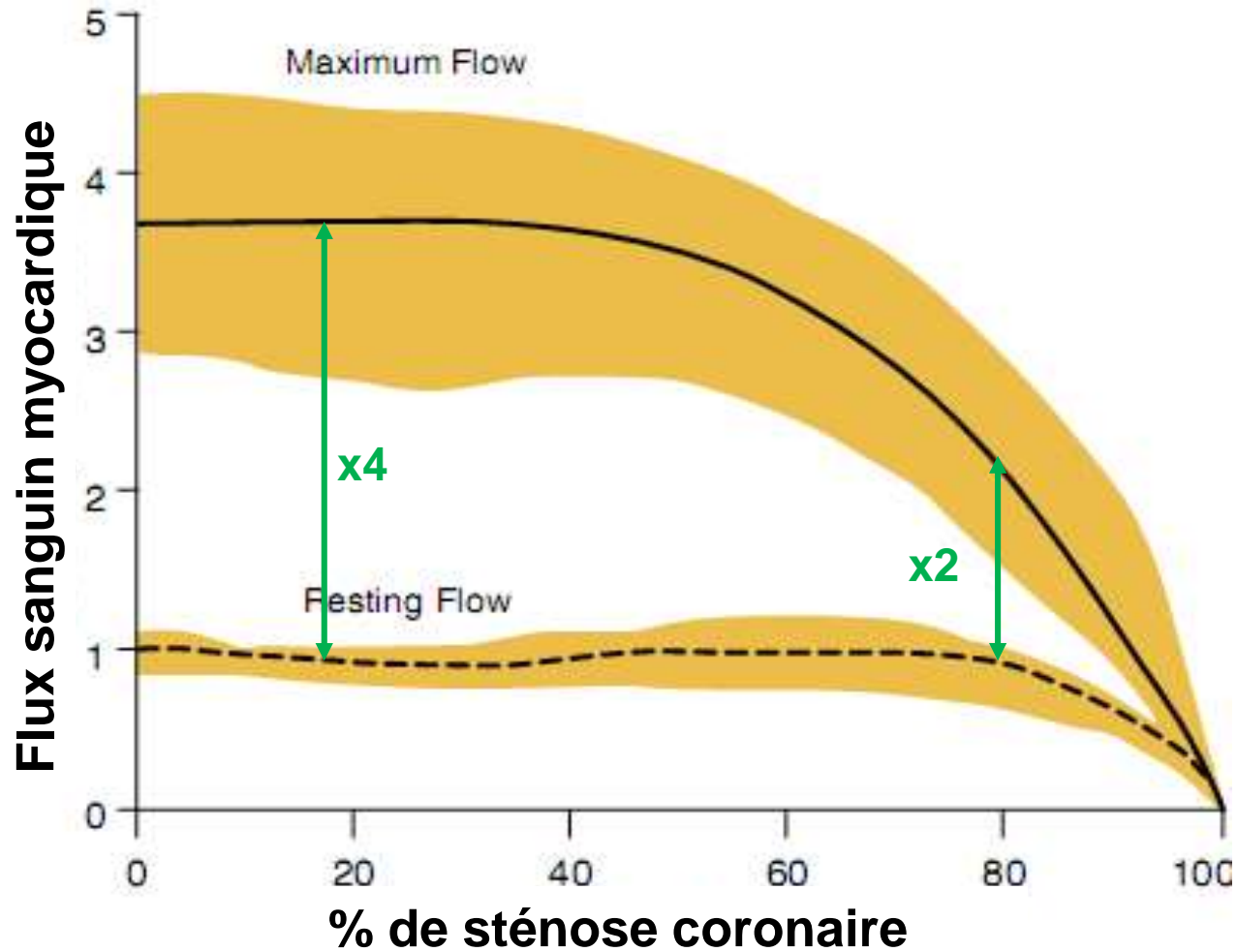


La perfusion myocardique en Médecine Nucléaire

François Rouzet, MD, PhD

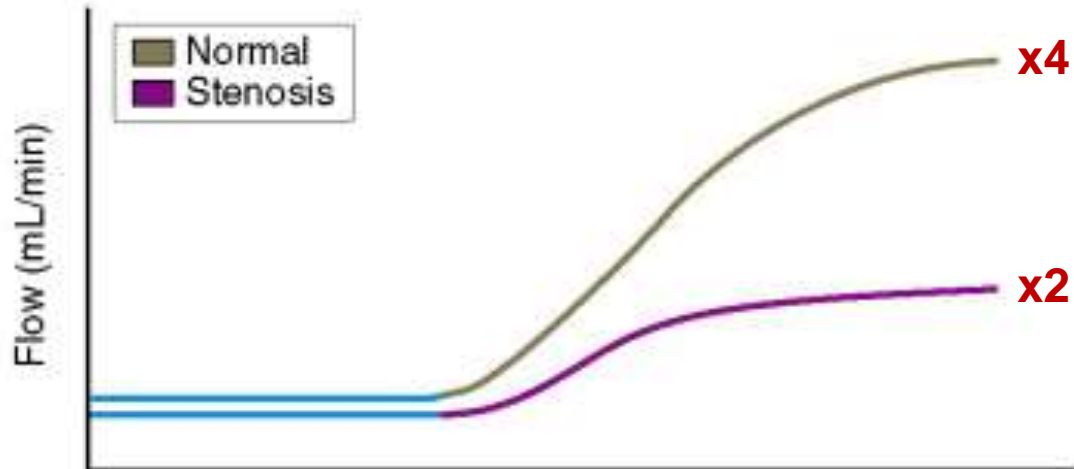
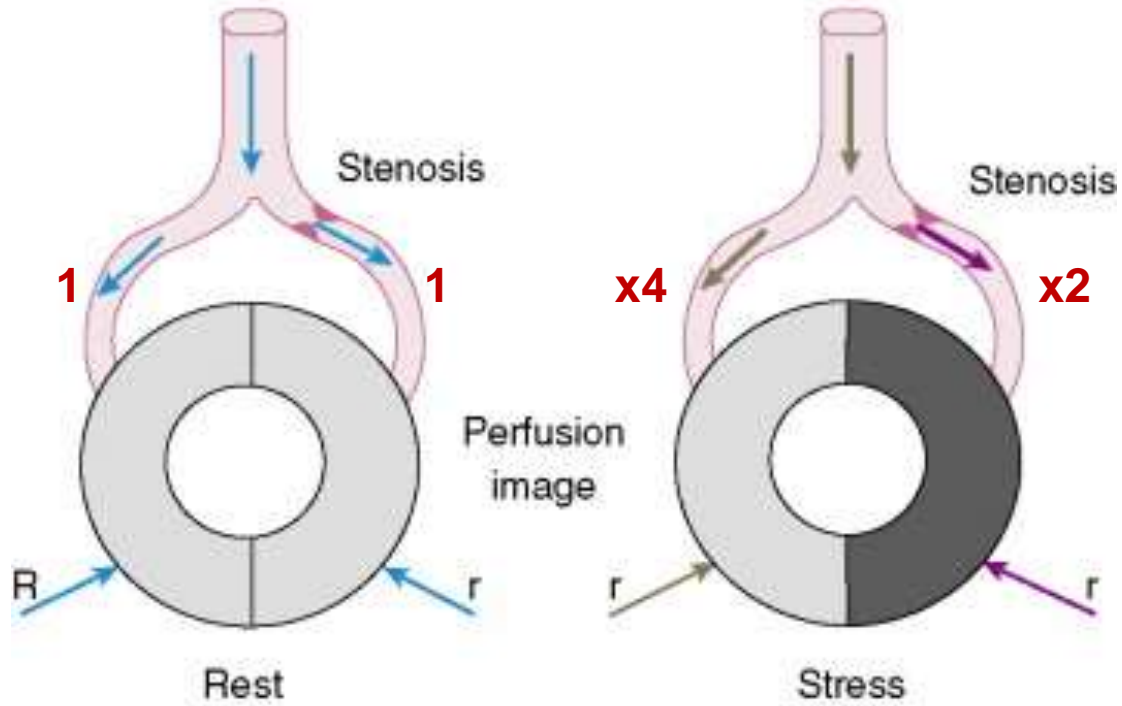
- Service de Médecine Nucléaire, GH Bichat-Claude Bernard, Paris, France
- LVTS (Inserm U1148), Team 4: cardiovascular imaging
- Université Paris Diderot, Sorbonne Paris Cité, France

L'insuffisance coronaire



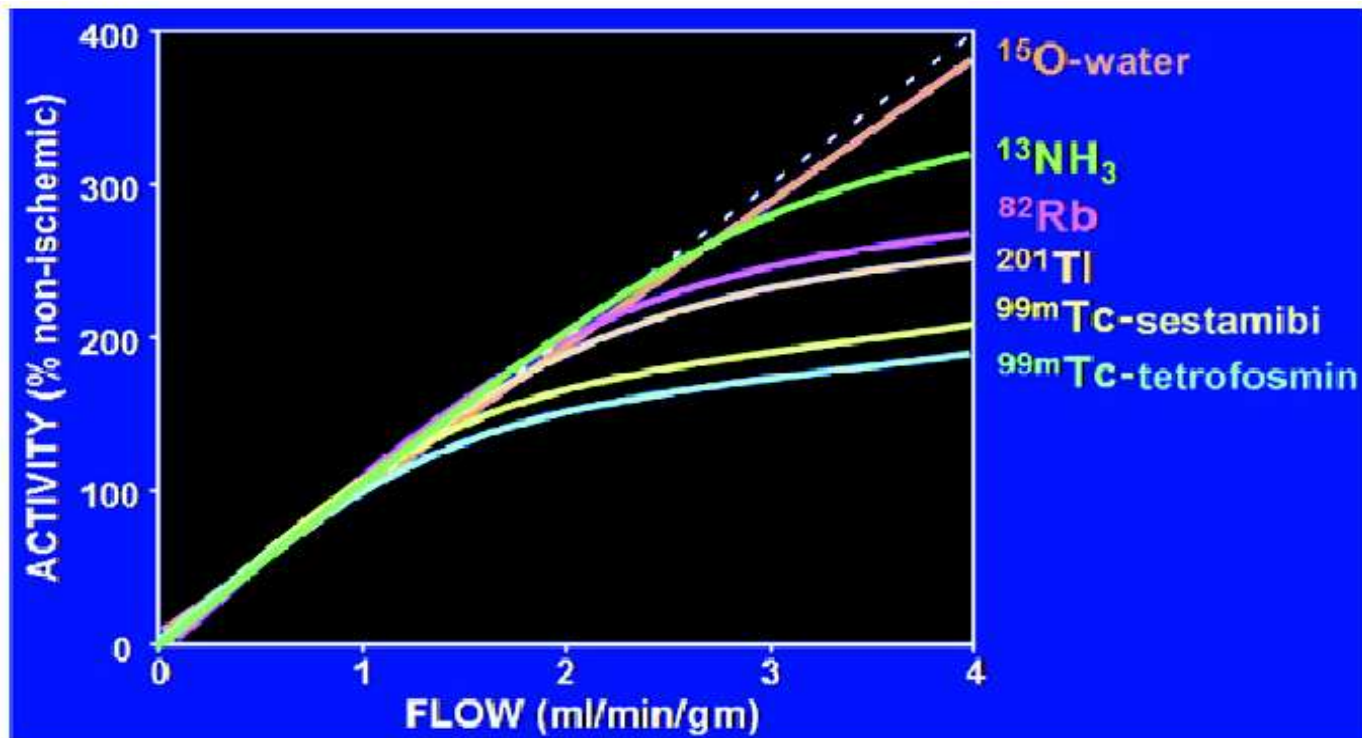
Coronary Artery

Flux (ml/min/g) :



Traceurs de perfusion

La captation myocardique des traceurs doit être proportionnelle au débit sanguin local.



