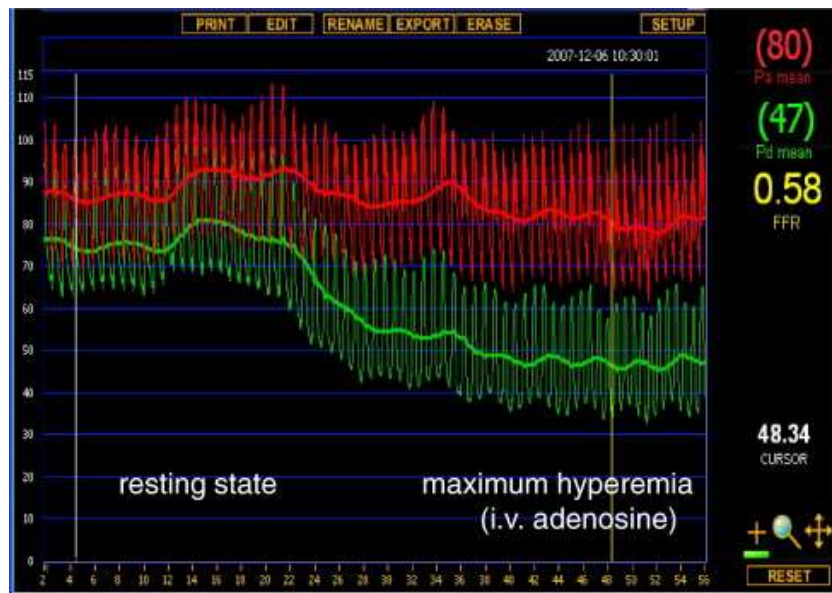
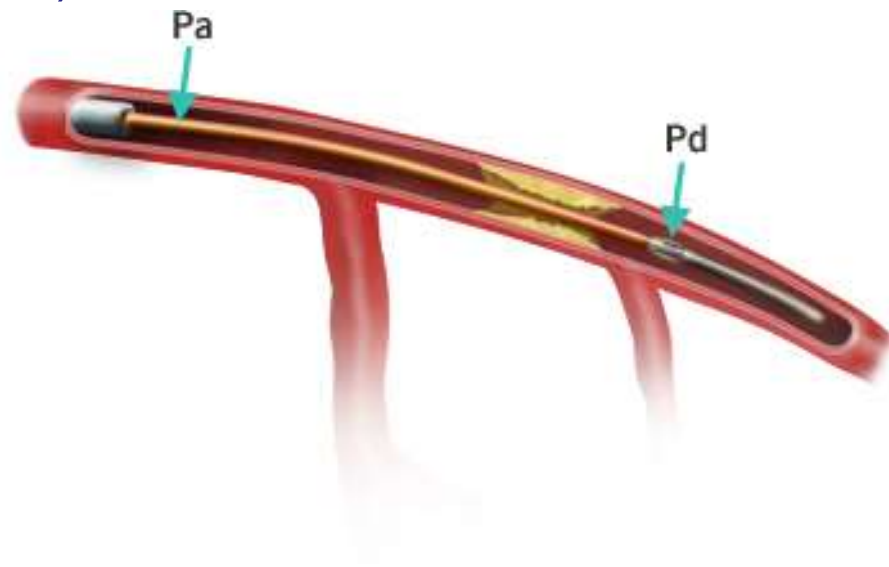


Anatomie vs. hémodynamique

Fractional Flow Reserve (FFR)

$$\text{FFR} = \frac{\text{Distal Coronary Pressure (Pd)}}{\text{Proximal Coronary Pressure (Pa)}}$$

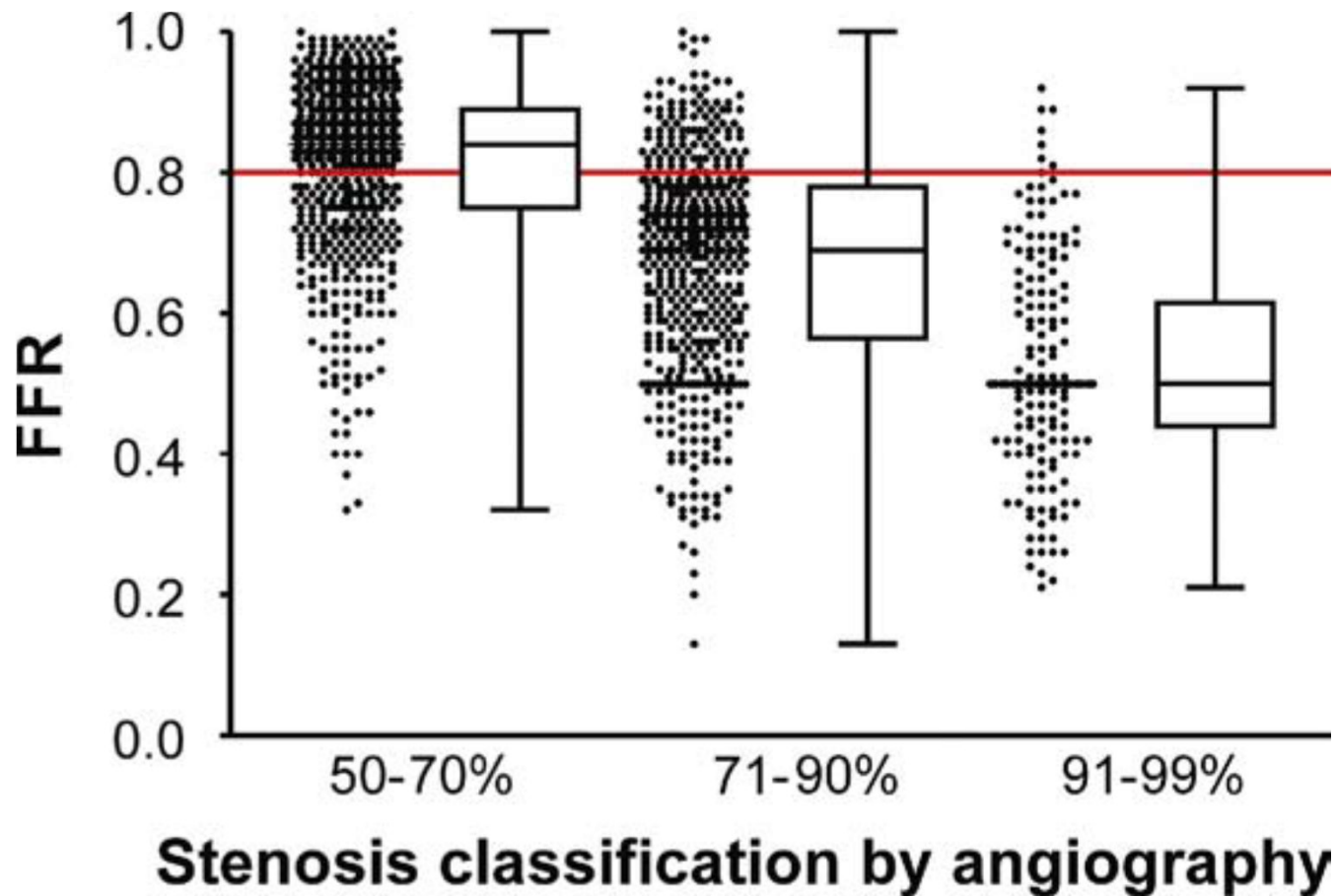
(During Maximum Hyperemia)



**Pas de retentissement
hémodynamique si :**

FFR >0,8

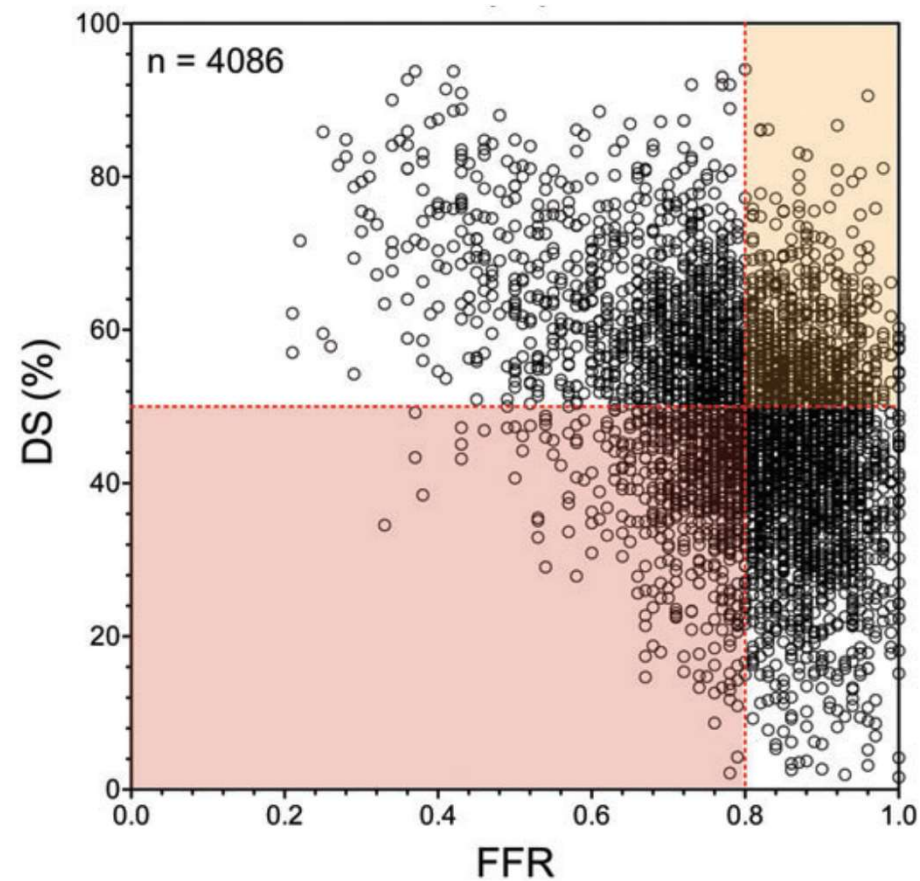
Anatomie vs. hémodynamique



Tonino et al, JACC 2010

Anatomie vs. hémodynamique

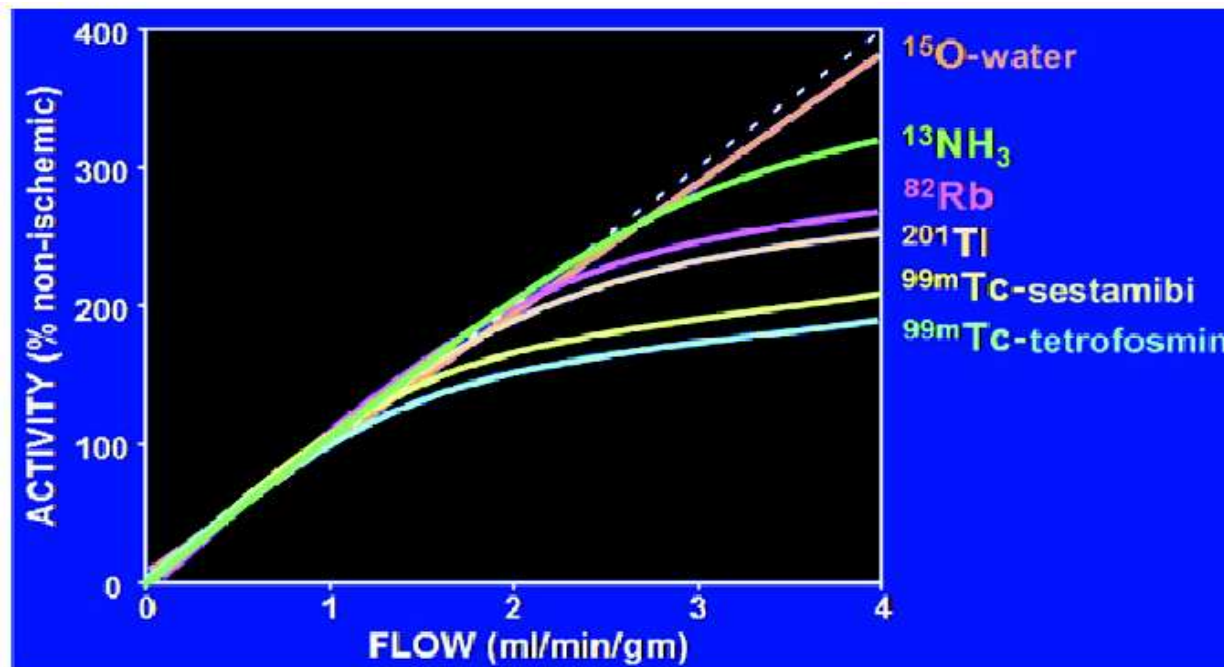
Discordance anatomie / hémodynamique



Toth et al, Eur Heart J 2014

Perfusion myocardique

La captation myocardique du traceur doit être proportionnelle au débit sanguin local



- Une altération du débit sanguin local va se traduire par une diminution de l'intensité de la fixation myocardique du traceur

Perfusion myocardique : SPECT

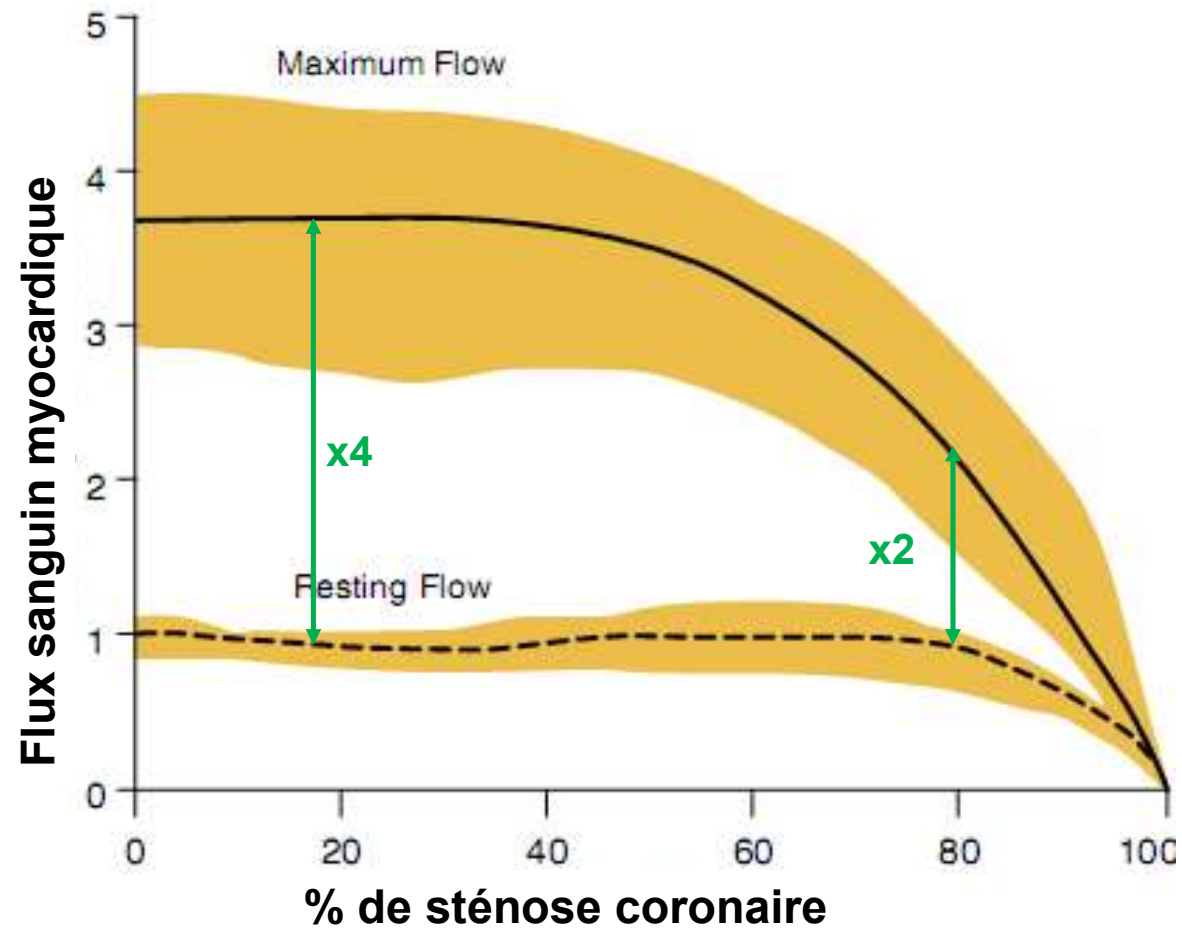
Radiotraceurs (TEMP)

	Thallium-201	Marqués au ^{99m} Tc
mécanisme	Na/K ATPase (analogue K ⁺)	Gradient électrochimique (mitochondries)
extraction	80-90%	40-65%
redistribution	OUI	NON

La captation et la rétention cardiaque de ces traceurs dépendent de :

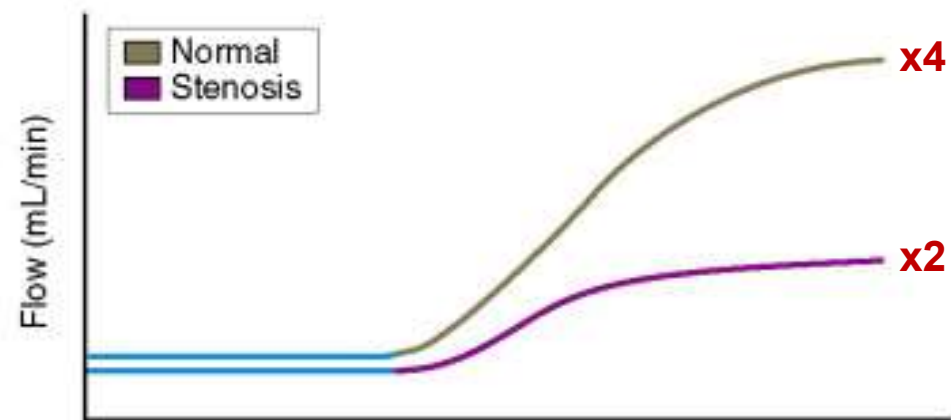
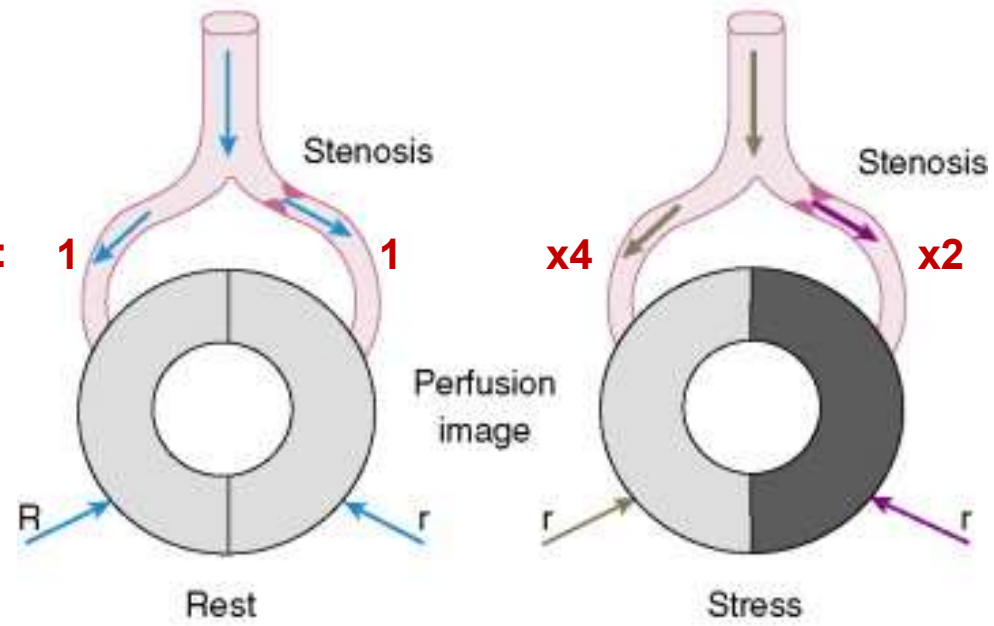
- La **perfusion** (débit sanguin coronaire)
- La **viabilité** des myocytes (capacité à produire de l'ATP)

Réserve coronaire (CFR)



Coronary Artery

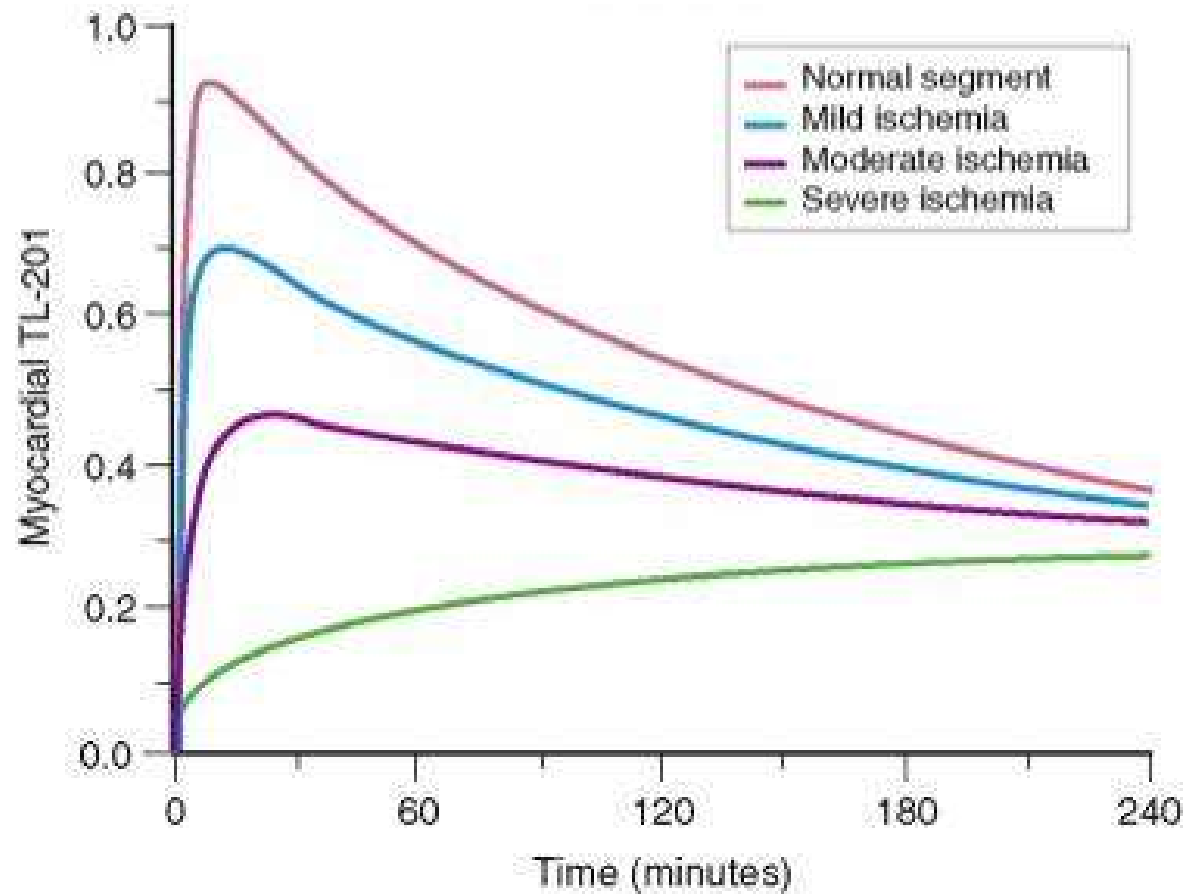
Flux (ml/min/g) :

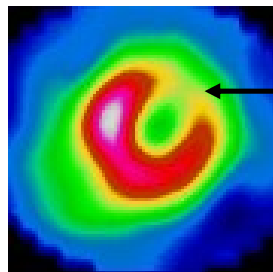
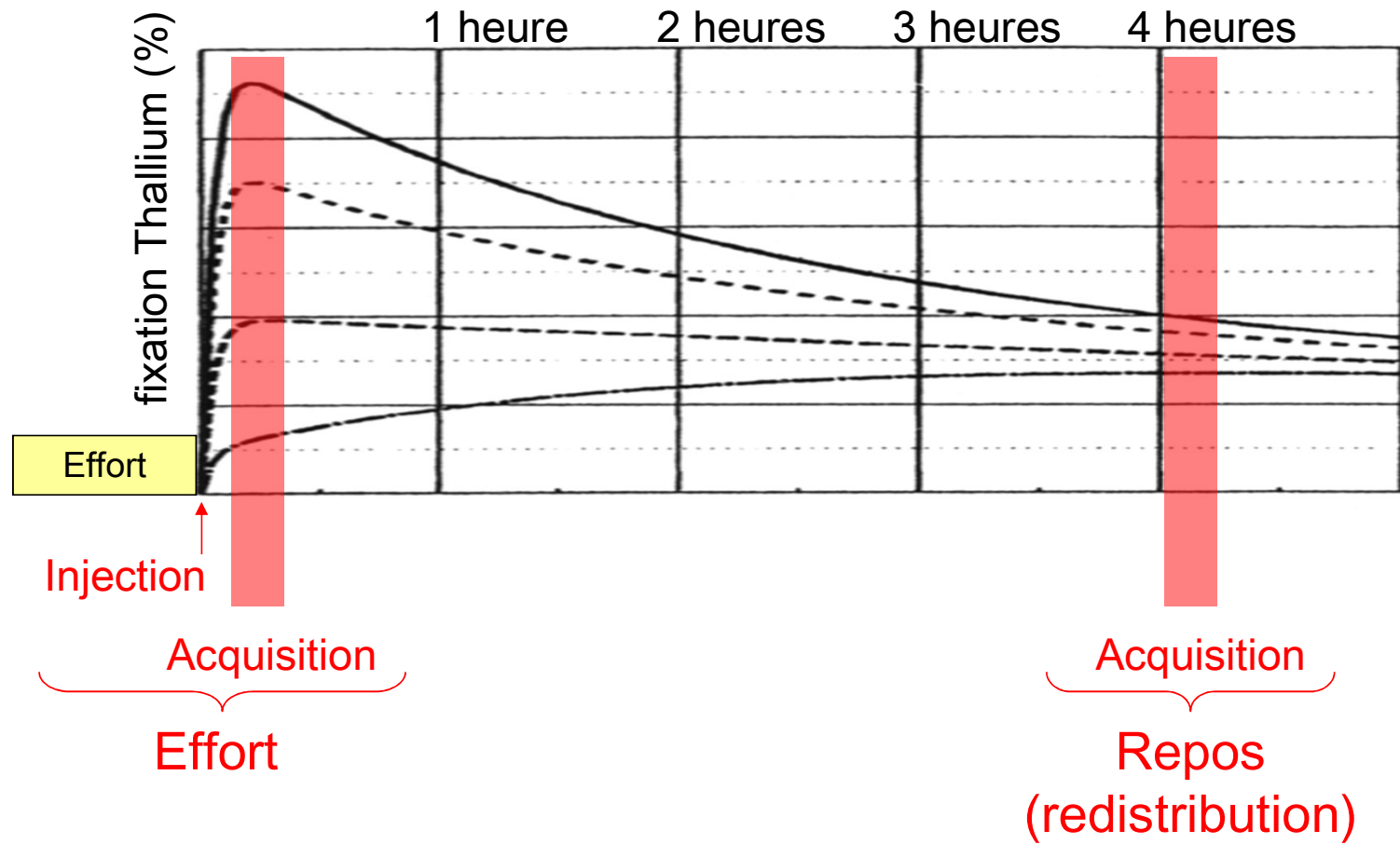


Tests de stimulation

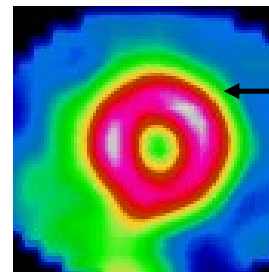
	MVO ₂	Flux
Effort	+++	++
Dobutamine	++	++
Vasodilatateurs directs Dipyridamole / Adenosine / Regadenoson	0	+++

Redistribution du Thallium



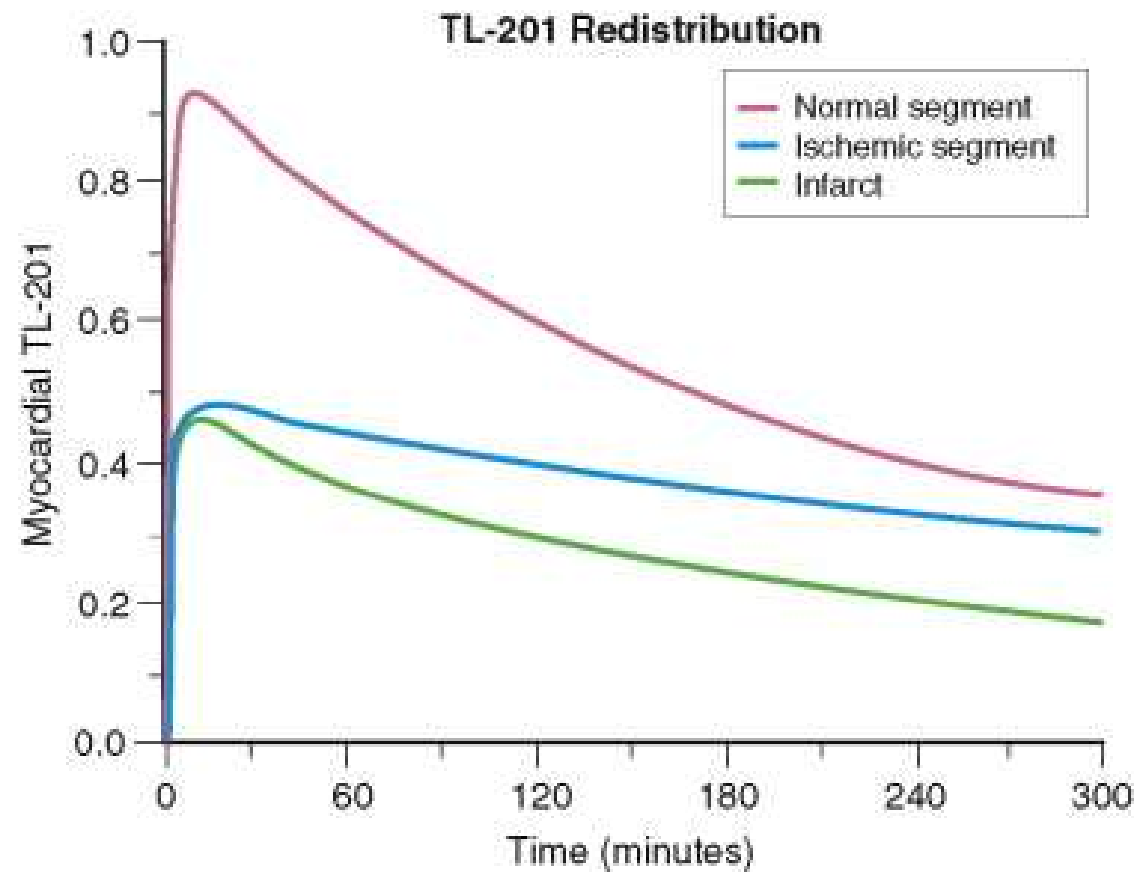


Hypofixation
 focale du
Thallium



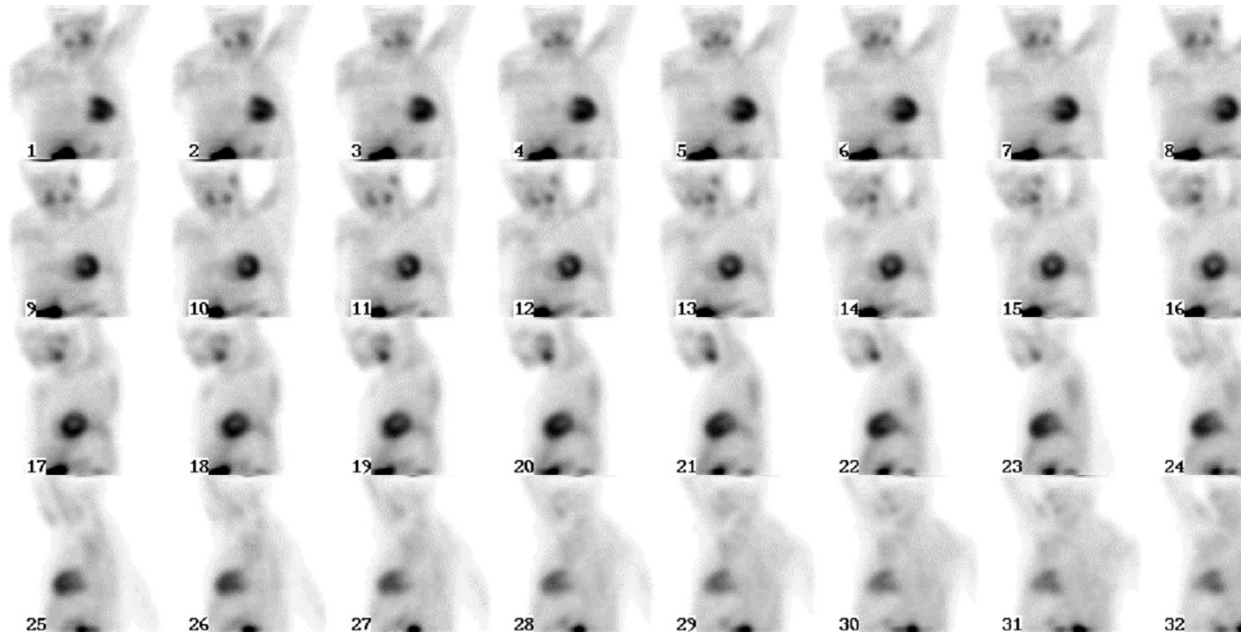
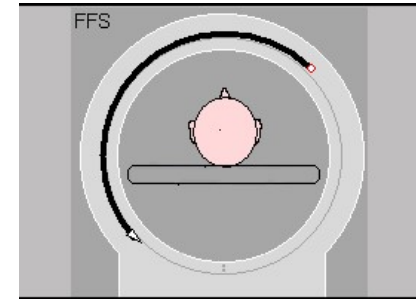
Redistribution