Une baisse du **débit sanguin local** va se traduire par une diminution proportionnelle de la **captation myocardique du traceur**.

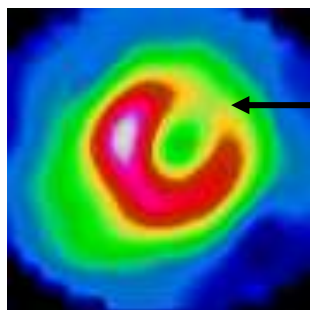
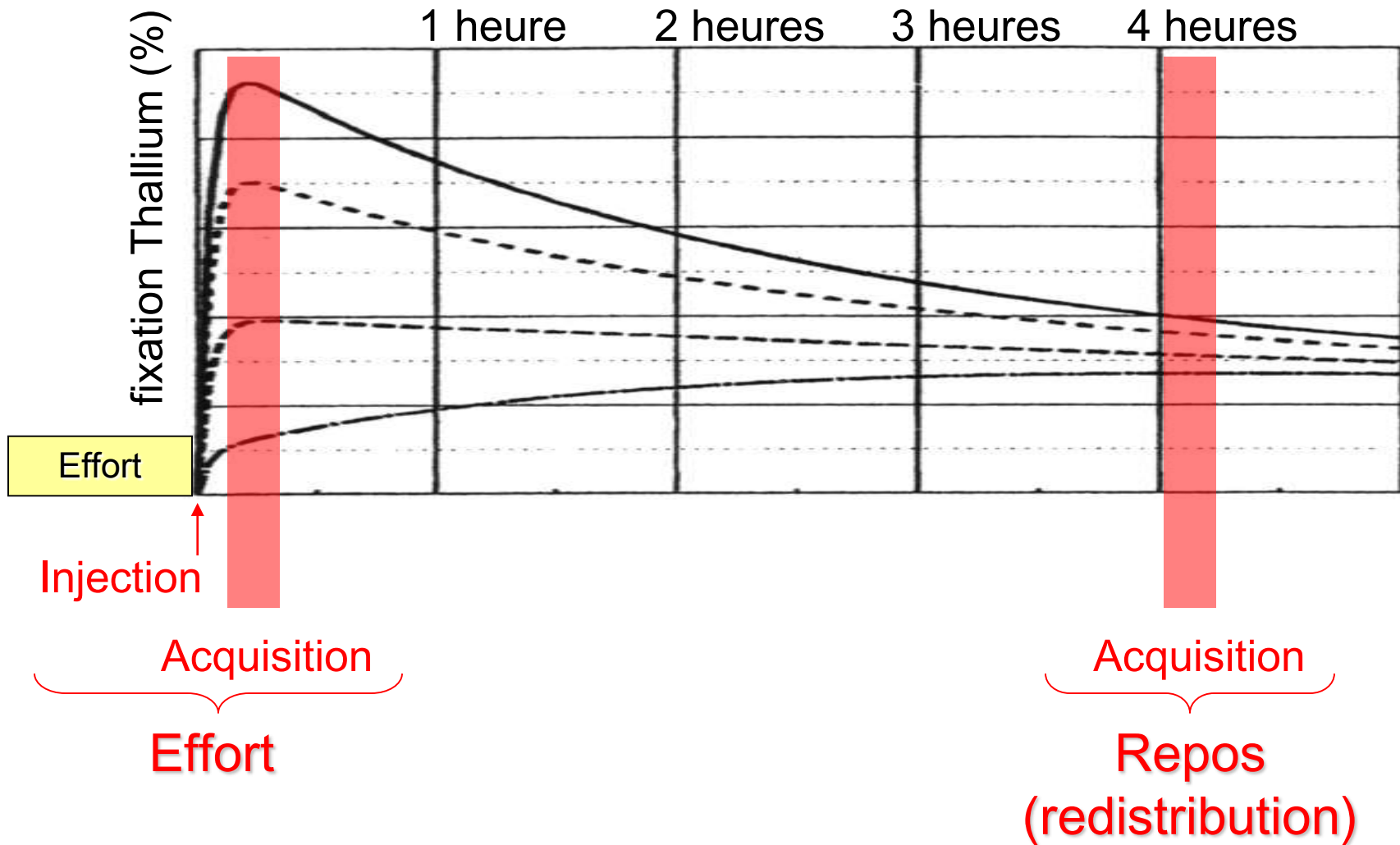
Principes de la SMP

Radiotraceurs (TEMP)

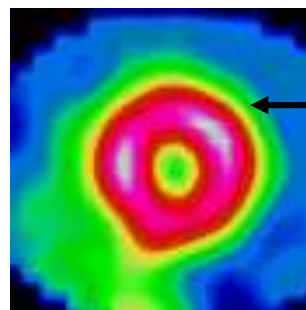
| | Thallium-201 | Marqués au ^{99m} Tc |
|----------------|---|---|
| mécanisme | Na/K ATPase (analogue K ⁺) | Gradient électrochimique (mitochondries) |
| extraction | 80-90% | 40-65% |
| redistribution | OUI | NON |

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)



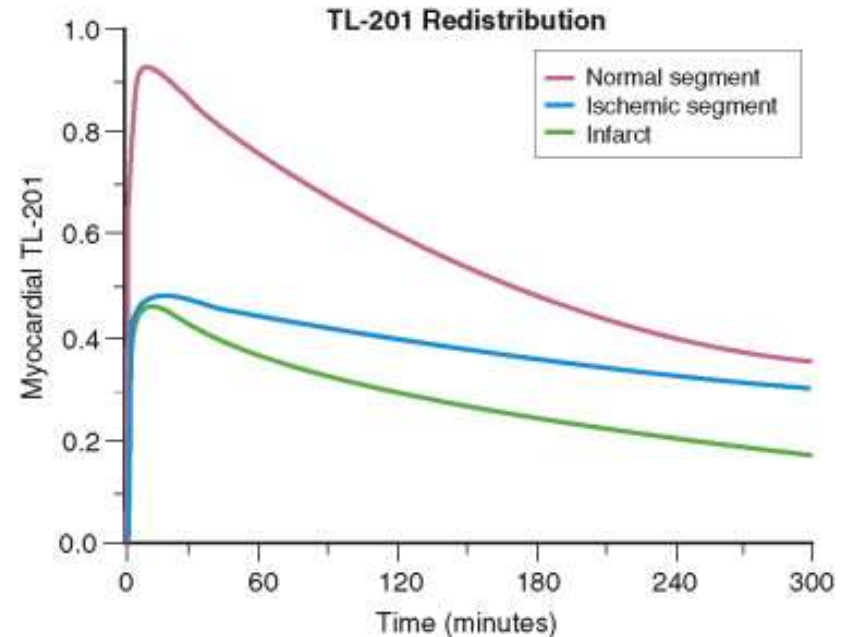
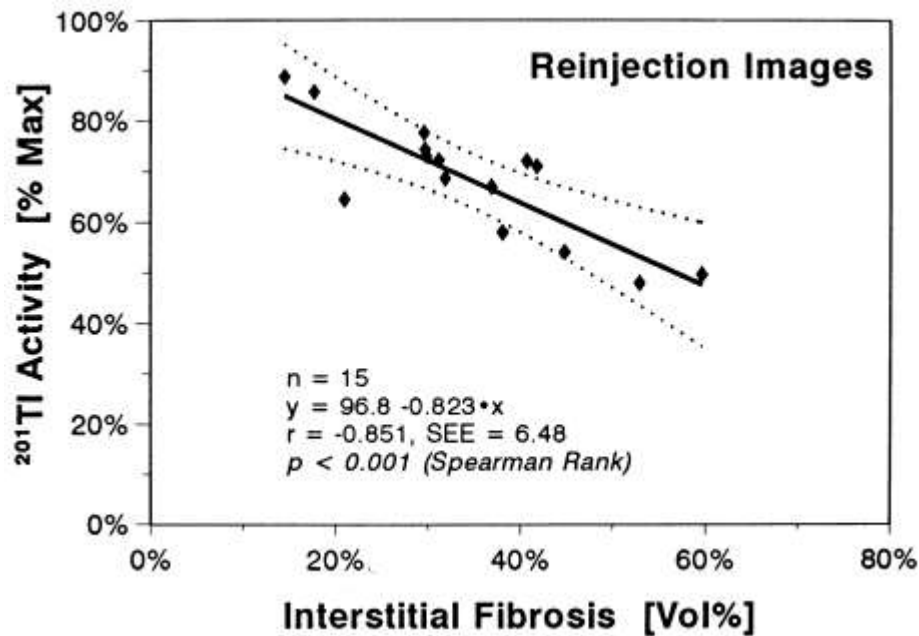
Hypofixation focale du Thallium