Redistribution du Thallium



Caméras conventionnelles

- images planaires successives / 180° (15 min)
- Reconstruction → tomographies (SPECT)

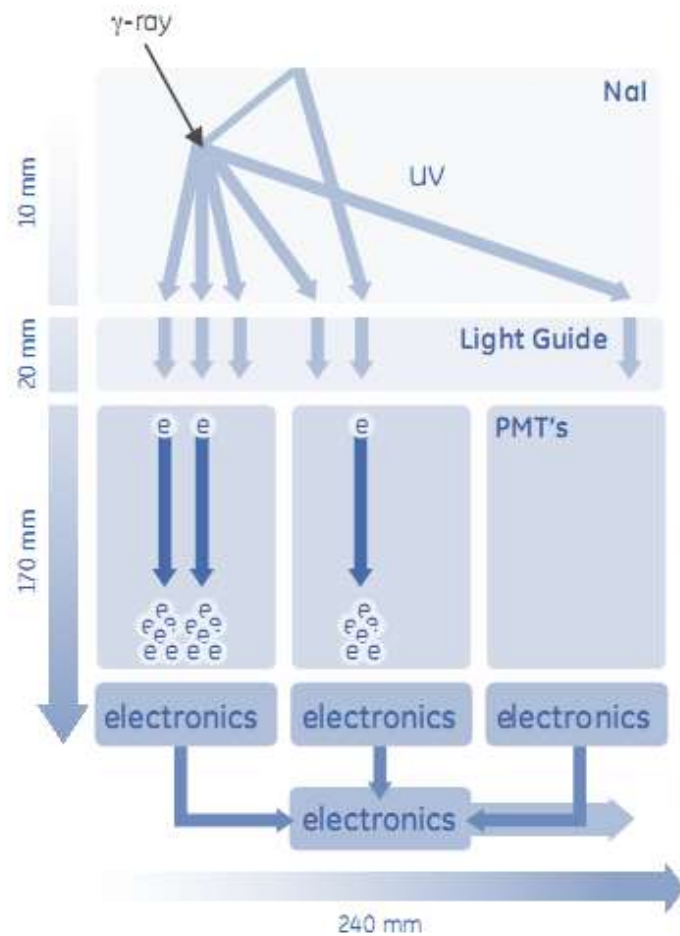


Caméras de nouvelle génération (CZT)

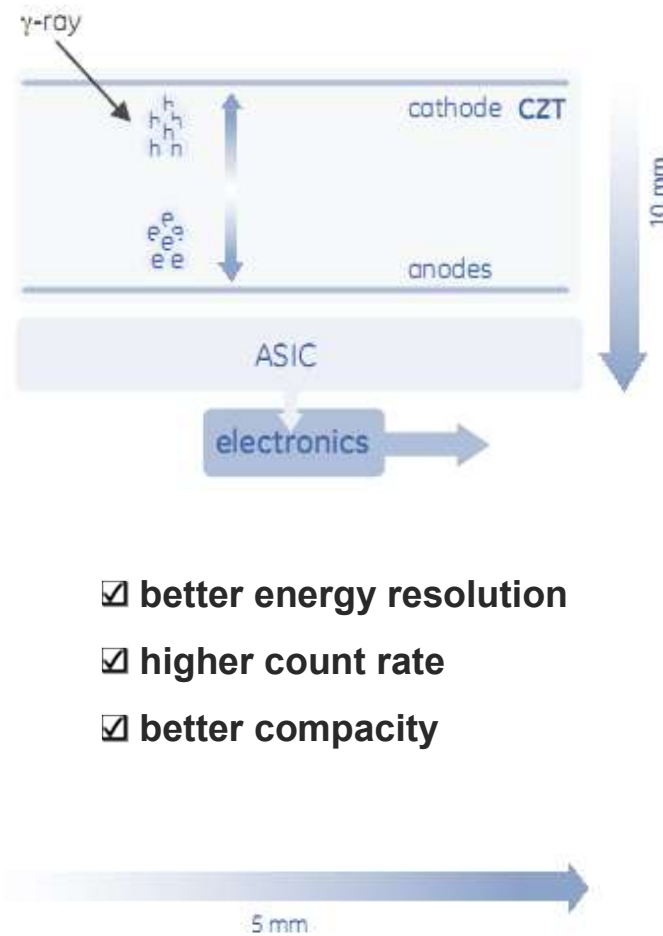
Acquisition 3D centrée sur le coeur



Scintillation detector



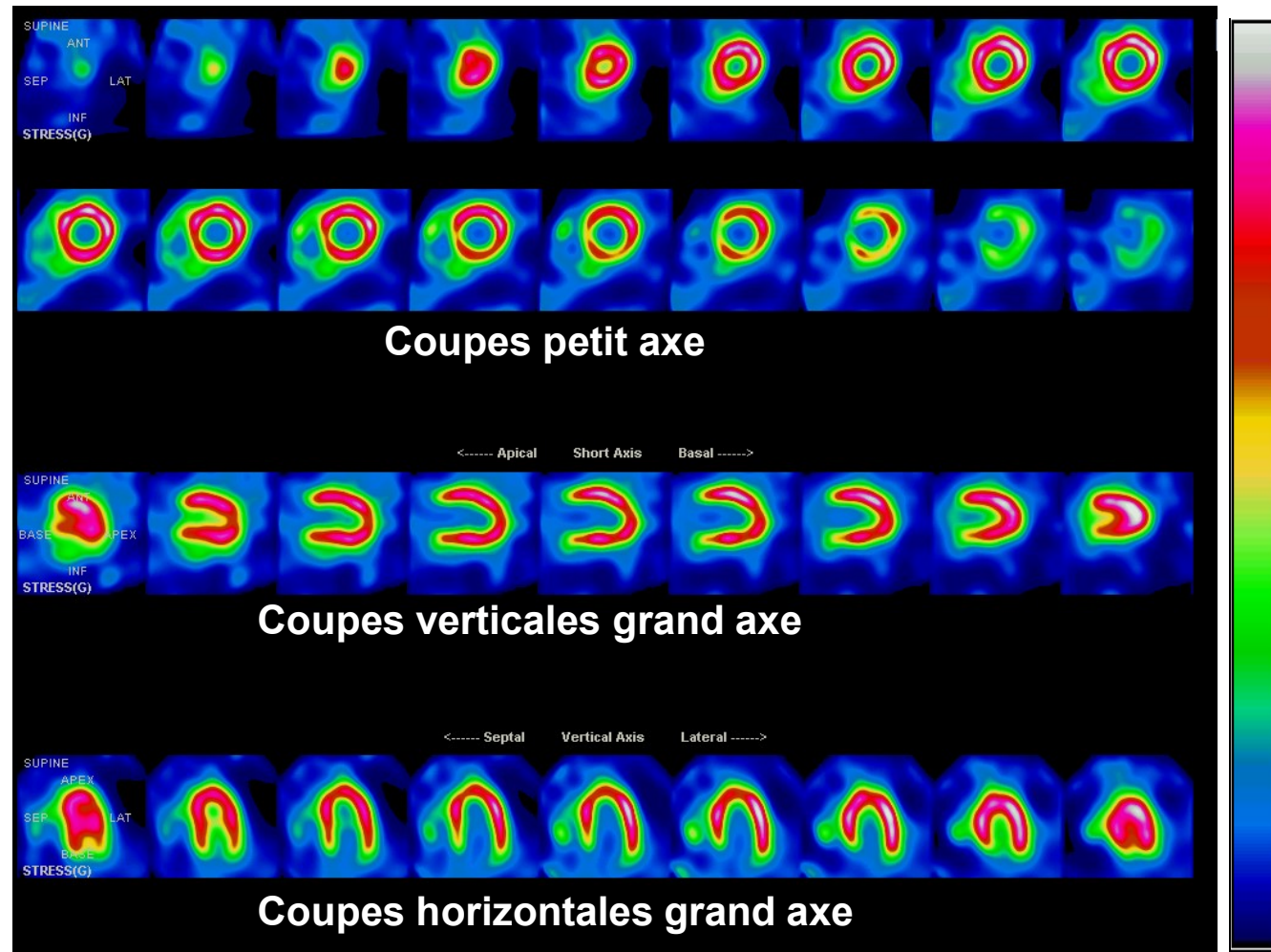
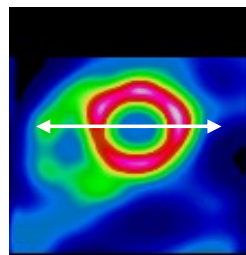
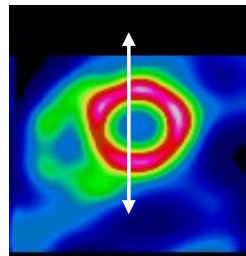
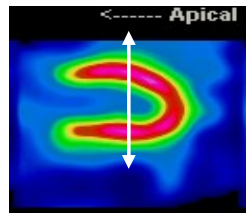
Solid-state detector (CZT)



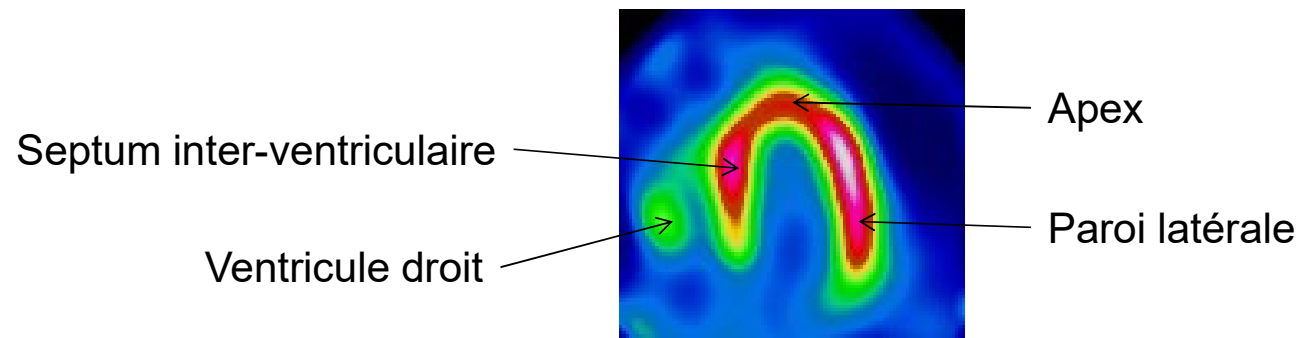
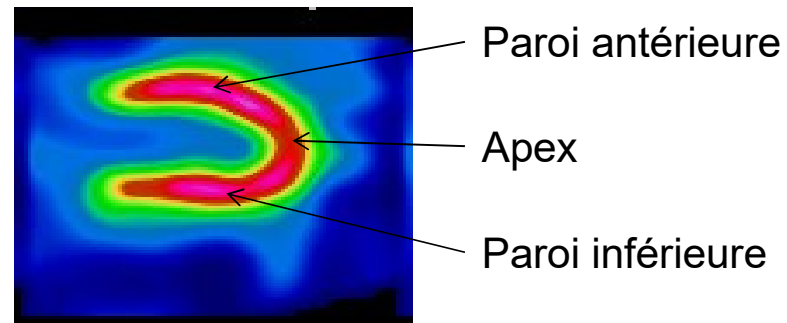
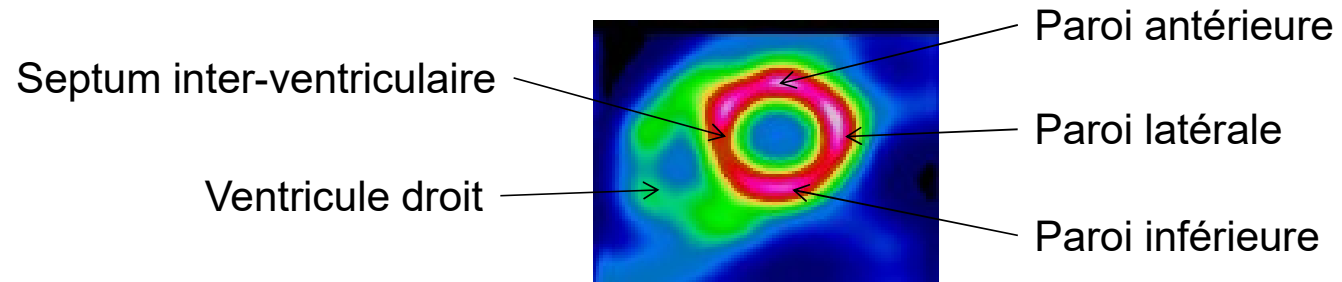
- ✓ better energy resolution
- ✓ higher count rate
- ✓ better compacity

Courtesy GEMS

Examen normal

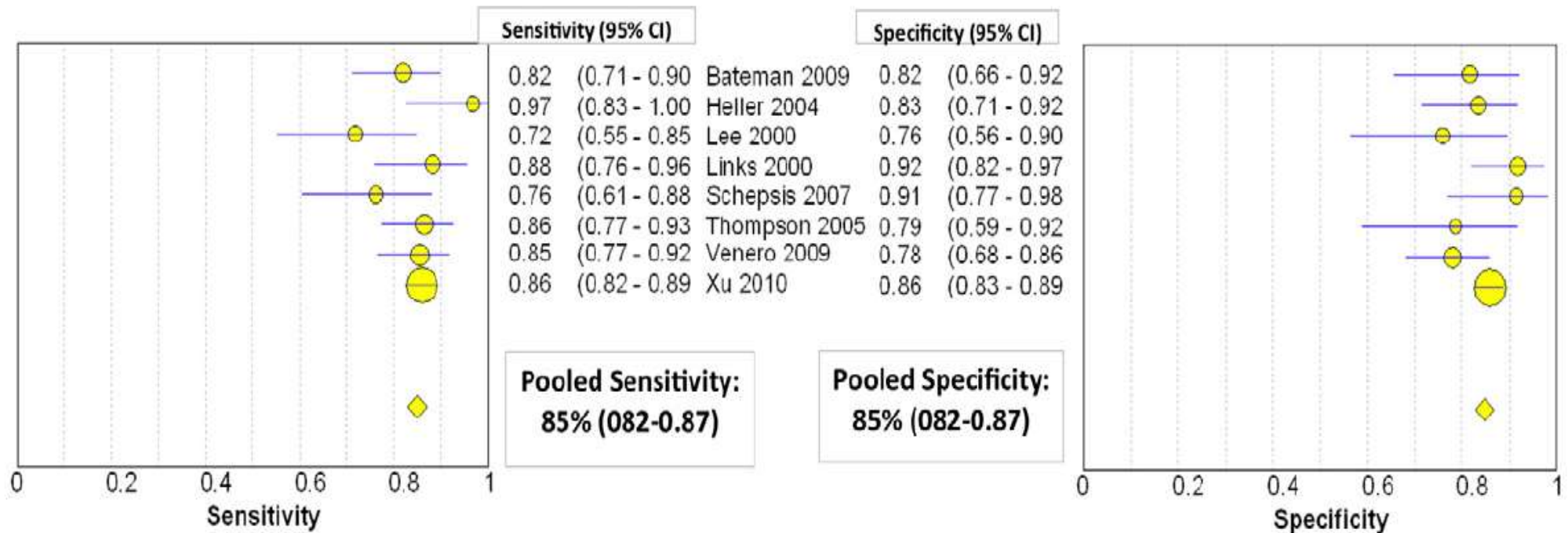


Les parois du ventricule gauche



Valeur diagnostique de la SPECT

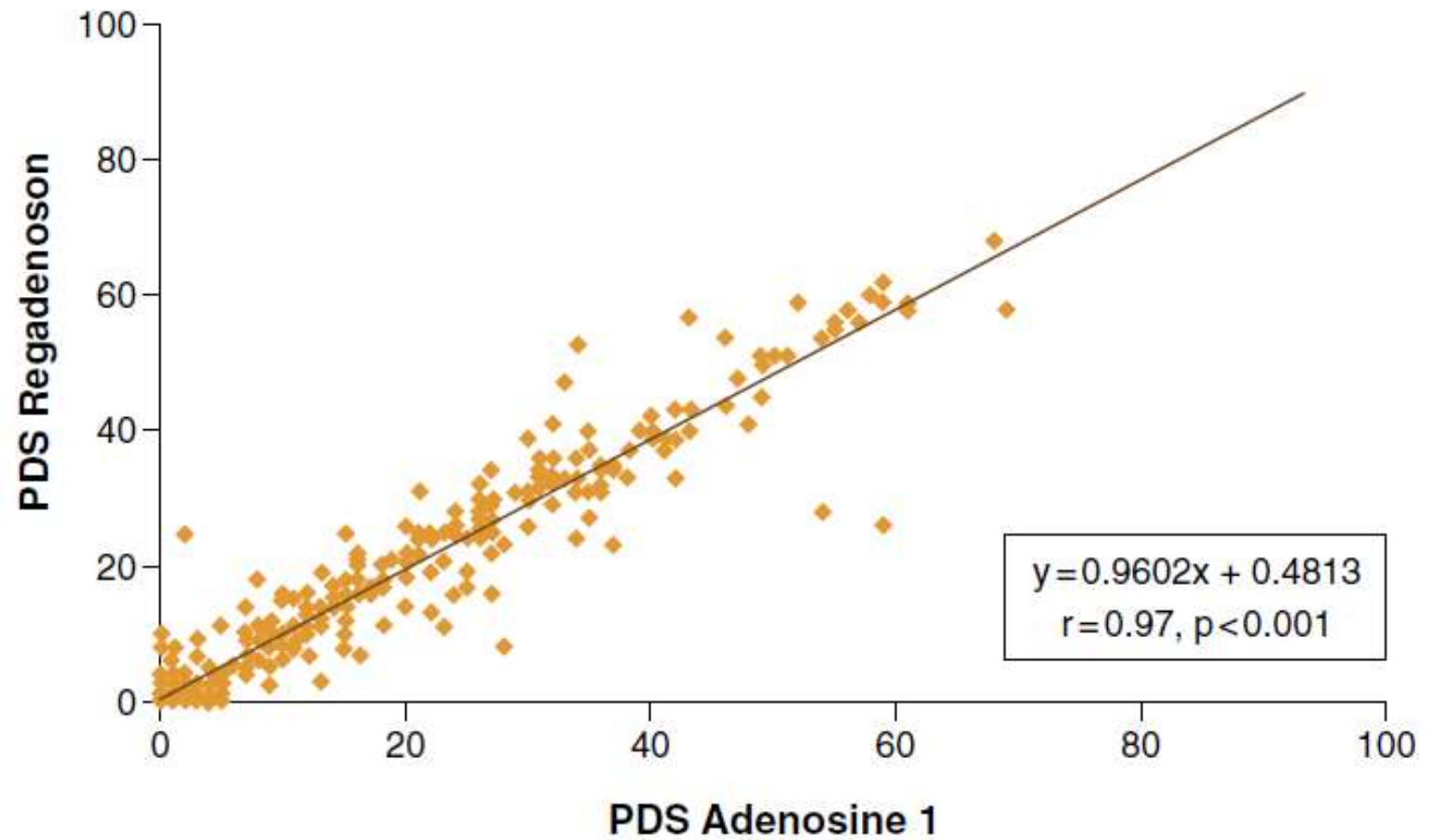
8 études (2000-2012), 1755 patients, vs. coronarographie



Mc Ardle et al, J Am Coll Cardiol 2012

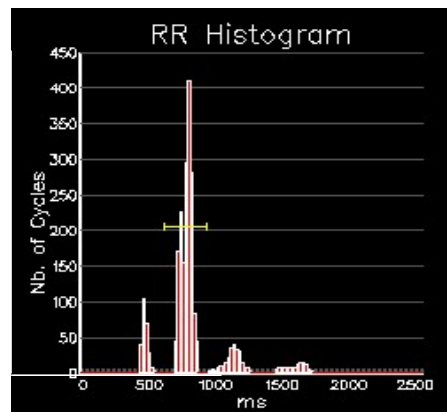
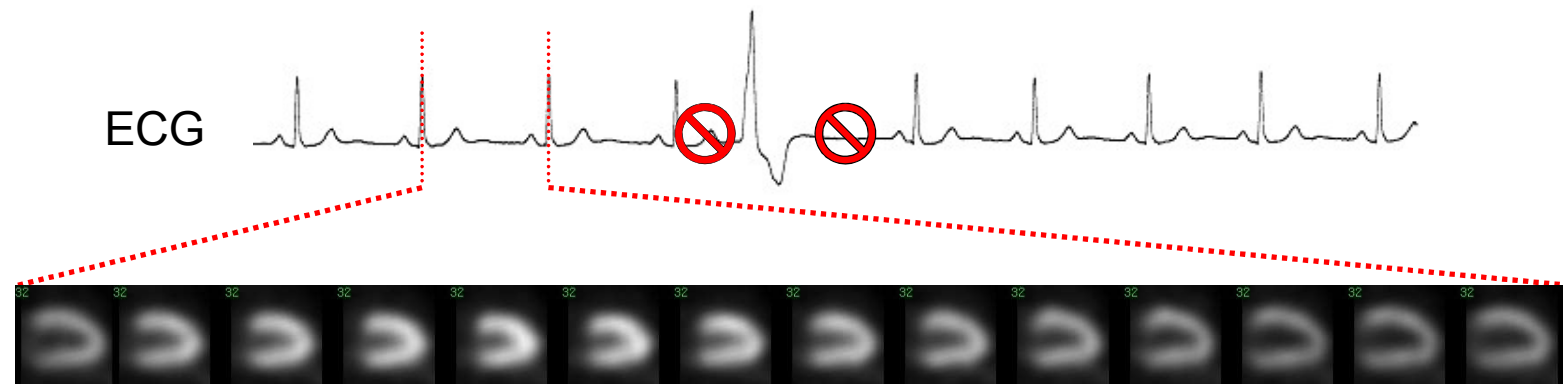
Reproductibilité

ADVANCE MPI 2 trial (Mahmorian P et al, iJACC 2009)



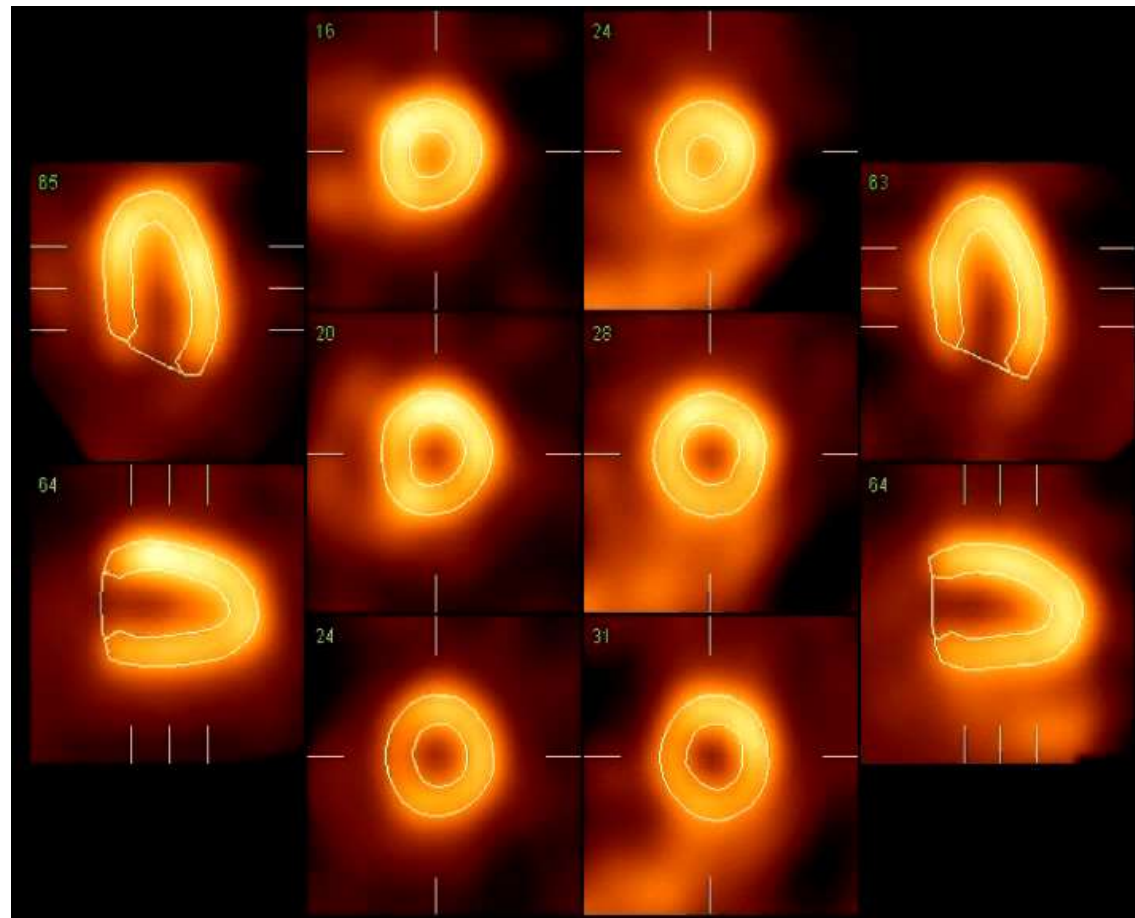
PDS: perfusion defect size

Synchronisation à l'ECG



Analyse de la cinétique

²⁰¹Tl stress

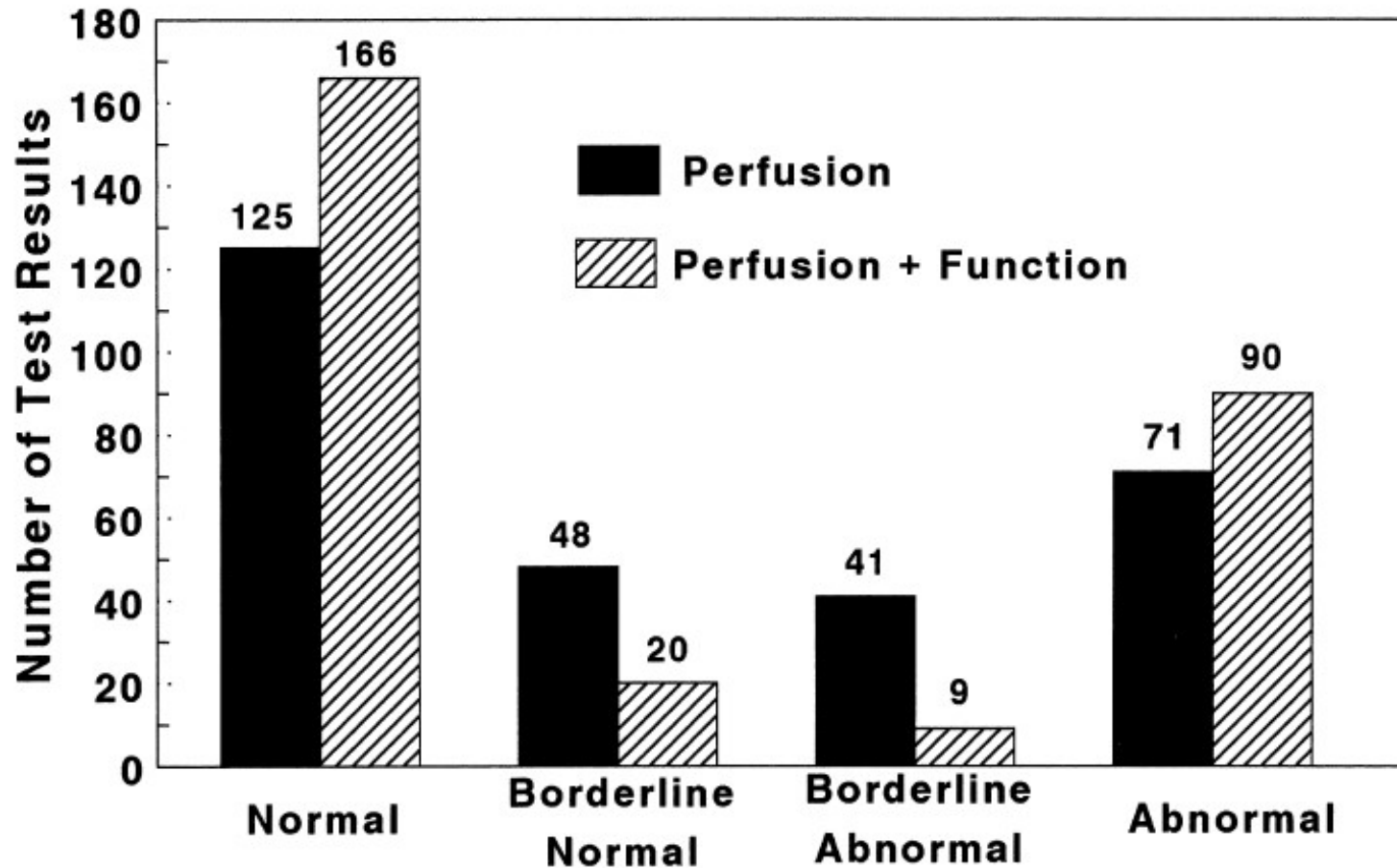


MIBI rest

Study	1
Dataset	STRESS(G)
Date	2010-07-05 10:44:25
Volume	29ml [1]
EDV	69ml [6]
ESV	26ml [2]
EF	62%
Area	80cm² [1]

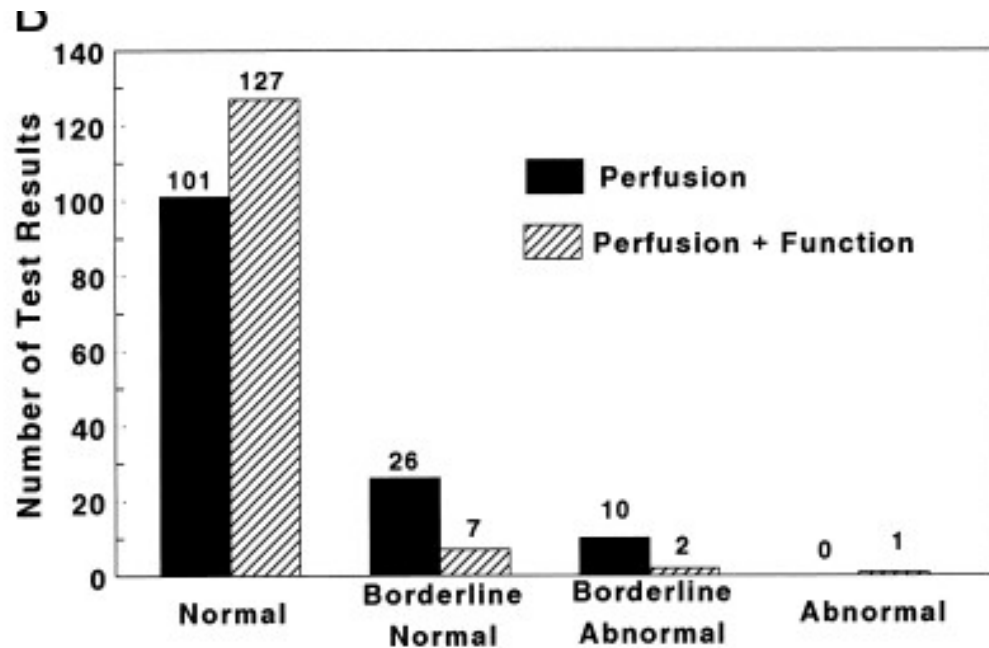
Study	1
Dataset	REST(G)
Date	2010-07-05 12:12:39
Volume	28ml [1]
EDV	75ml [6]
ESV	26ml [2]
EF	66%
Area	77cm² [1]