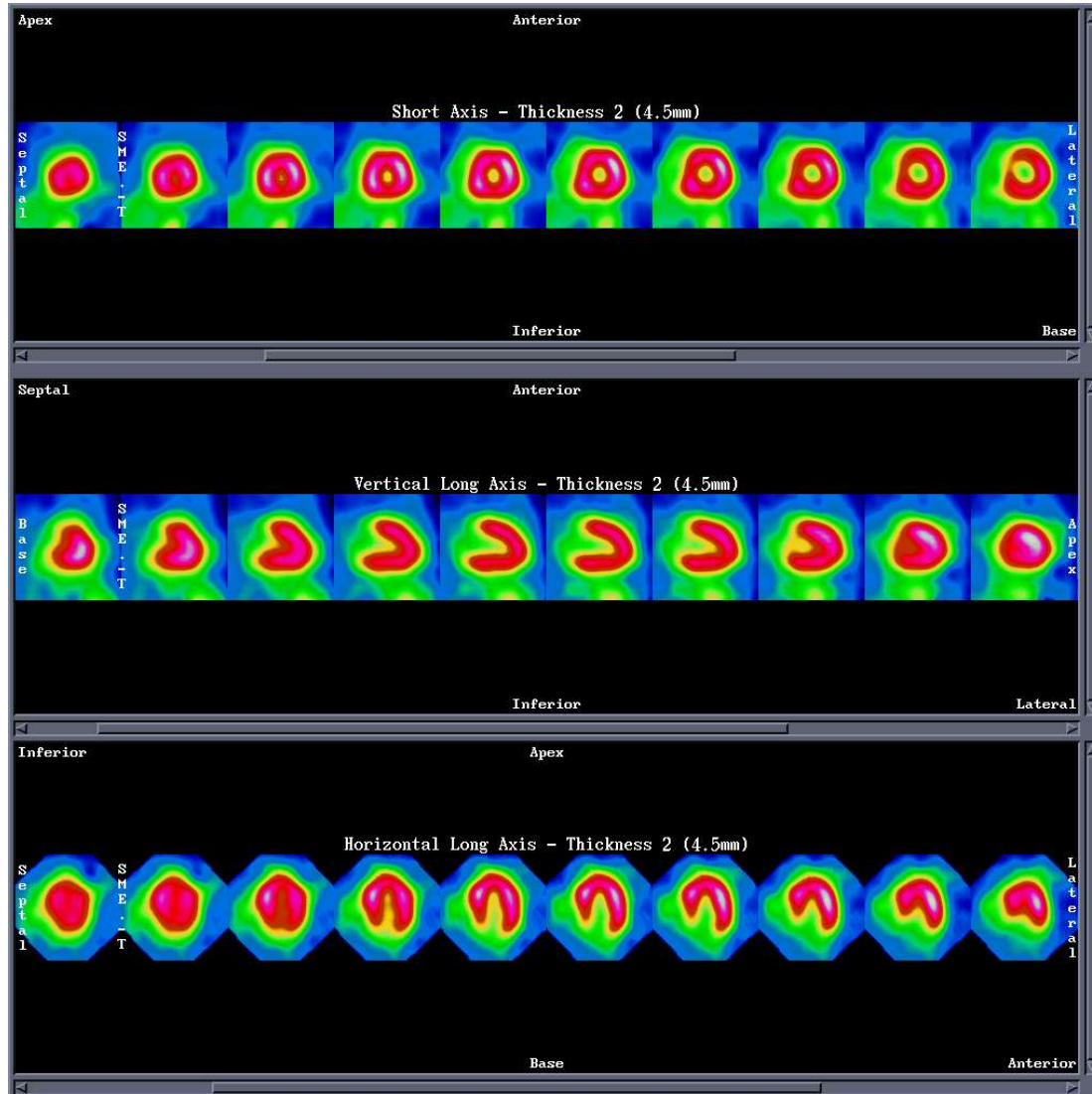
Redistribution

Viabilité myocardique : SPECT

Lorsqu'ils sont injectés au repos, la fixation myocardique des traceurs de perfusion dépend principalement de la viabilité des myocytes.



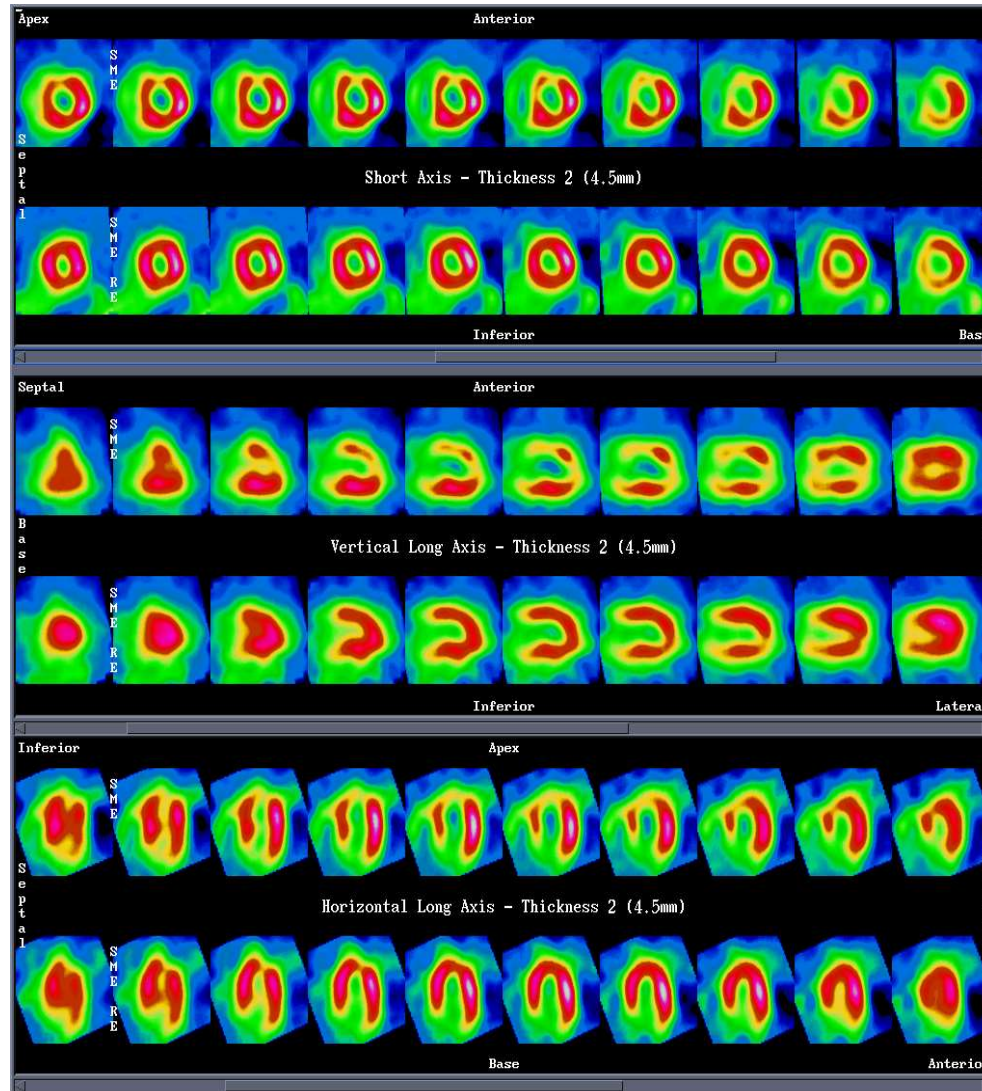
Examen normal



Ischémie du territoire antéro-septo-apical ⇒ artère inter-ventriculaire antérieure