Additional value of gated-SPECT

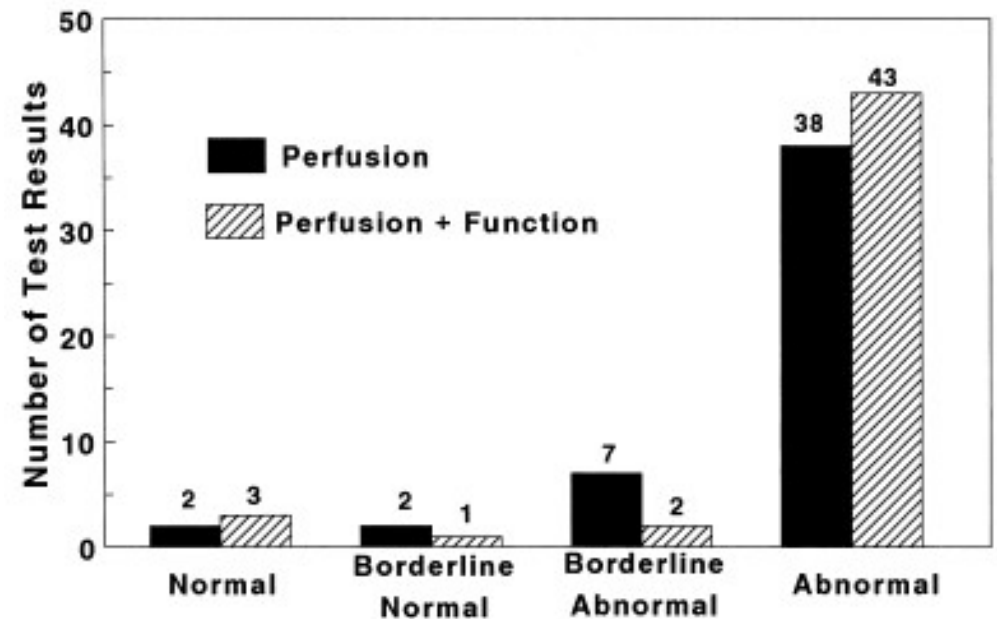


Smanio PE et al, J Am Coll Cardiol 1997

Additional value of gated-SPECT



<10% pretest likelihood



Coronary artery disease

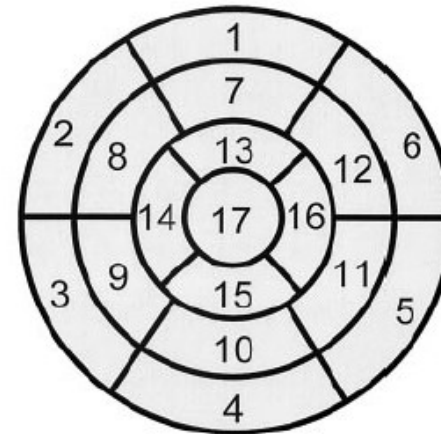
Smanio PE et al, J Am Coll Cardiol 1997

Synthèse : analyse de la SMP

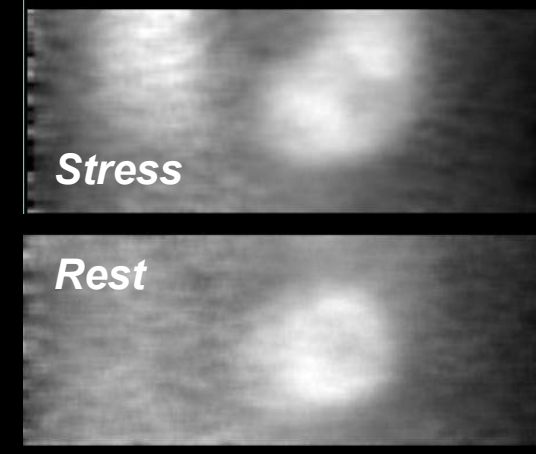
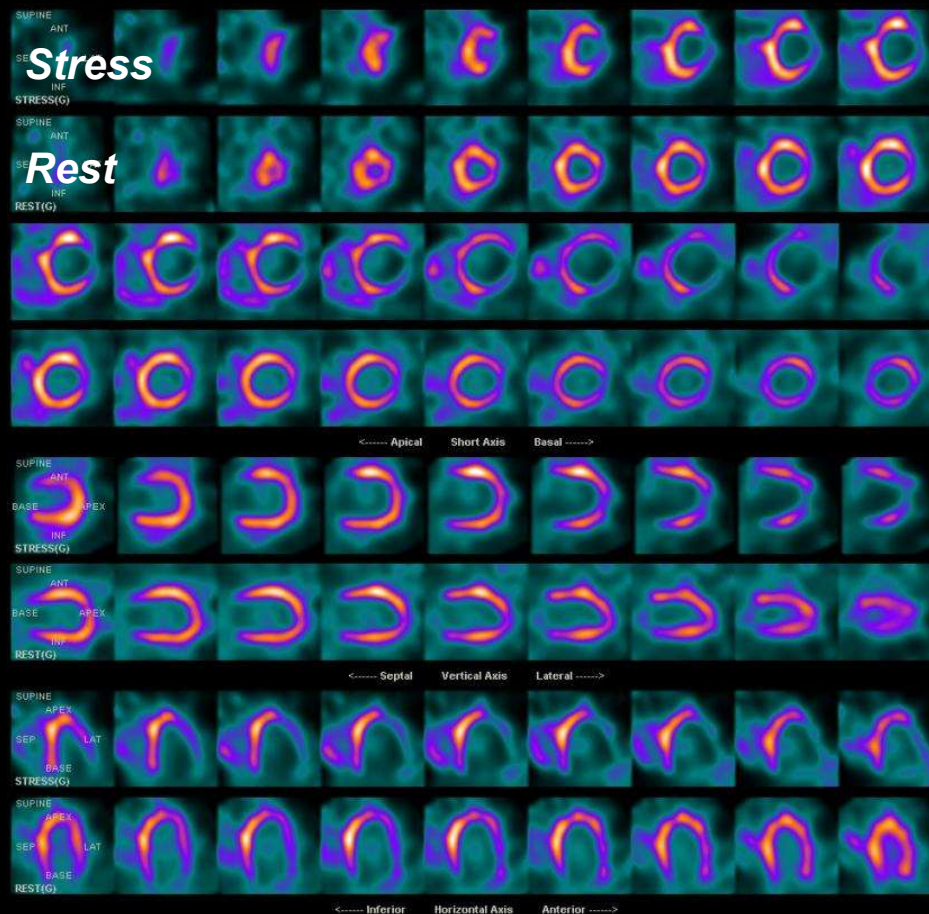
	Perfusion effort	Perfusion repos	Cinétique repos
Normal	normale	normale	normale
Ischémie	abaissée	normale	normale
Nécrose	abaissée	abaissée	abaissée

Synthèse : critères de sévérité

- Etendue du territoire à risque (modèle 17 segments)
 - Dysfonction systolique VG d'effort
 - *atteinte pluri-tronculaire ou IVA proximale*
-
- Altération réversible de la FEVG
 - Signes indirects de dysfonction VG
 - Fixation pulmonaire du Thallium
 - Dilatation ventriculaire gauche réversible
 - Visualisation marquée du VD

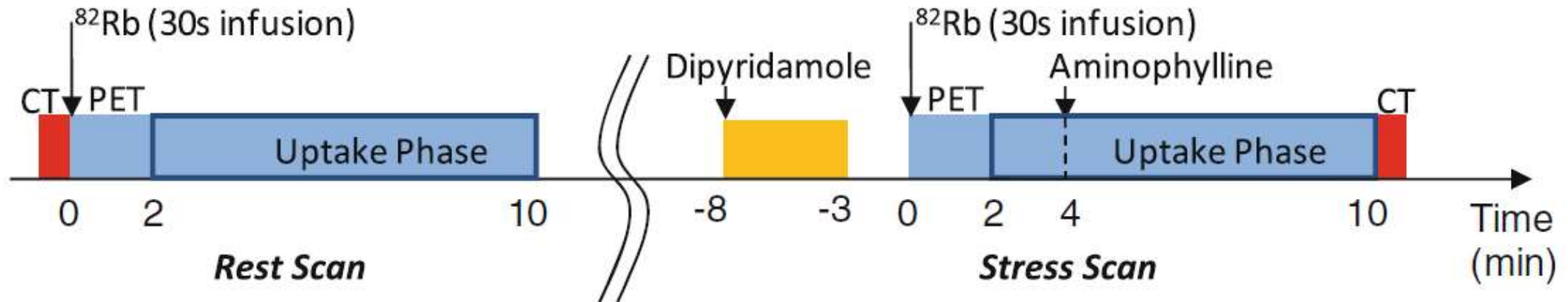


58 year old male
1.78 m / 146 Kg (BMI: 46.1 Kg/m²)
CABG 10 years earlier, shortness of breath
²⁰¹Tl : 131 + 67 MBq



Perfusion myocardique : TEP

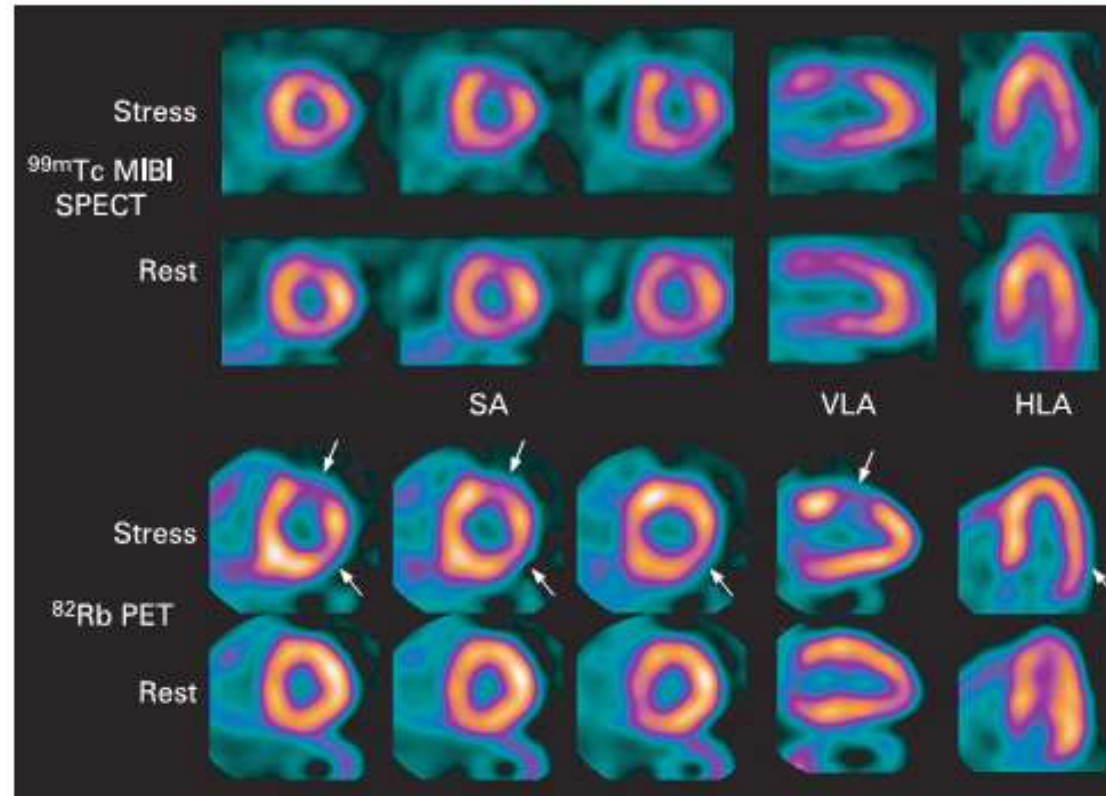
Acquisition protocol with ^{82}Rb



Perfusion myocardique : TEP

SPECT

PET

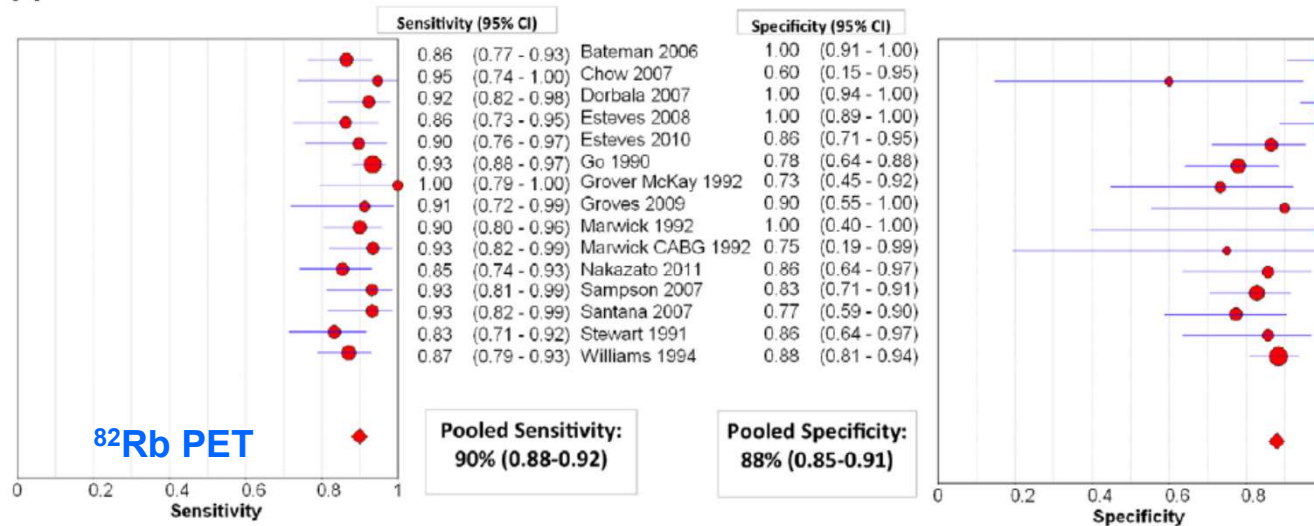


Analyse qualitative : amélioration du contraste entre segments ischémiques et non ischémiques.

Valeur diagnostique

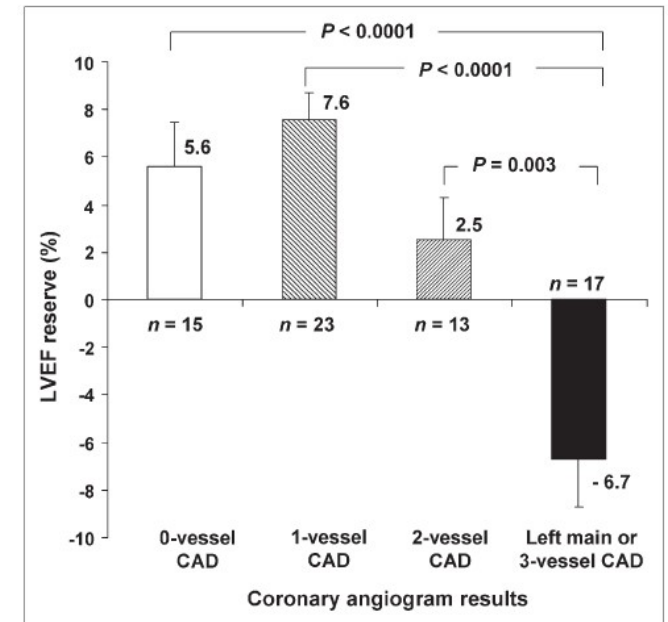
Anomalies perfusionnelles (score segmentaire)

A



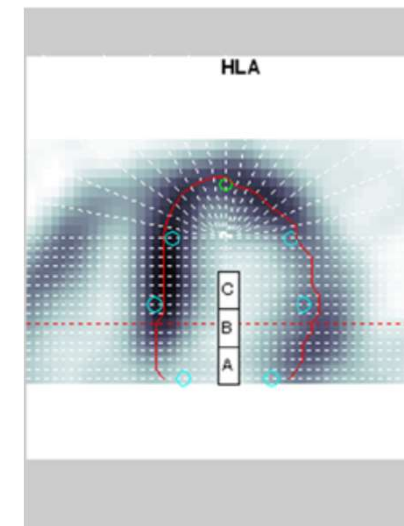
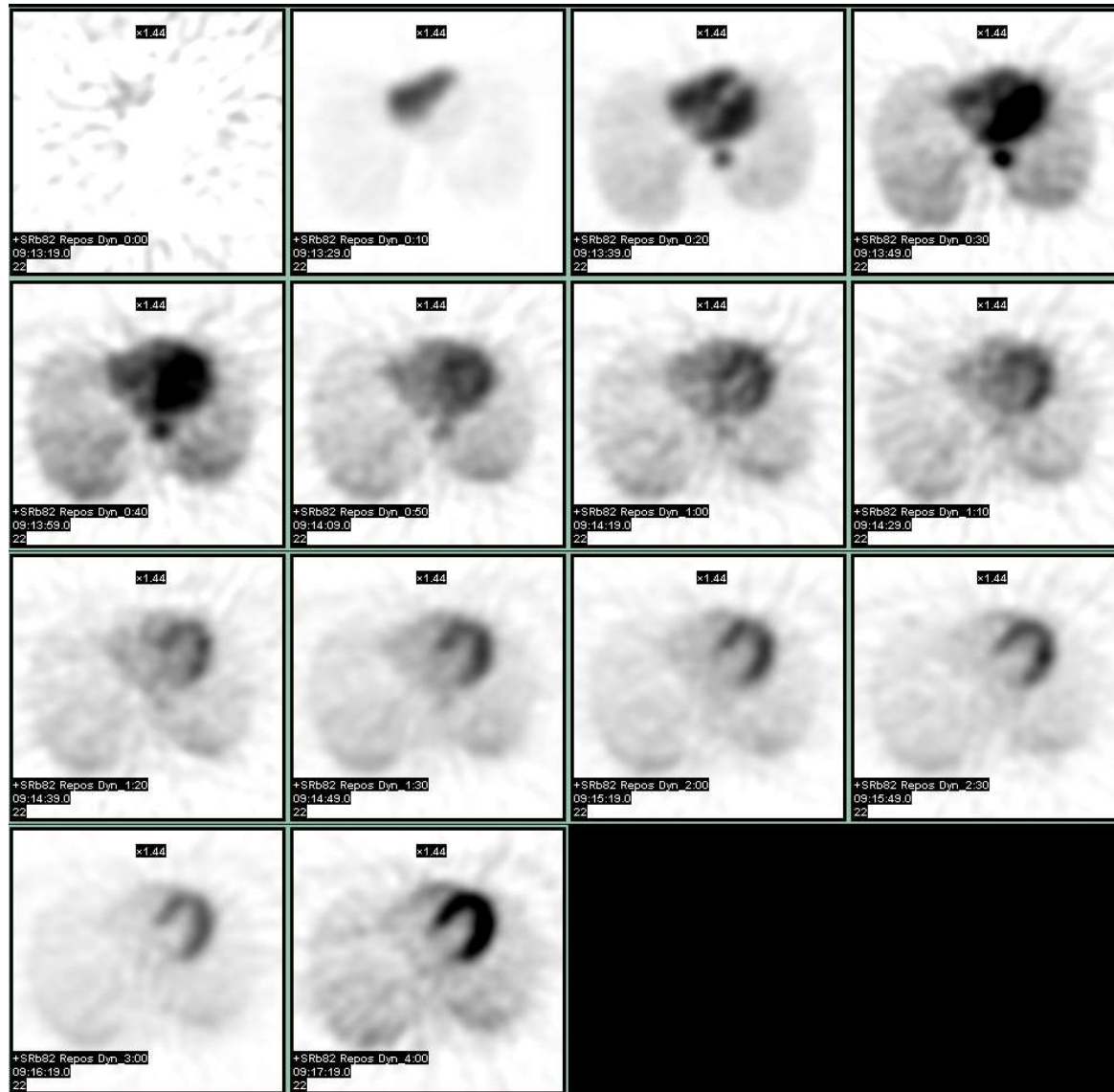
Mc Ardle et al, J Am Coll Cardiol 2012

Δ FEVG

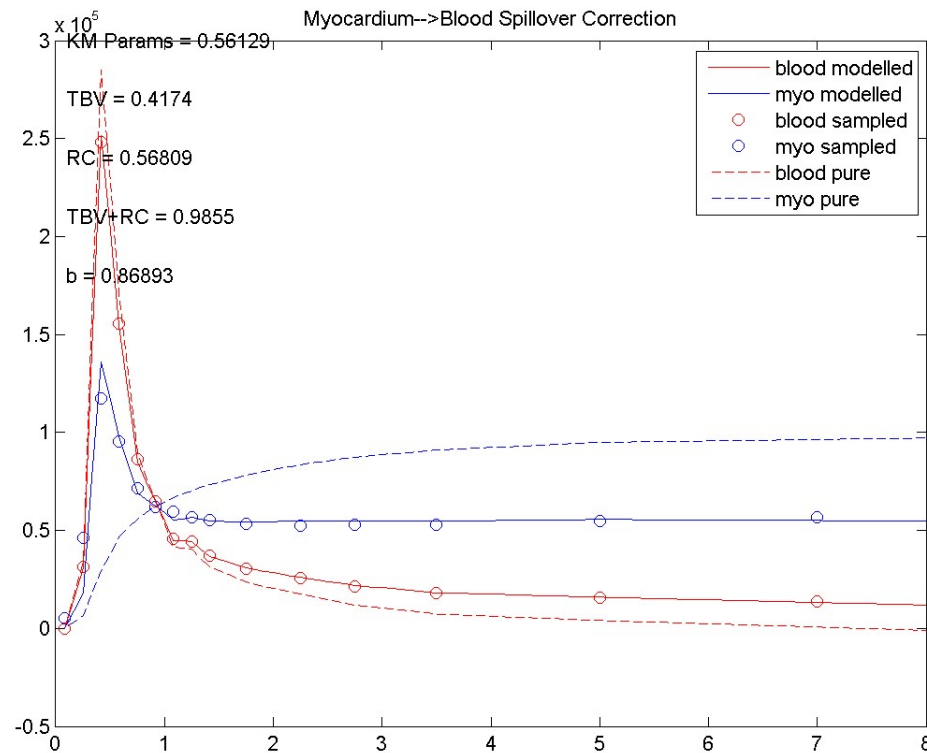


Dorbala et al. J Nucl Med 2007

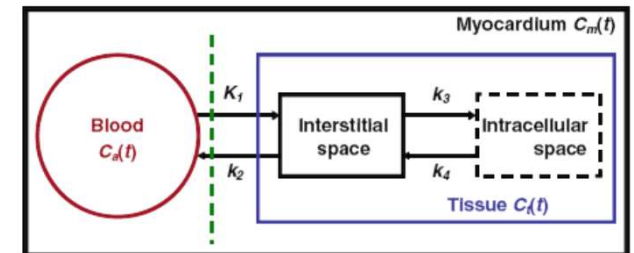
Flux = acquisition dynamique



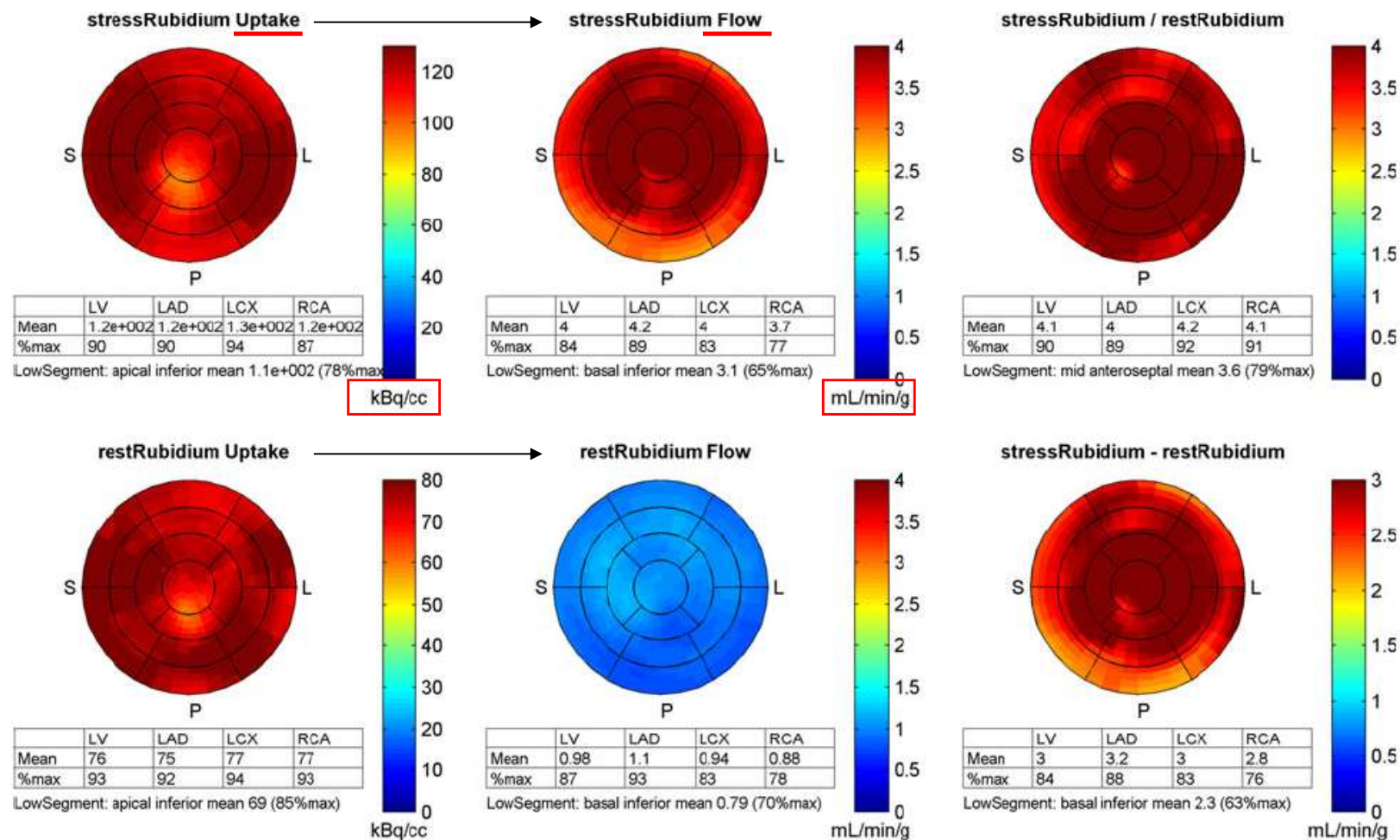
Quantification du flux



Modèle compartimental décrivant les échanges **dynamiques** de l'activité entre le sang et le myocarde

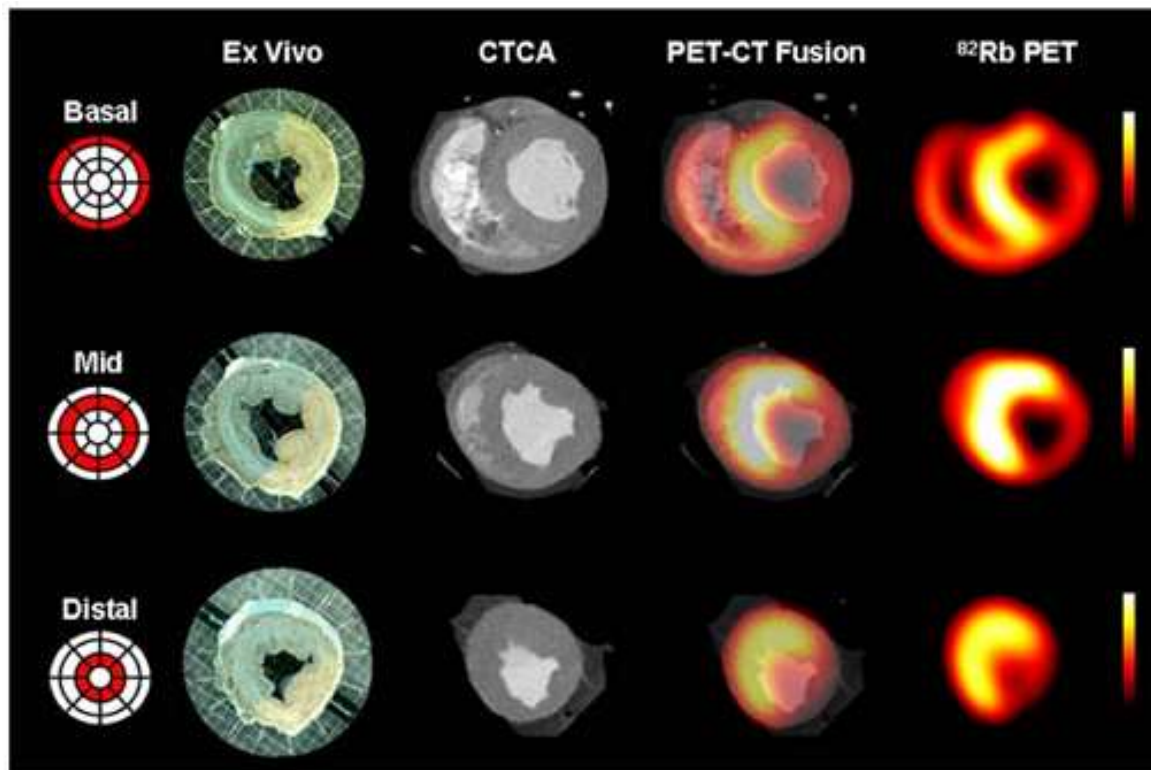


Klein R et al., J Nucl Cardiol 2010

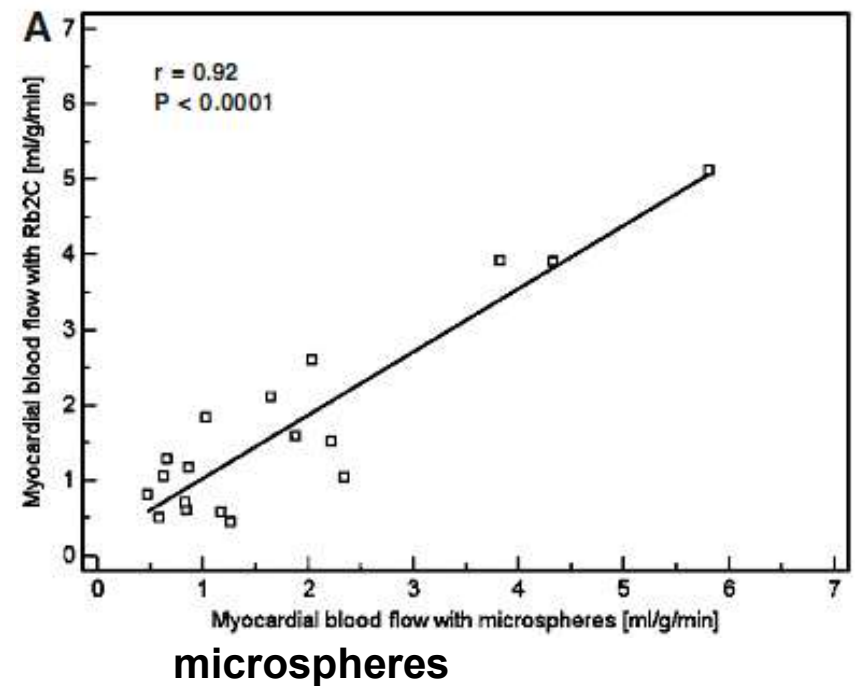


Perfusion myocardique en TEP

Absolute quantification of blood flow with PET



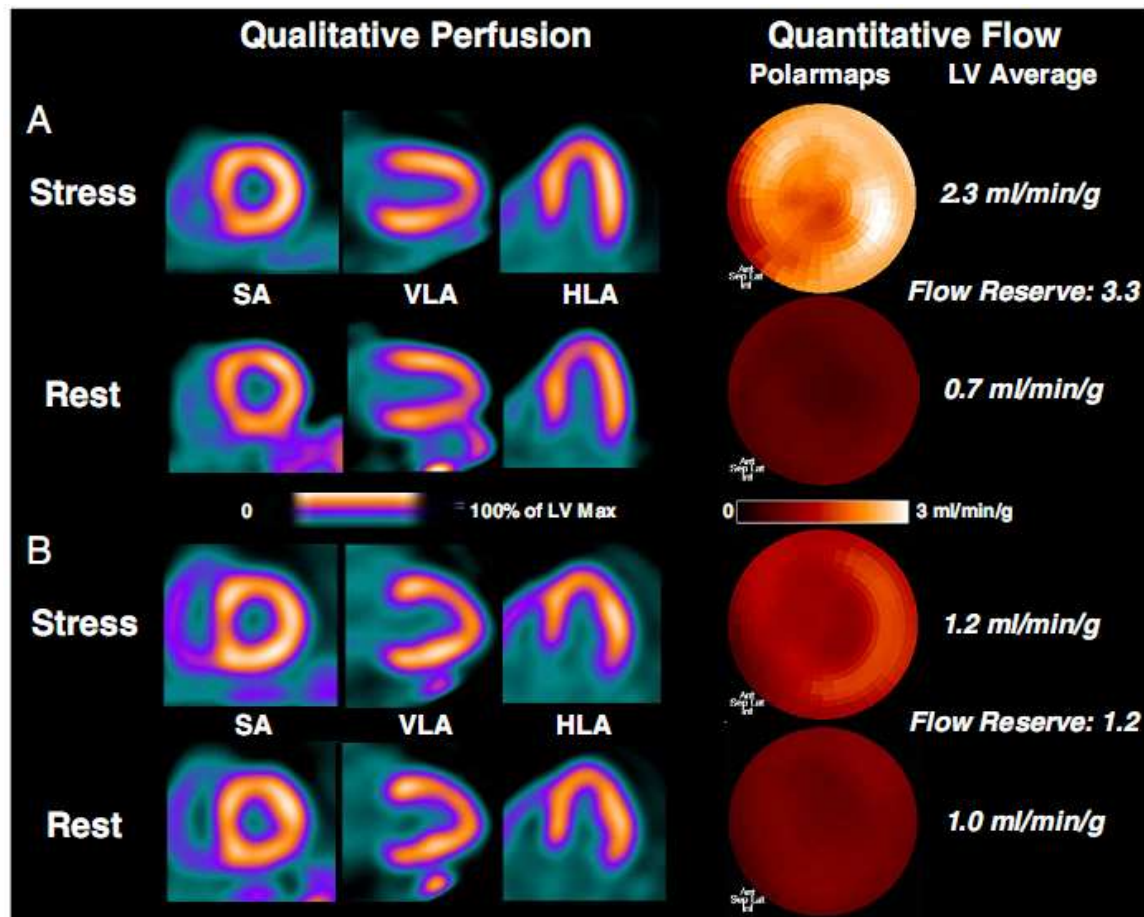
^{82}Rb uptake



Lautamaki et al., EJNM 2007

Quantification du flux

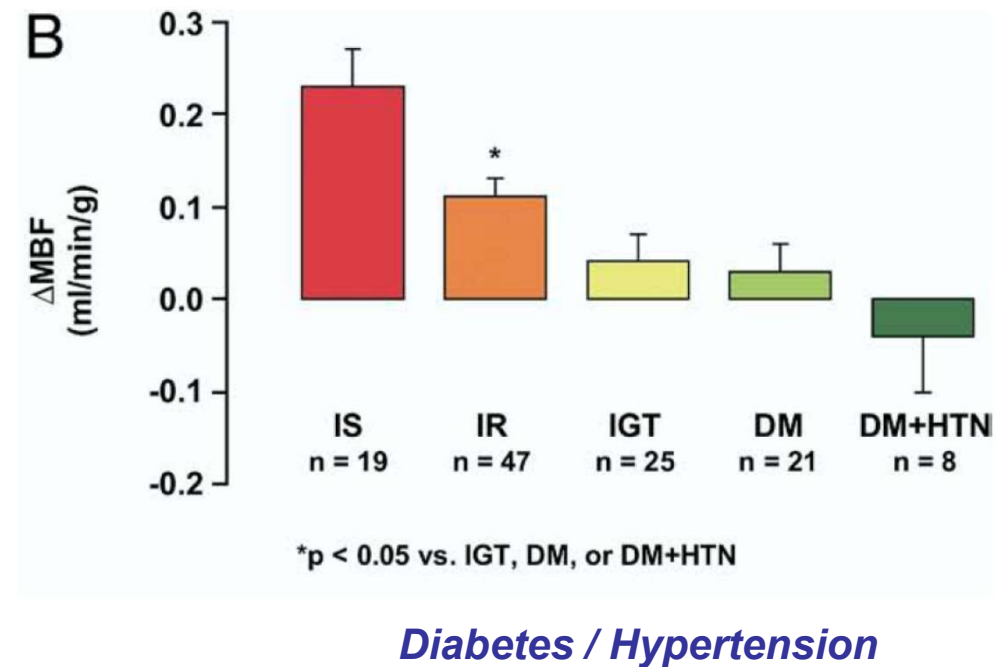
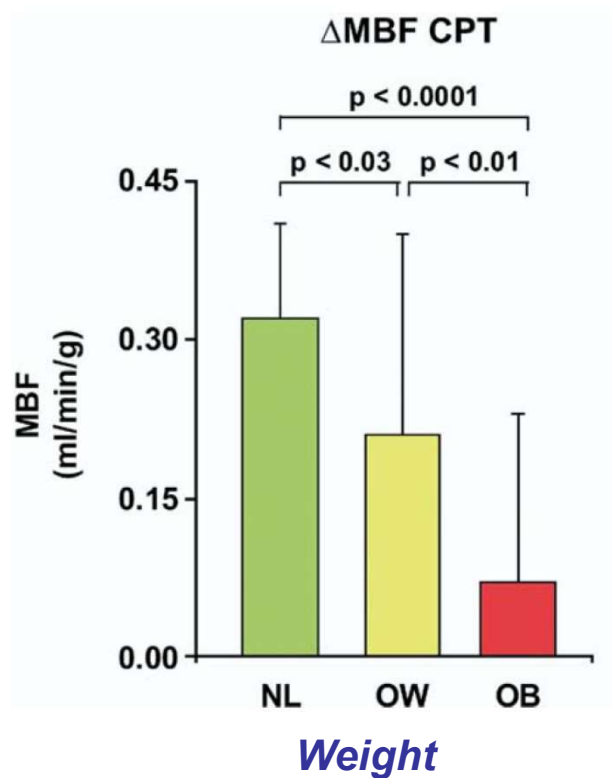
Quantification absolue du flux sanguin en TEP