effort

repos

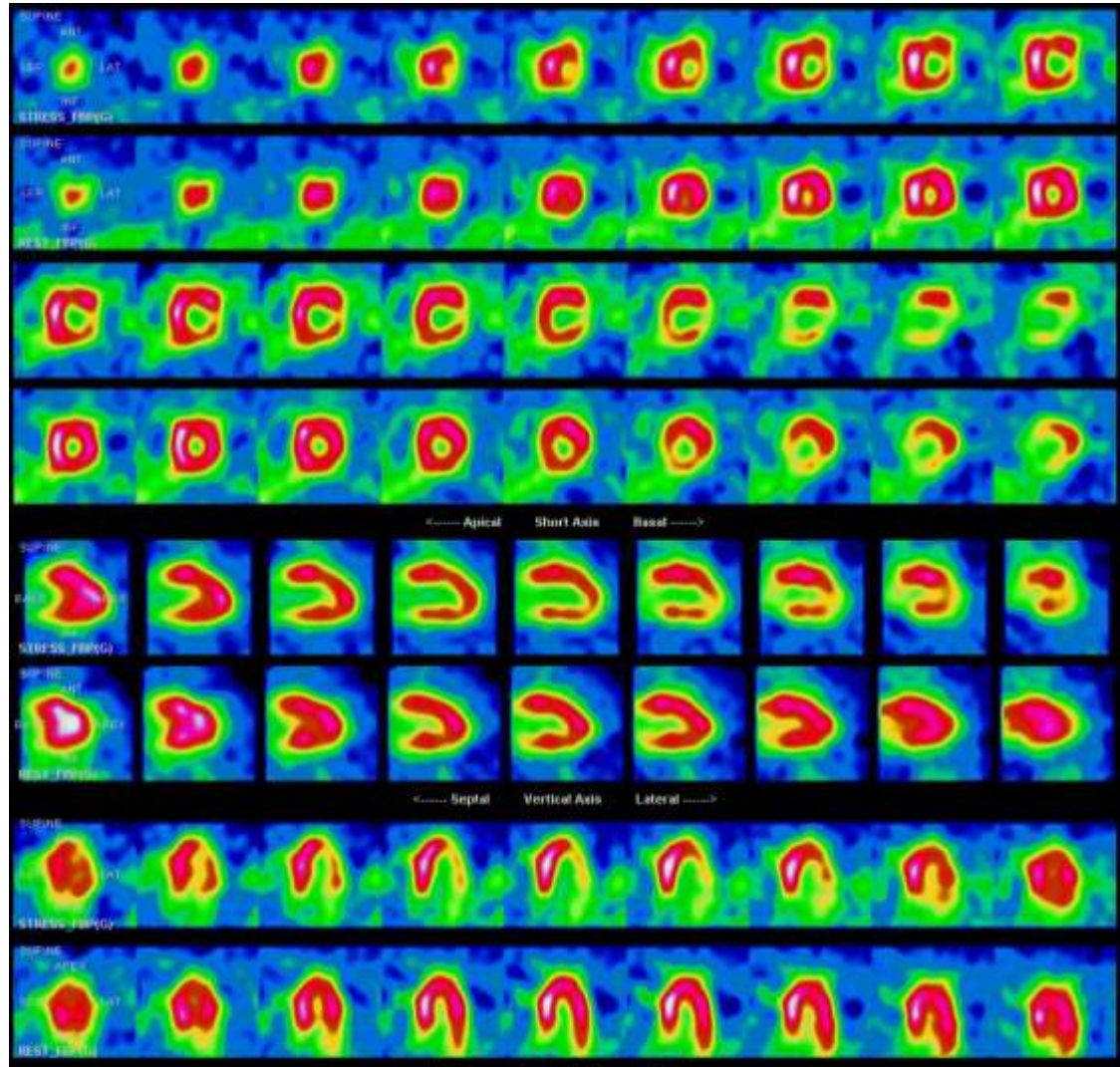


Ischémie du territoire latéral

⇒ artère circonflexe

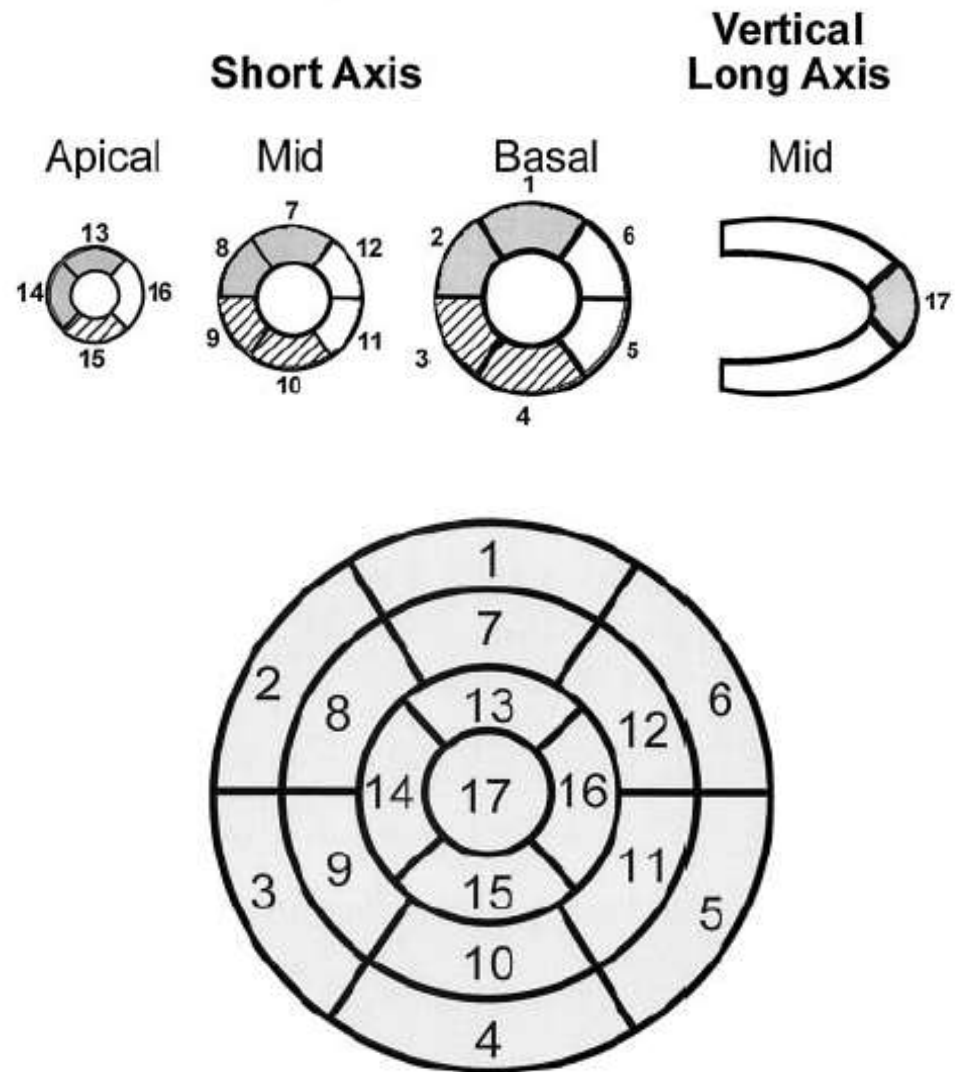
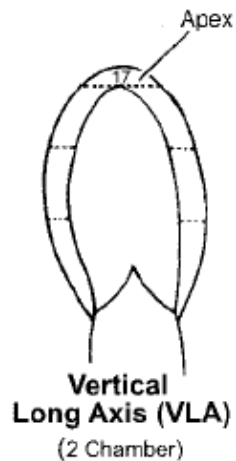
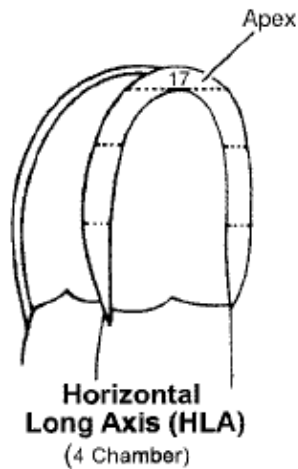
effort

repos



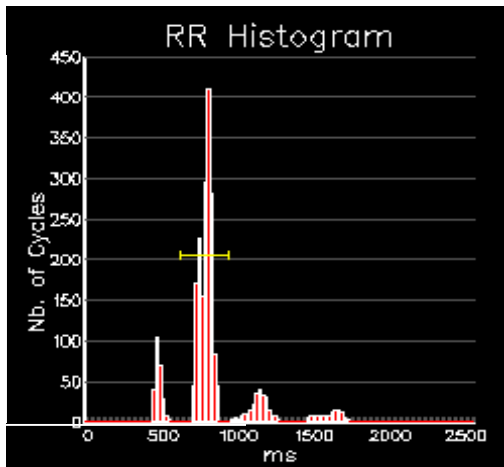
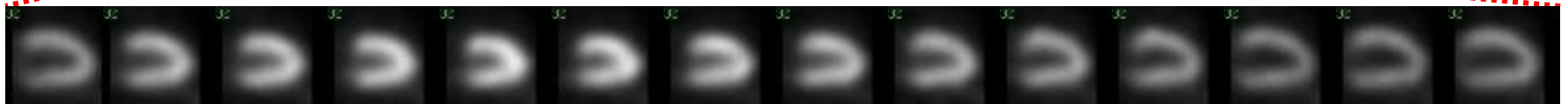
Quantification des anomalies perfusionnelles

Modèle à 17 segments



synchronisation à l'ECG

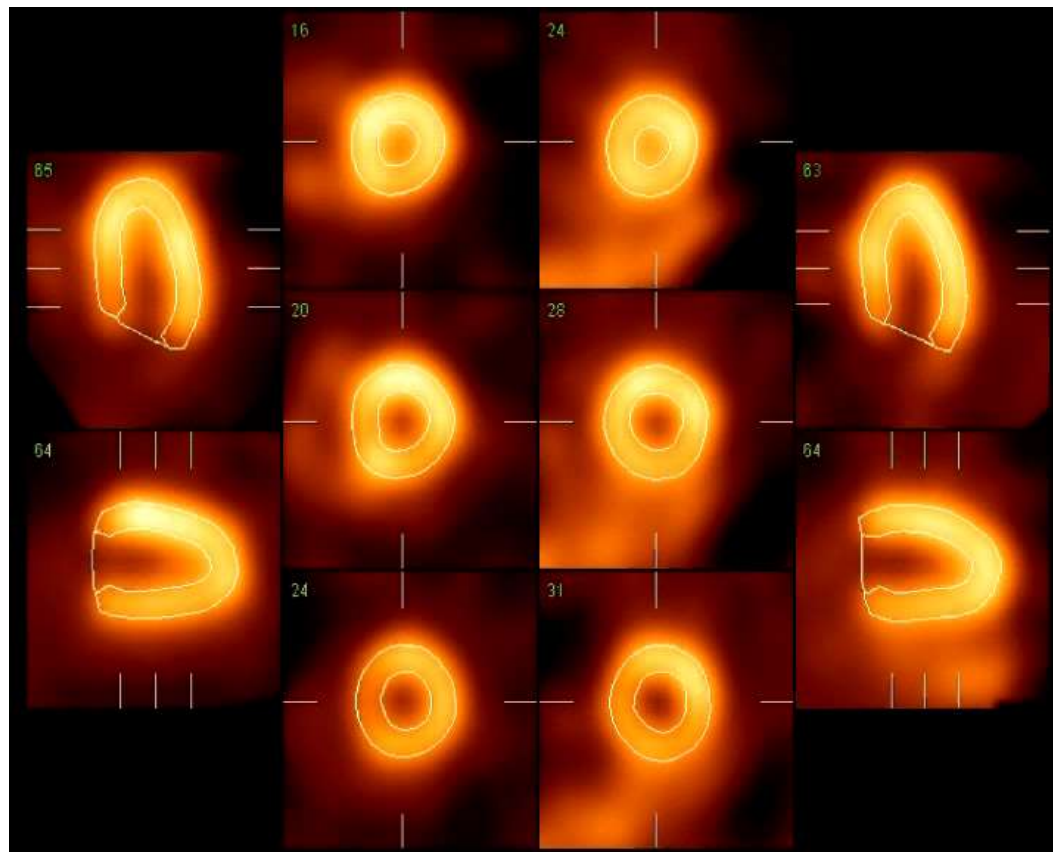
ECG



Analyse de la cinétique

201Tl stress

MIBI rest



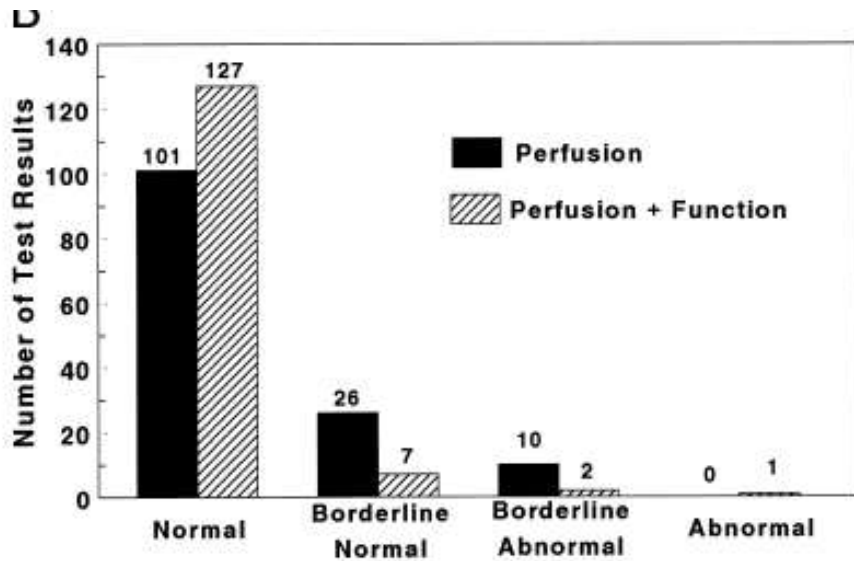
| | |
|---------|-----------------------------|
| Study | 1 |
| Dataset | STRESS(G) |
| Date | 2010-07-05 10:44:25 |
| Volume | 29ml [1] |
| EDV | 69ml [6] |
| ESV | 26ml [2] |
| EF | 62% |
| Area | 80cm² [1] |

| | |
|---------|-----------------------------|
| 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] |