Normal

Ischémie équilibrée

Microvascular dysfunction and risk factors



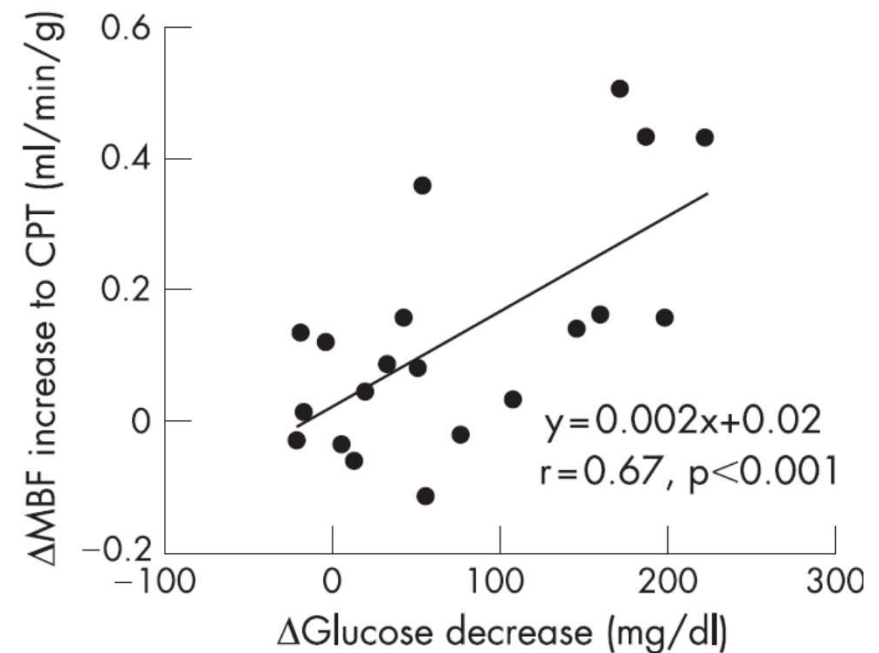
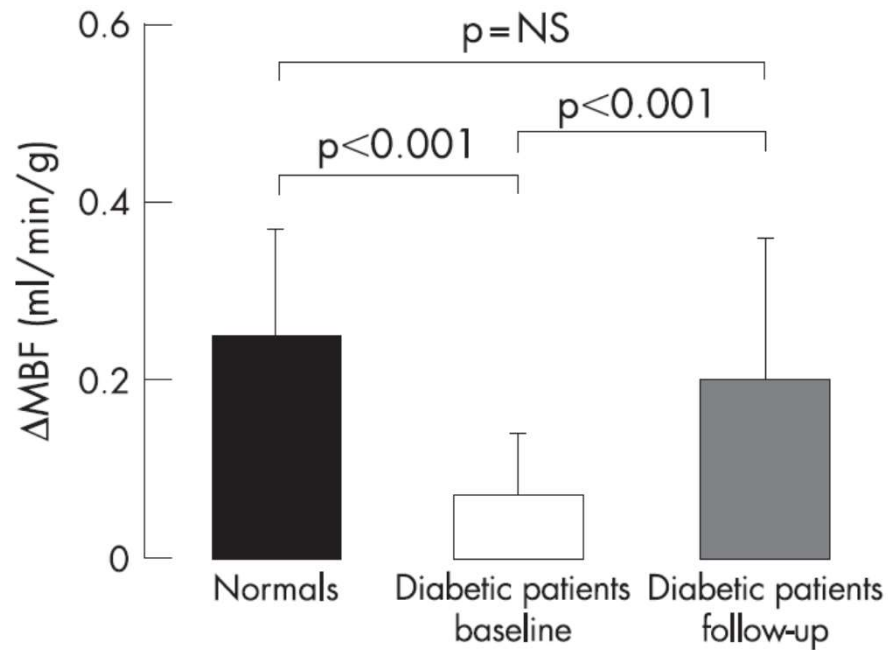
OW = overweight; OB = obese;

IR = normoglycemic insulin resistance, IGT = impaired glucose tolerance; DM = Diabetes mellitus, HTN = Hypertension.

Schelbert HR, JACC 2009 ; Prior JO et al, Circulation 2005 ; Schindler et al, JACC 2006

MBF improvement with glycemic control

20 patients DM2, 18 matched controls



Schindler TH et al. Heart 2007

Flux sanguin myocardique

Microcirculation

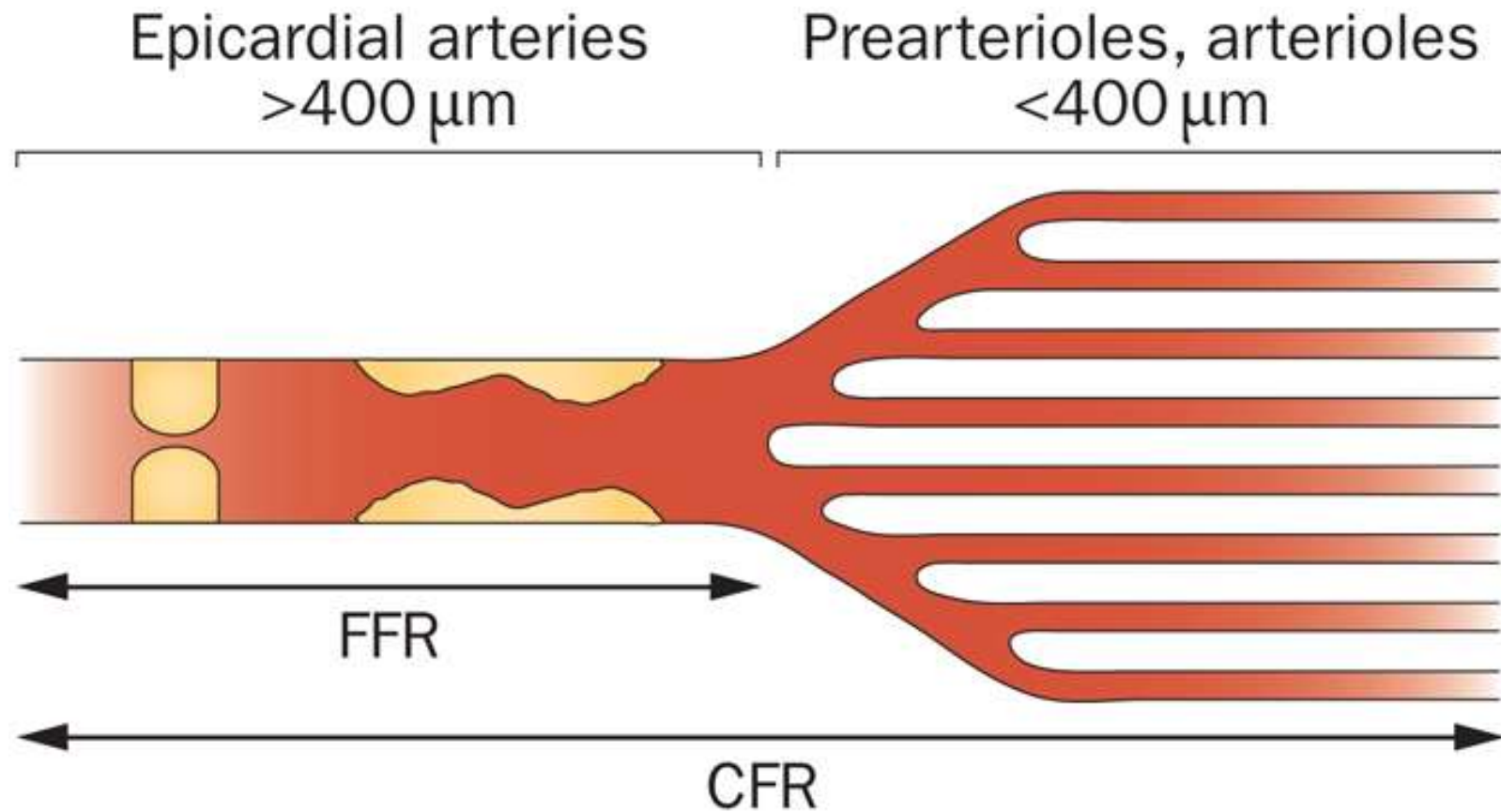


Résistances circulation coronaire



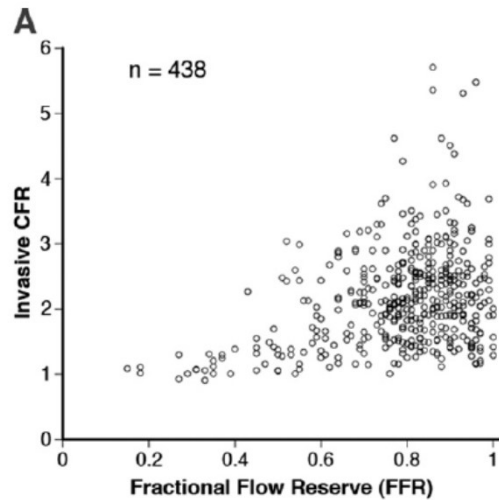
Camici PG, Rimoldi OE, J Nucl Med 2009

CFR vs. FFR

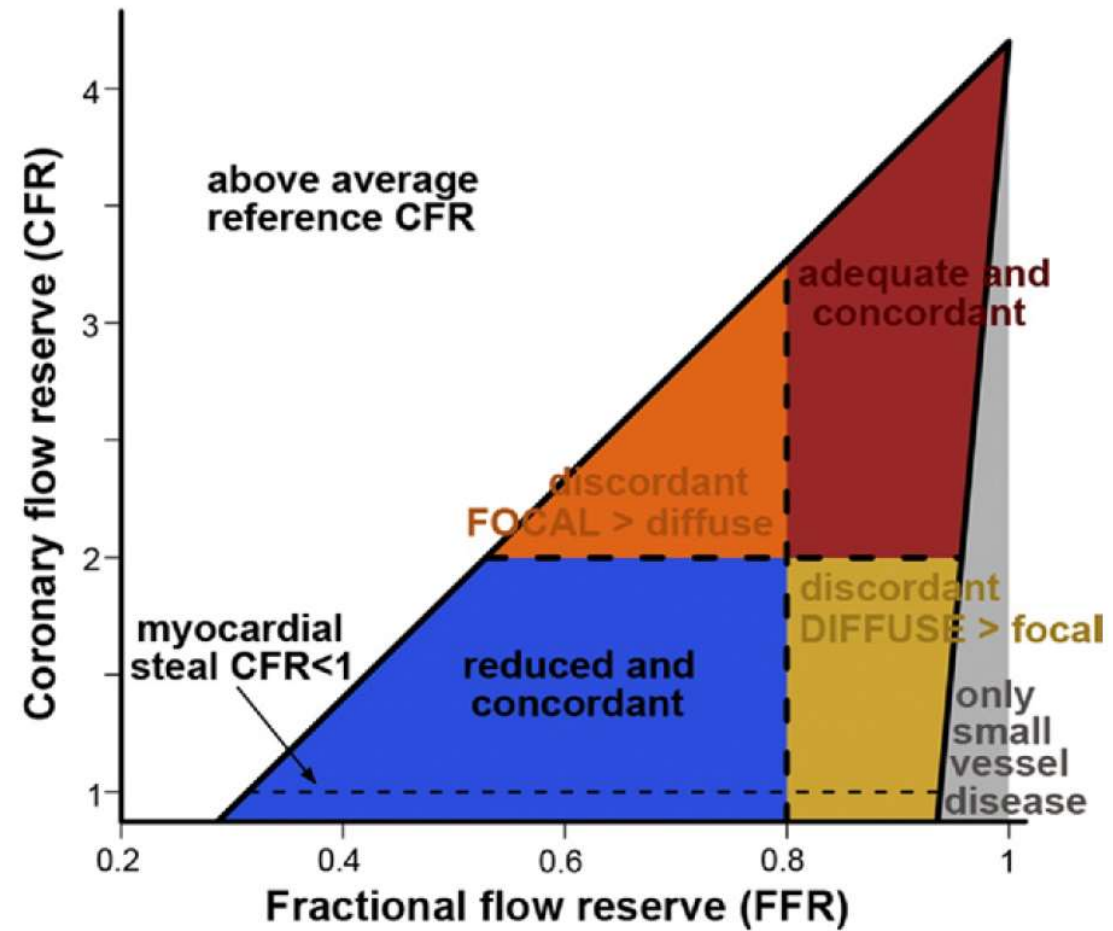
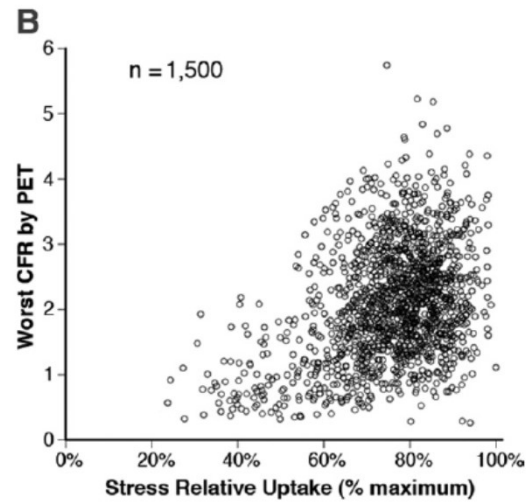