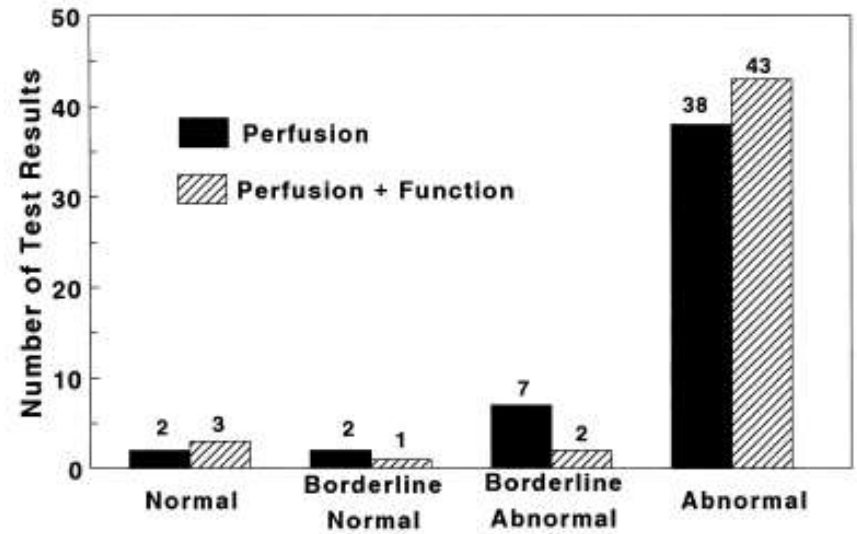
Synthèse : analyse de la SMP

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

Additional value of gated-SPECT



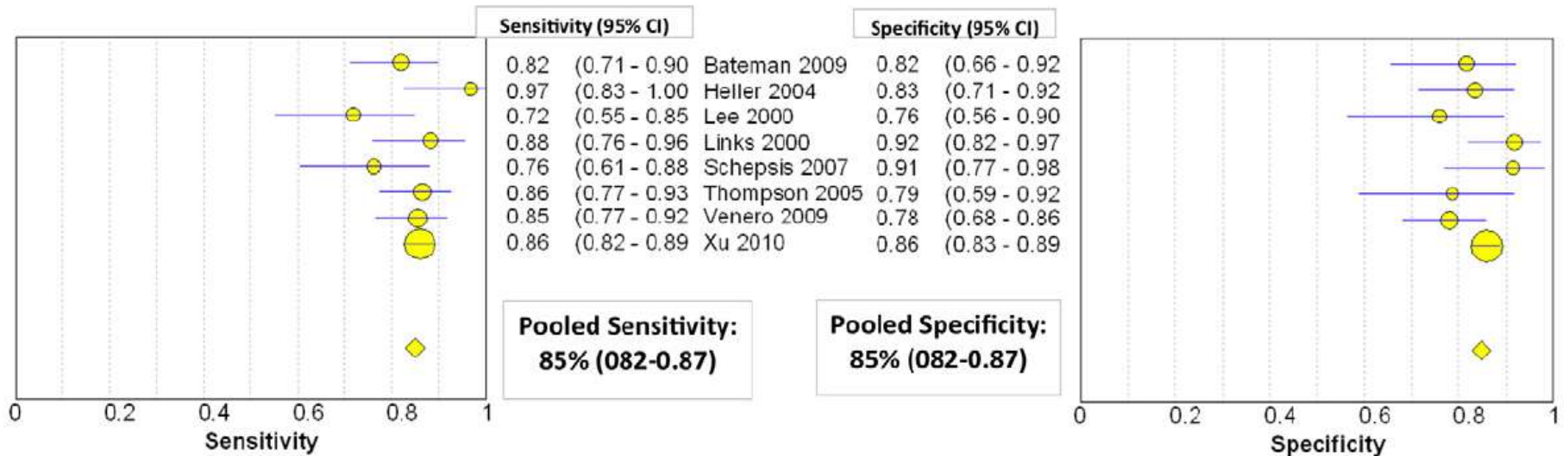
<10% pretest likelihood



Coronary artery disease

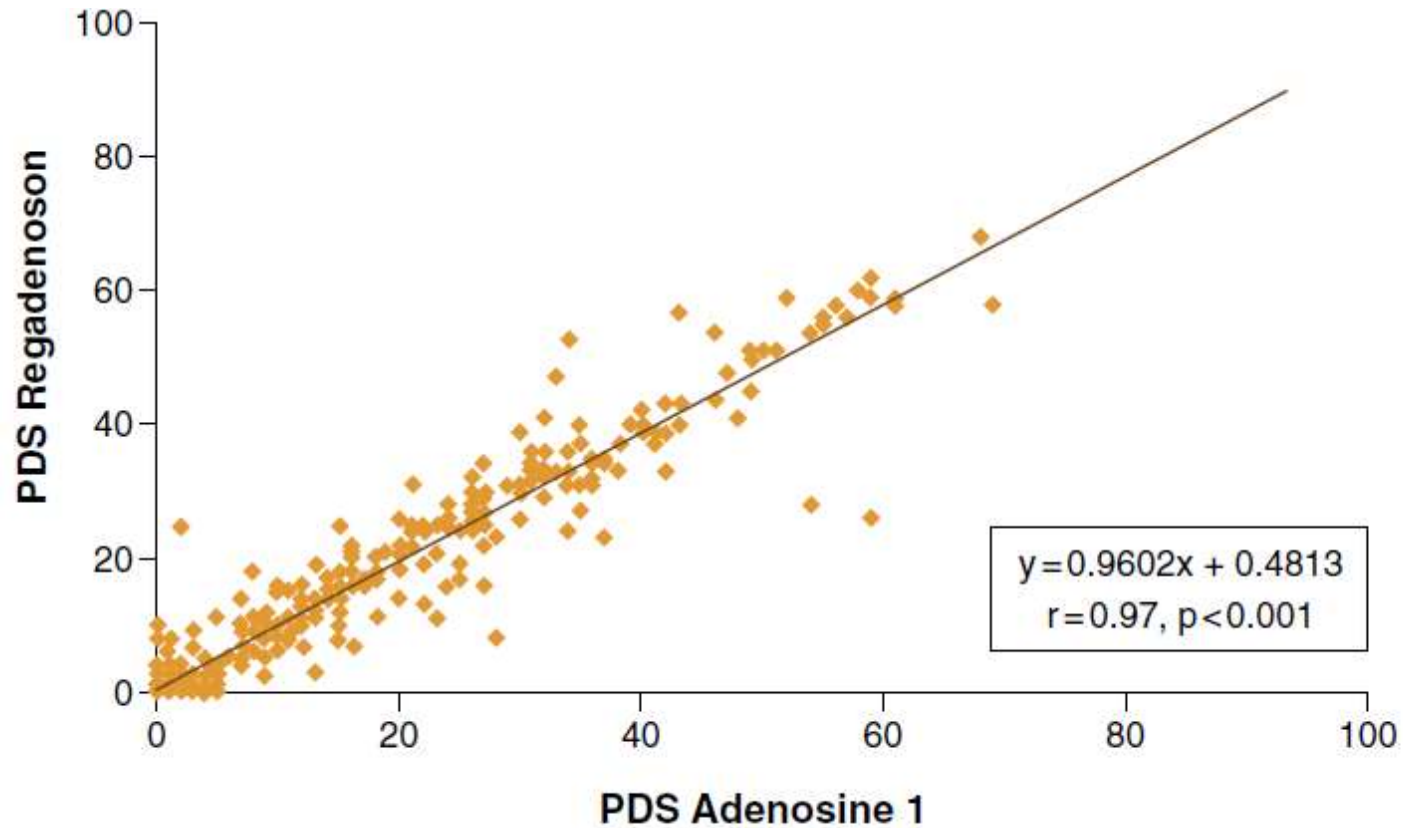
Valeur diagnostique de la SPECT

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



Reproductibilité

ADVANCE MPI 2 trial

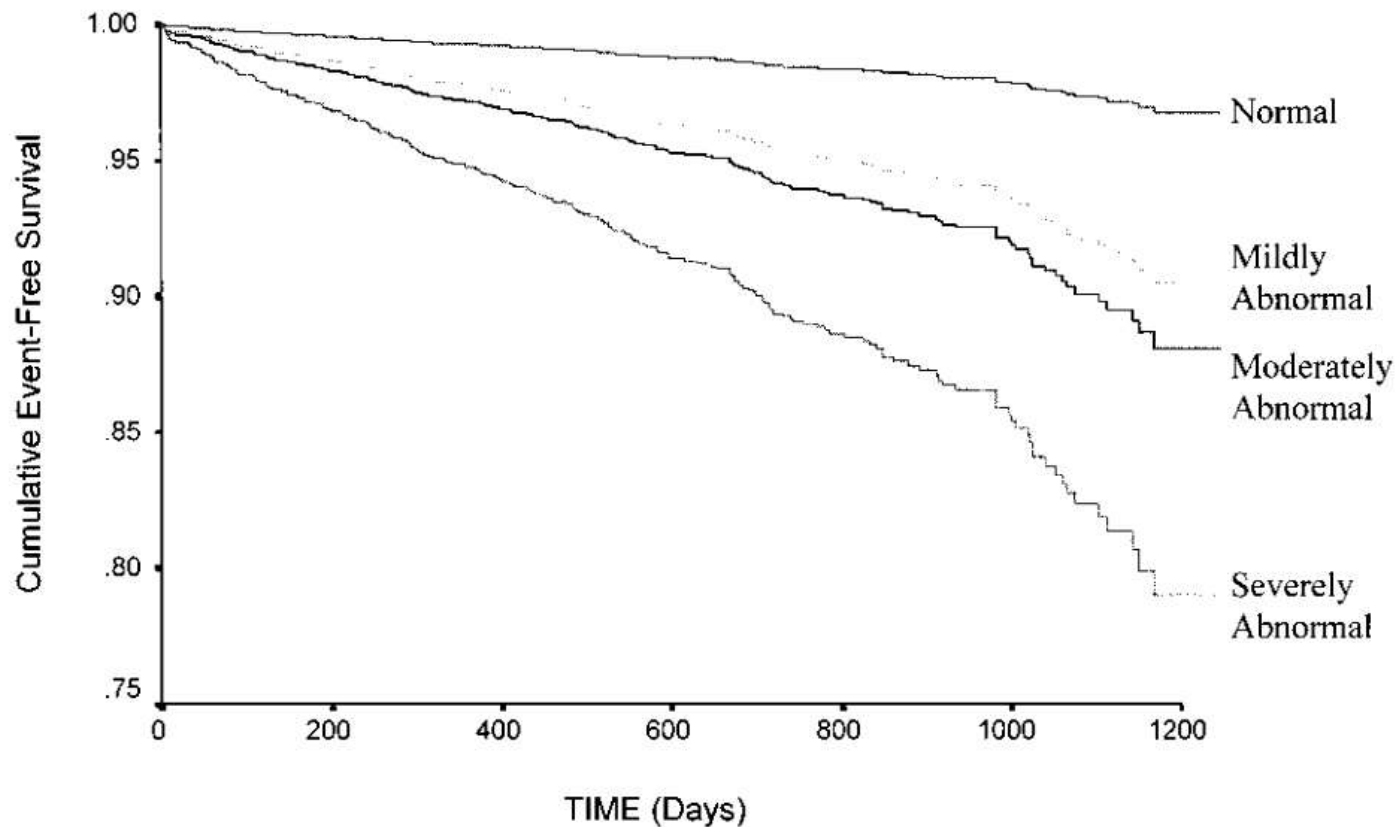