CFR vs. FFR

Invasive
CFR



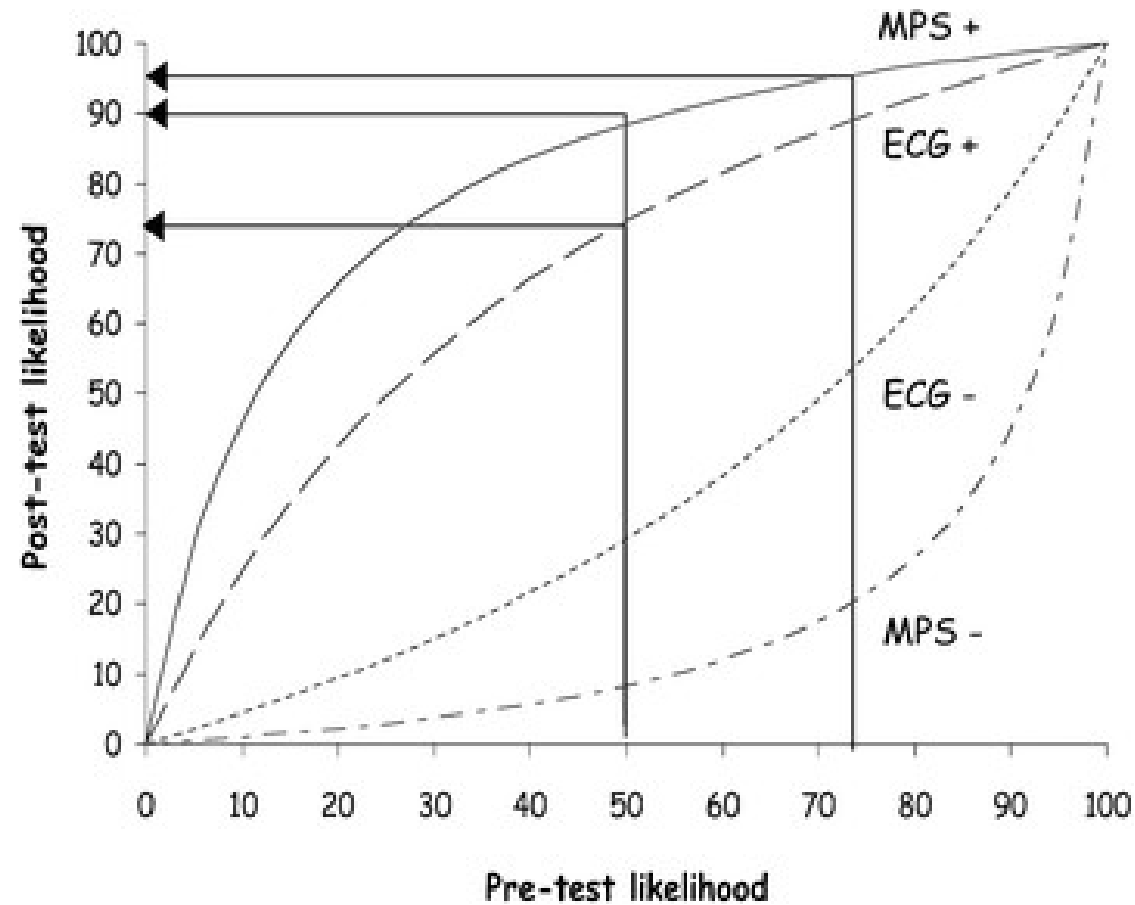
PET-derived
CFR



Gould KL et al, iJACC 2012

Diagnostic

Valeur additionnelle maximale : probabilité pré-test intermédiaire



Underwood et al, Eur J Nucl Med 2004

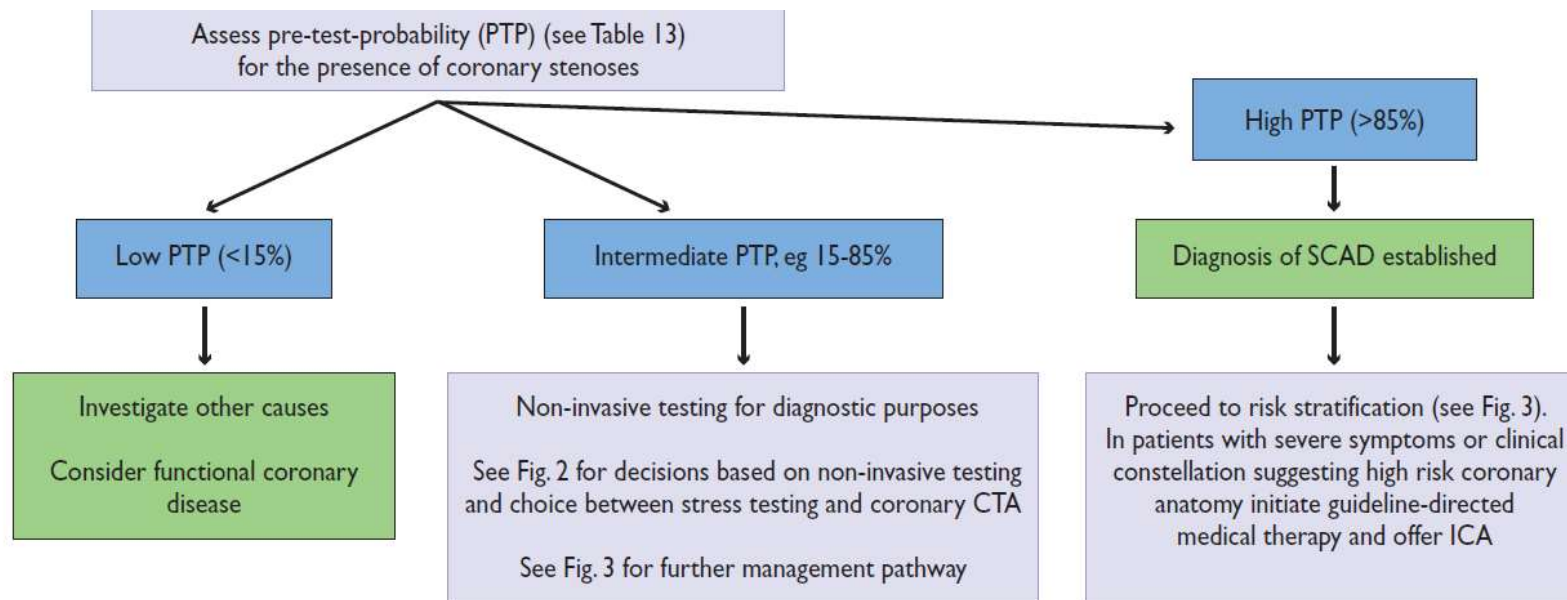
Probabilité pré-test

Exemple de tableau fournissant une estimation du risque pré-test
(en réalité surestimation de la prévalence car basé sur des séries anciennes)

	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

2013 ESC guidelines on the management of stable coronary artery disease

Diagnostic d'insuffisance coronaire



2013 ESC guidelines on the management of stable coronary artery disease

Recommendations	Class	Level	Ref.
An imaging stress test is recommended as the initial test for diagnosing SCAD if the PTP is between 66–85% or if LVEF is <50% in patients without typical angina.	I	B	143, 144
An imaging stress test is recommended in patients with resting ECG abnormalities which prevent accurate interpretation of ECG changes during stress.	I	B	117, 145
Exercise stress testing is recommended rather than pharmacologic testing whenever possible.	I	C	-
An imaging stress test should be considered in symptomatic patients with prior revascularization (PCI or CABG).	IIa	B	146, 147
An imaging stress test should be considered to assess the functional severity of intermediate lesions on coronary arteriography.	IIa	B	148, 149

2014 ESC/EACTS Guidelines on myocardial revascularization

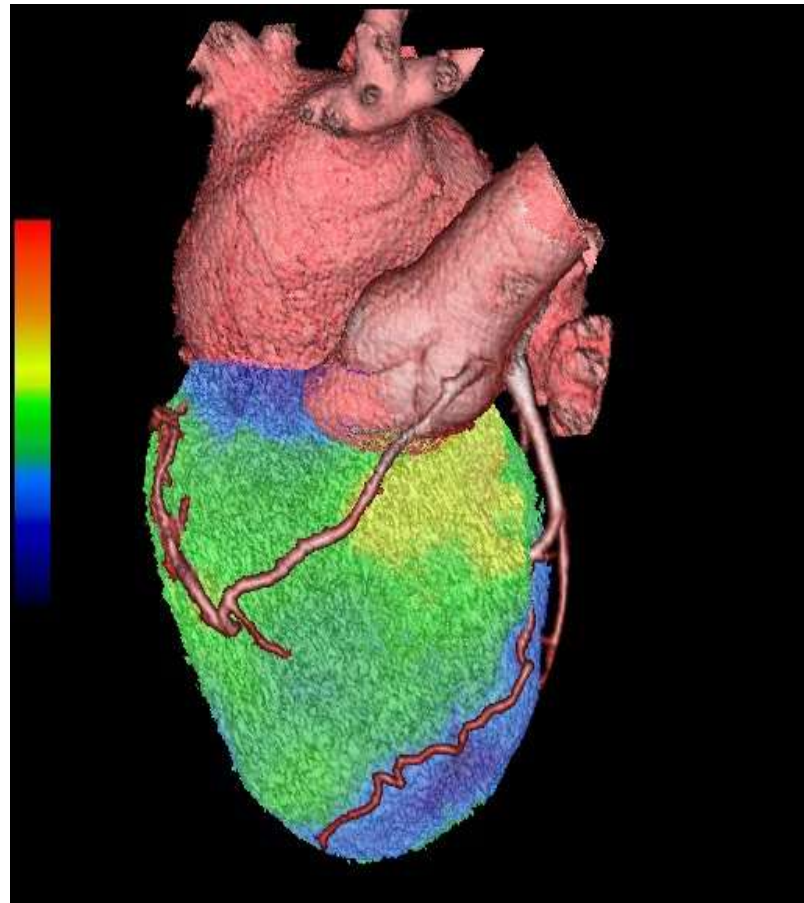
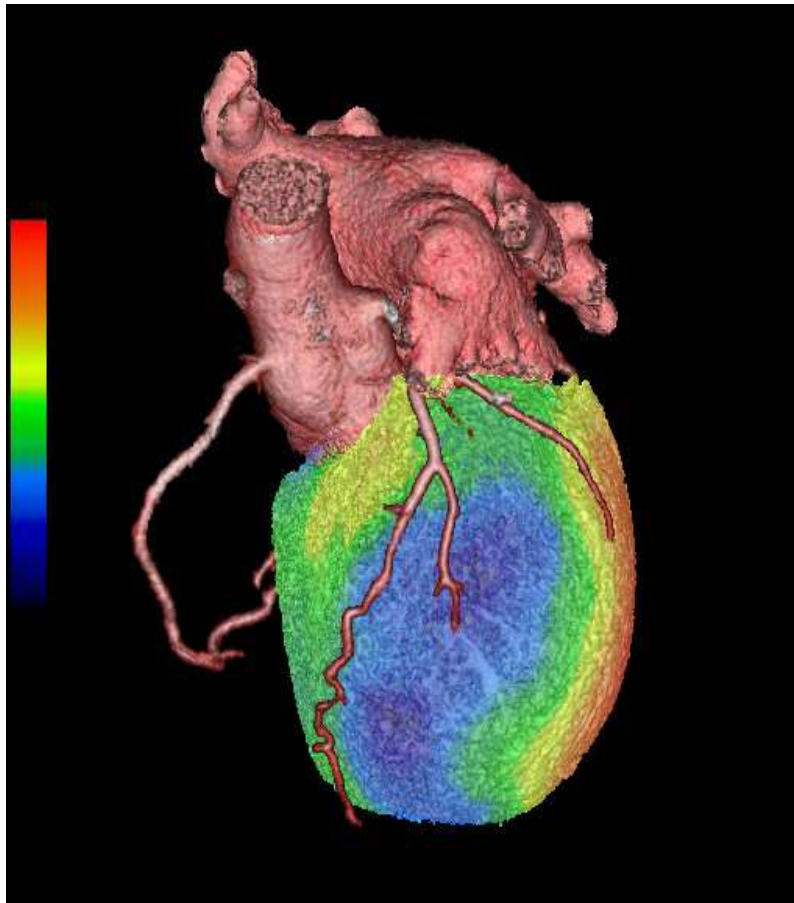
Coronaropathie stable

Exclusion des syndromes coronaires aigus

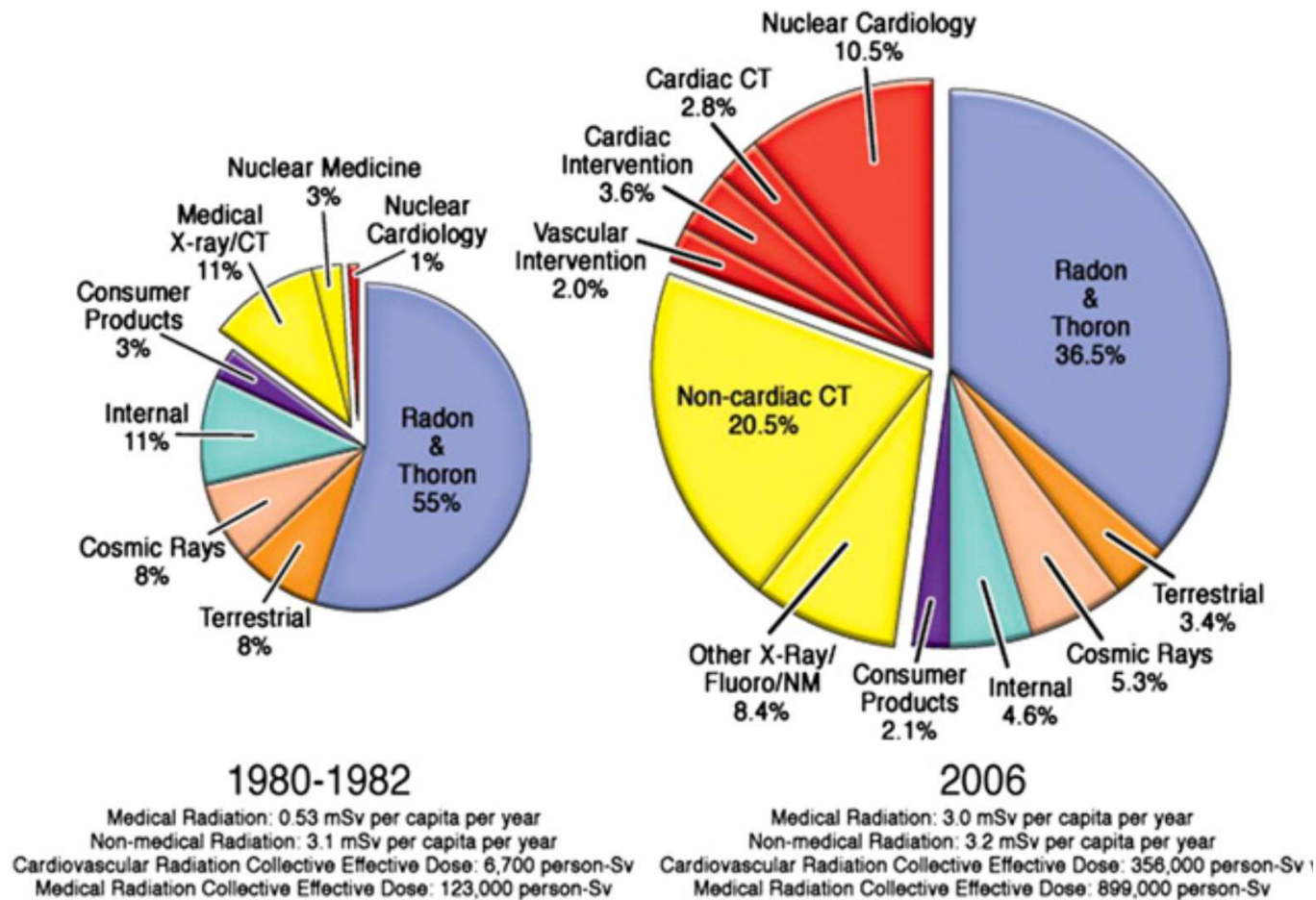
Indications for diagnostic testing in patients with suspected CAD and stable symptoms

	Asymptomatic ^a		Symptomatic						
			Probability of significant disease ^b						
			Low (<15%)		Intermediate (15–85%)		High (>85%)		
	Class ^c	Level ^d	Class ^c	Level ^d	Class ^c	Level ^d	Class ^c	Level ^d	Ref ^e
Anatomical detection of CAD									
Invasive angiography	III	A	III	A	IIb	A	I	A	50–52,54
CT angiography ^{f,g}	III	B	III	C	IIa	A	III	B	57–62
Functional test									
Stress echo	III	A	III	A	I	A	III	A	63–65
Nuclear imaging	III	A	III	A	I	A	III	A	60,66–70
Stress MRI	III	B	III	C	I	A	III	B	71–75
PET perfusion	III	B	III	C	I	A	III	B	67,69,70,76,77
Combined or hybrid imaging test									
	III	C	III	C	IIa	B	III	B	78–83

Imagerie hybride?



Dosimétrie



Dorbala et al, J Nucl Med 2015

1. Respecter les indications : cf. recommandations

2. Choix du traceur et de l'activité (dépend de la caméra)

Estimation of Effective Radiation Dose from Various Myocardial Perfusion Radiotracers (13)

Radiopharmaceutical	Effective dose (mSv/MBq)	Administered activity				Estimated dose (mSv)	
		MBq		mCi			
		Full dose	Half dose	Full dose	Half dose	Full-dose study	Half-dose study
^{82}Rb rest or stress	0.0017	1,480	740	40	20	2.52	1.26
^{13}N -ammonia rest or stress	0.0027	740	370	20	10	2.0	1.0
$^{99\text{m}}\text{Tc}$ -sestamibi rest	0.0079	296	148	8	4	2.34	1.17
$^{99\text{m}}\text{Tc}$ -sestamibi stress	0.009	888	444	24	12	8.0	4.0
$^{99\text{m}}\text{Tc}$ -tetrofosmin rest	0.0069	296	148	8	4	2.0	1.0
$^{99\text{m}}\text{Tc}$ -tetrofosmin stress	0.0069	888	444	24	12	6.13	3.1
^{201}Tl	0.14	148	74	4	2	20.72	10.36

3. Choix du protocole