PDS: perfusion defect size

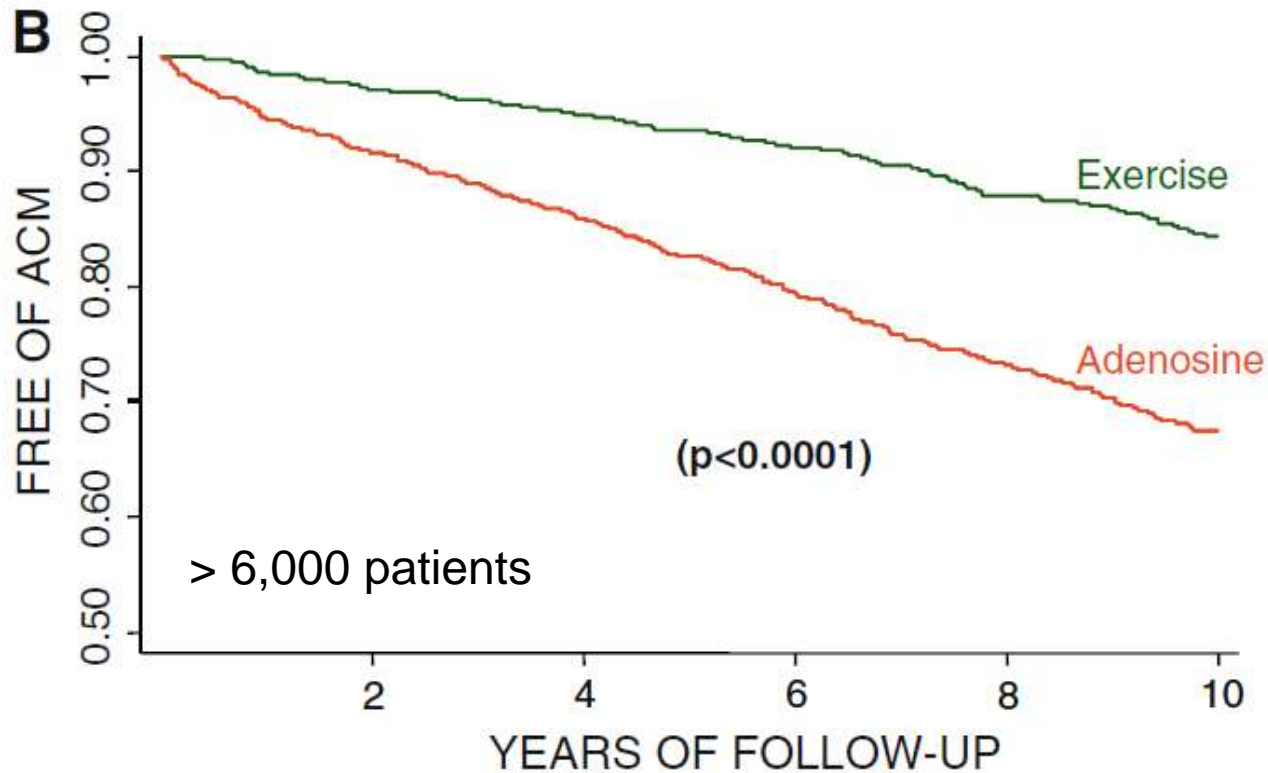
Valeur pronostique de la SPECT

Prognostic value (summed score)

5183 patients, follow-up 642±226 days



Exercise vs. Pharmacologic stress

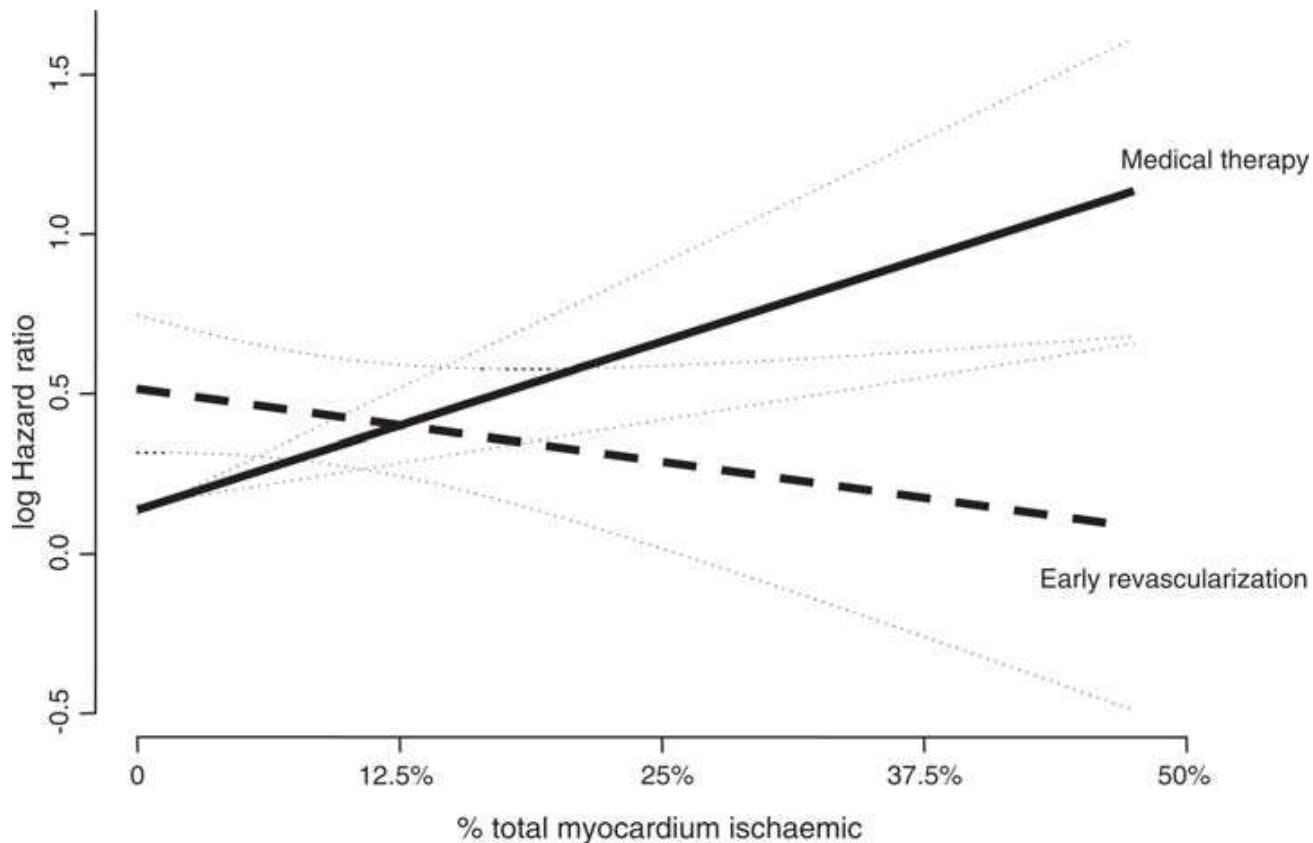


Comparative survival in exercise and adenosine patients following propensity-matching based on age, gender, chest pain symptom, and CAD risk factors.
ACM, All-cause mortality.

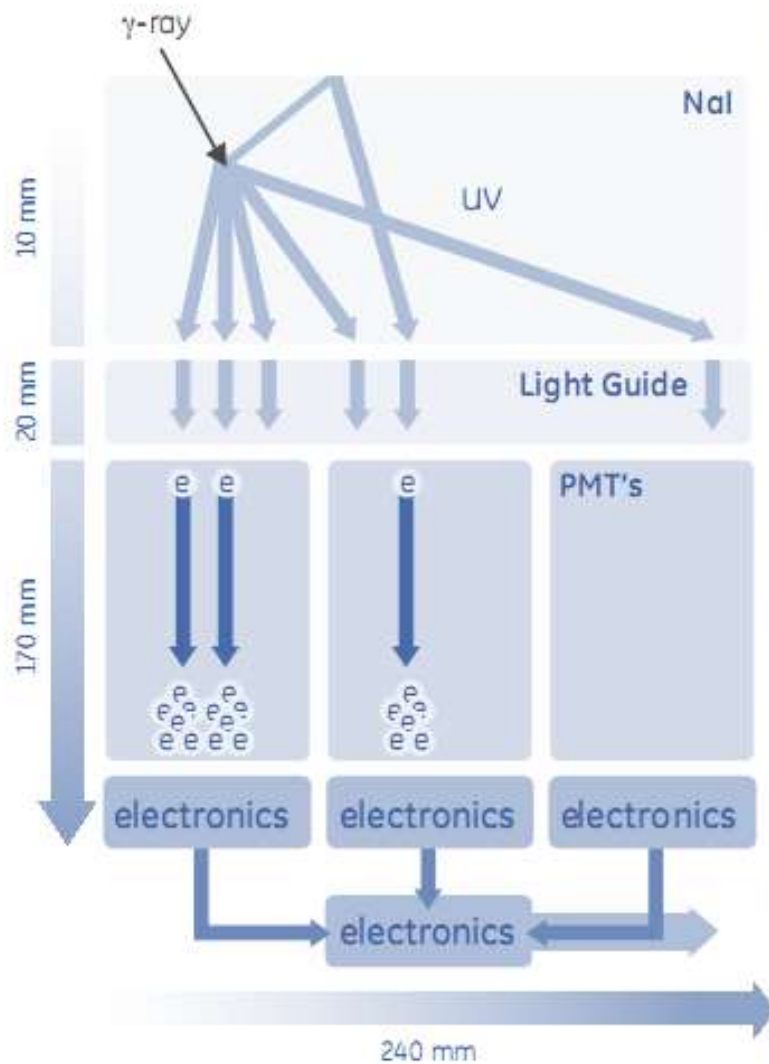
Valeur pronostique de la SPECT

Therapeutic benefit of revascularization

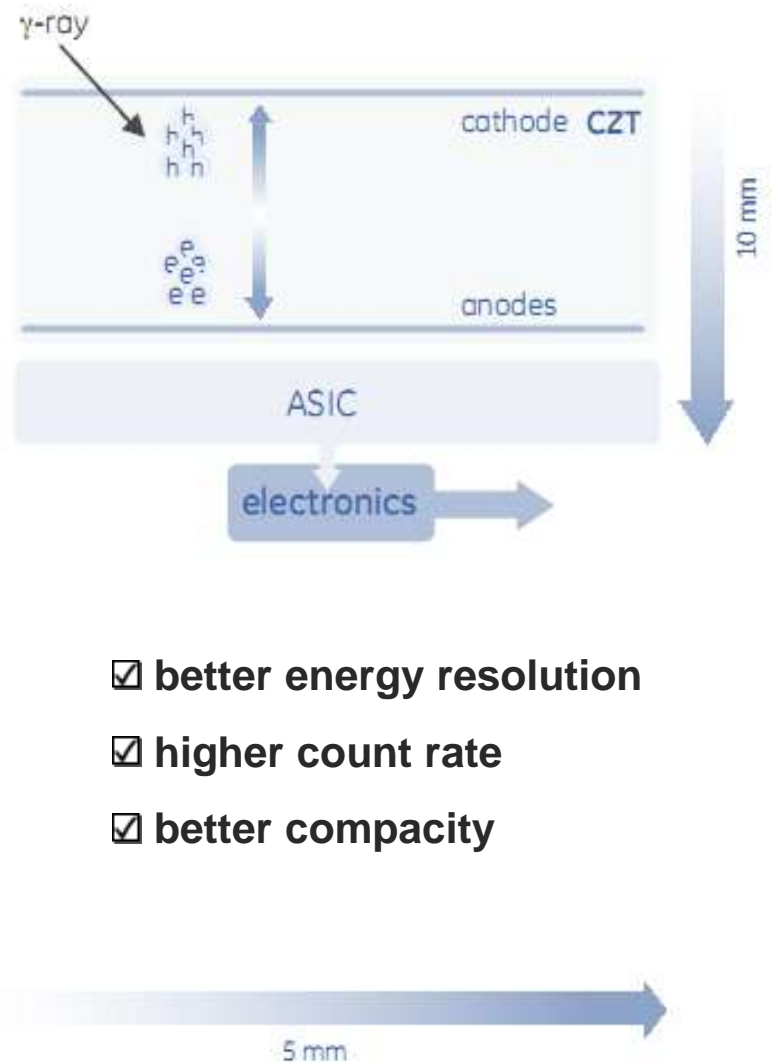
13 555 patients , mean follow-up 8 years



Scintillation detector



Solid-state detector (CZT)



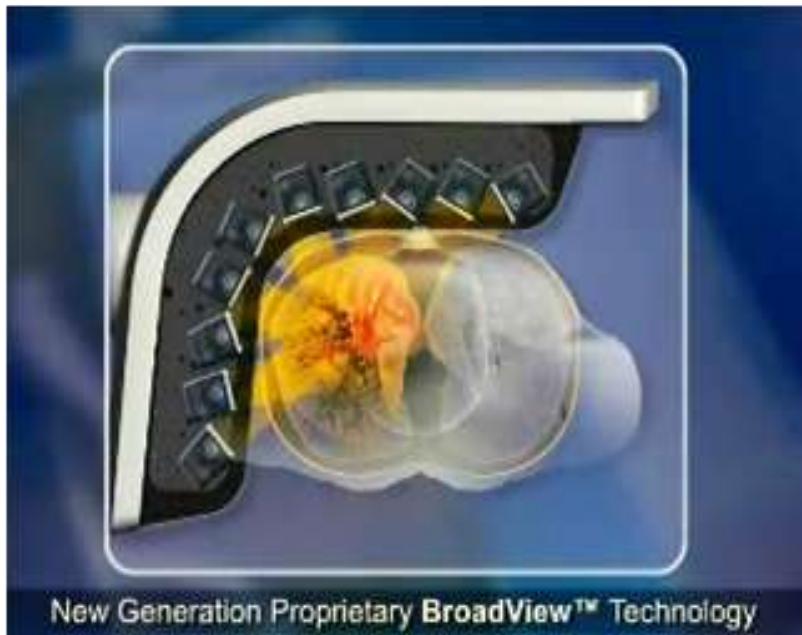
- ☑ better energy resolution
- ☑ higher count rate
- ☑ better compacity



**D-SPECT
(Spectrum Dynamics)**



**Discovery NM 530c
(GE Healthcare)**



Sensitivity in cardiac area

| | A-SPECT | D-SPECT | Ratio |
|--------------------------------------|----------------|----------------|--------------|
| Scan duration (min) | 12.5 | 2.0 | 0.16 |
| Total counts | 15.83 million | 2.67 million | 0.17 |
| Myocardium counts | 1.44 million | 1.90 million | 1.32 |
| Myocardium counts/total counts | 9.1% | 71.4% | |
| CPM from myocardium | 113,667 | 953,333 | 8.39 |

CPM, Counts per minute.

Dosimétrie

Diminution de la durée + de la dosimétrie

| Characteristic | Low-dose stress-only | High-dose stress-only | Full dose rest-stress | P value low-high | P value low-full |
|-------------------------------|----------------------|-----------------------|-----------------------|------------------|------------------|
| BMI (kg/m ²) | 25.0 ± 4.5 | 30.7 ± 6.5 | 28.5 ± 5.3 | <.0001 | <.0001 |
| Time (minutes) | 5.0 ± 0.0 | 3.0 ± 0.0 | 3.0 ± 0.1 | <.0001 | <.0001 |
| Total counts (kcounts) | 2765.7 ± 962.3 | 2400.6 ± 788.7 | 3286.9 ± 812.5 | .003 | <.0001 |
| Counts rate (kcounts/seconds) | 9.2 ± 3.2 | 13.3 ± 4.4 | 18.2 ± 4.5 | <.0001 | <.0001 |
| Tc-99m activity | | | | | |
| (MBq) | 462.5 ± 11.1 | 1080.4 ± 129.5 | 1542.9 ± 133.2 | <.0001 | <.0001 |
| (mCi) | 12.5 ± 0.3 | 29.2 ± 3.5 | 41.7 ± 3.6 | | |
| Tc-99m effective dose* (mSv) | 4.2 ± 0.1 | 8.0 ± 0.9 | 11.8 ± 1.0 | <.0001 | <.0001 |
| Image quality (1-4) | 3.4 ± 0.5 | 3.4 ± 0.6 | 3.5 ± 0.4 | >.99 | .11 |
| Gating quality (% diagnostic) | 100% | 100% | 100% | NS | NS |

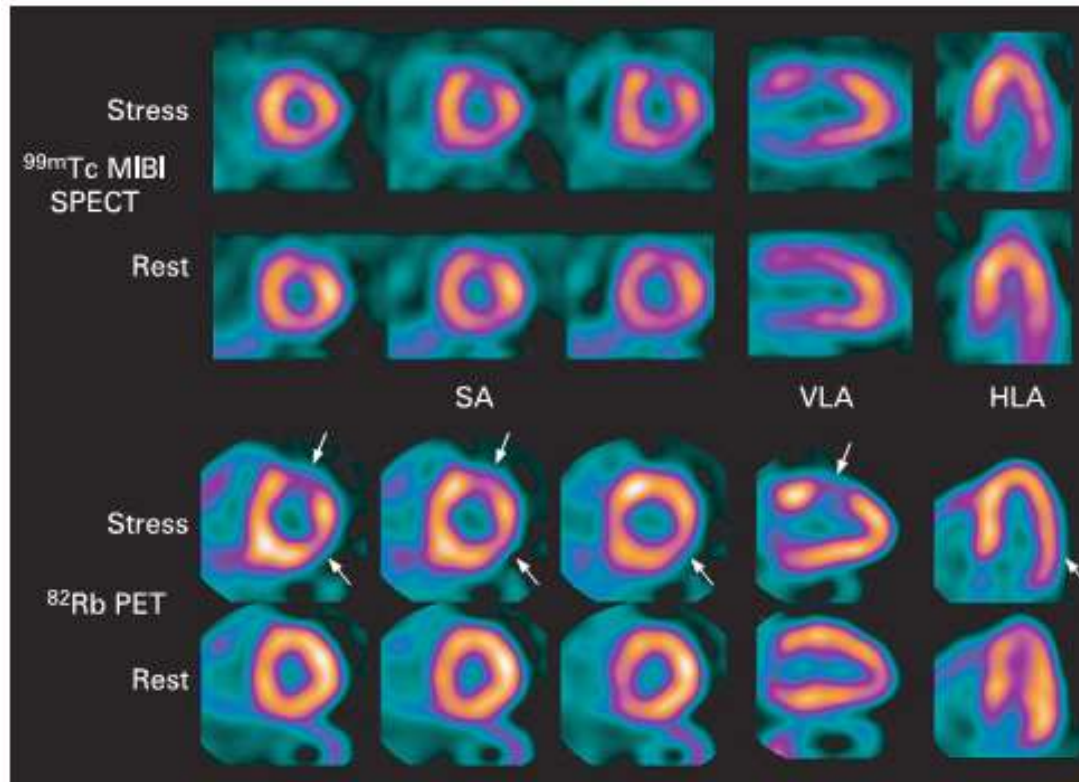
N = 103 for matched controls (gender, stressor, BMI ±5).

N total = 717. Activity in MBq (mCi) and effective dose in mSv was calculated from the total group which included low dose N = 209, high dose N = 140, full study N = 368.

*Based on ICRP Publication 103.¹³

Perfusion myocardique en TEP

SPECT

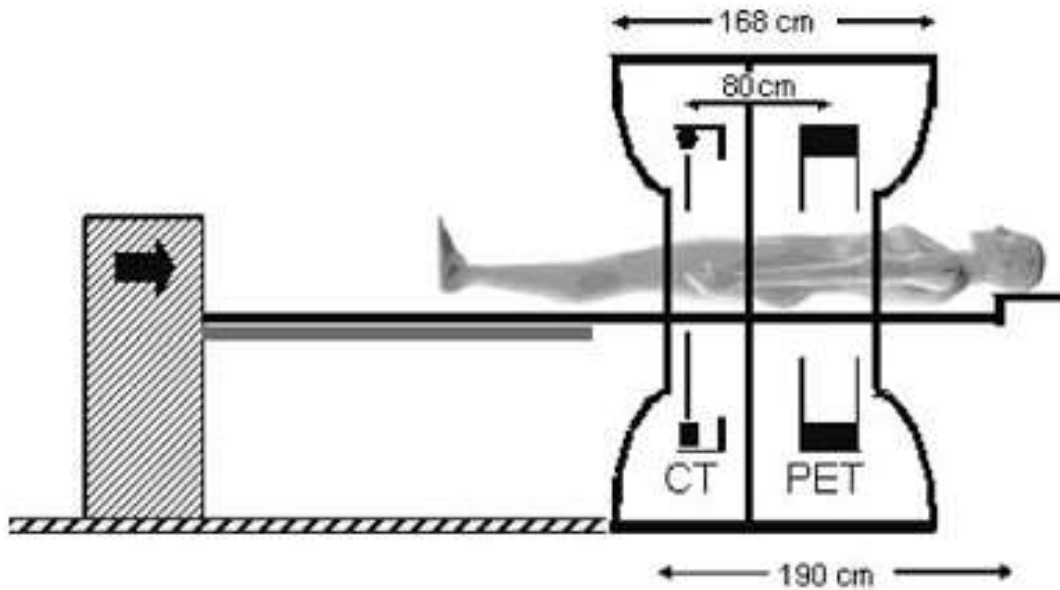


PET

Qualitatively:

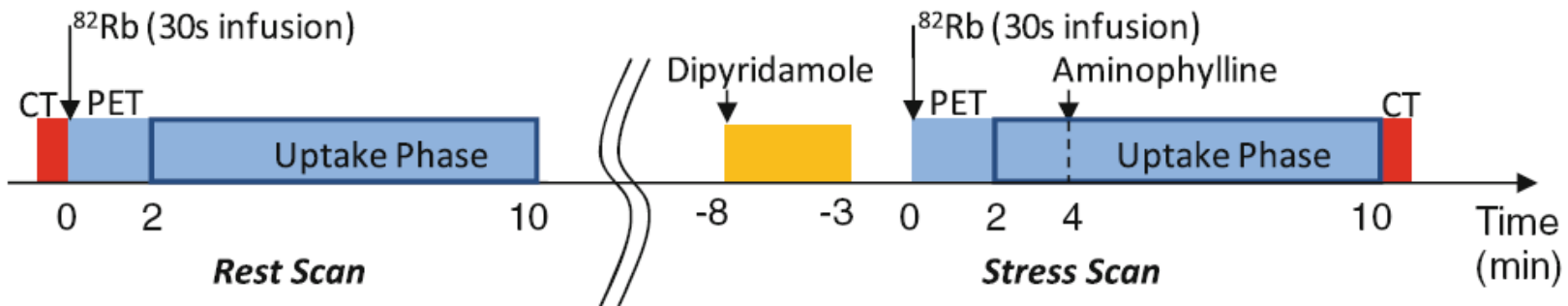
- Better contrast between ischaemic / non ischaemic segments
- No (much less...) attenuation artifacts

Perfusion myocardique en TEP

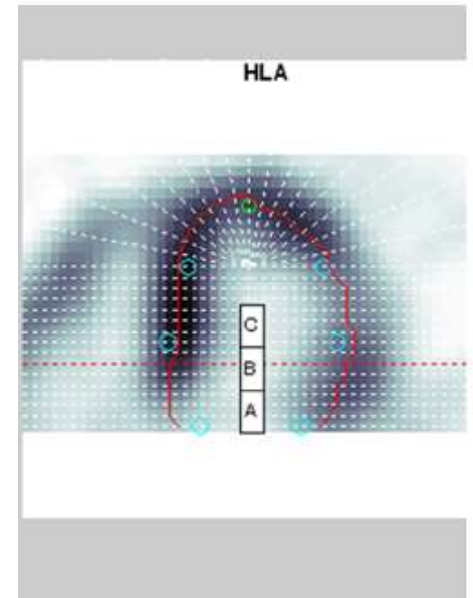
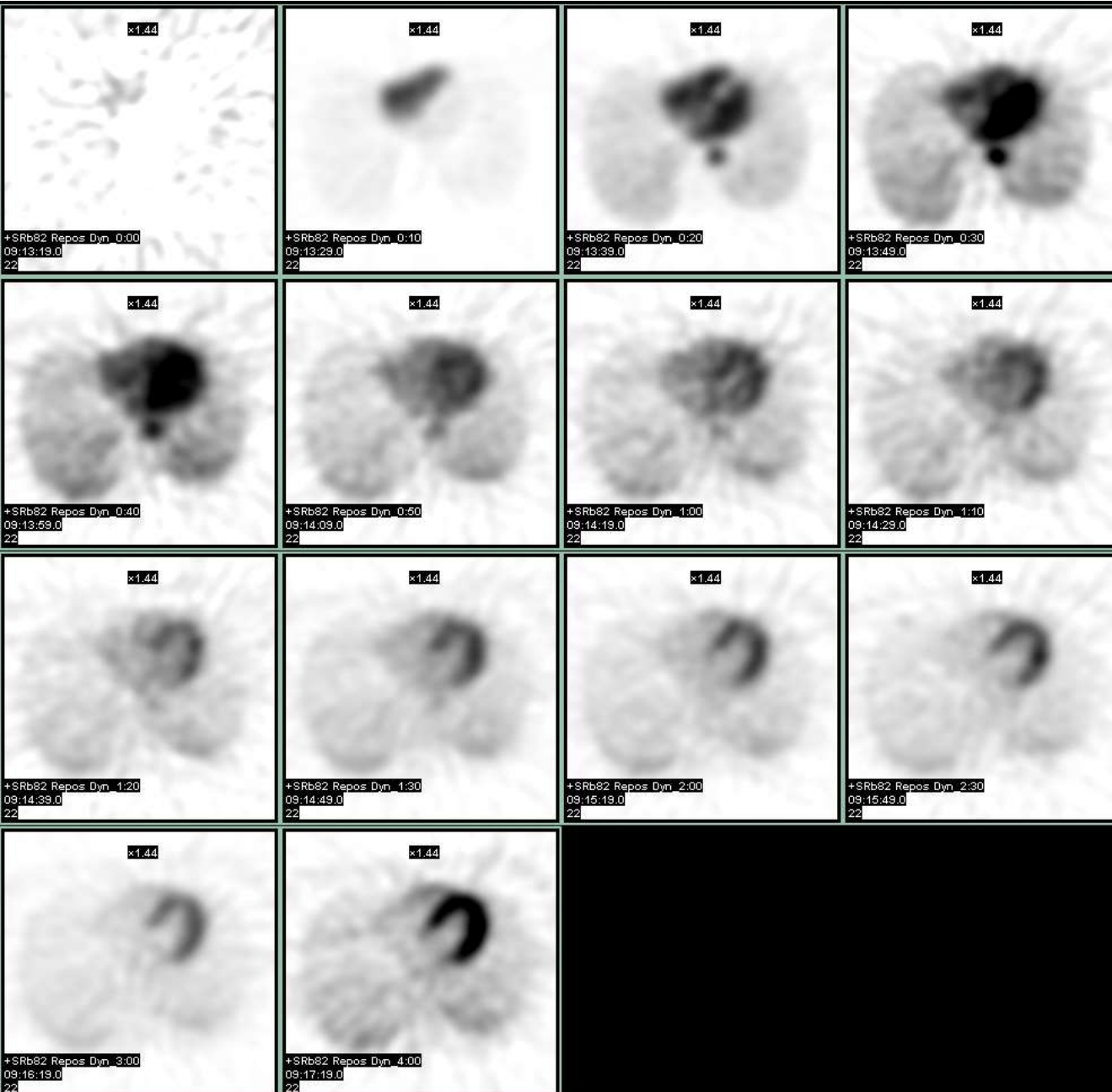


Correction
d'atténuation

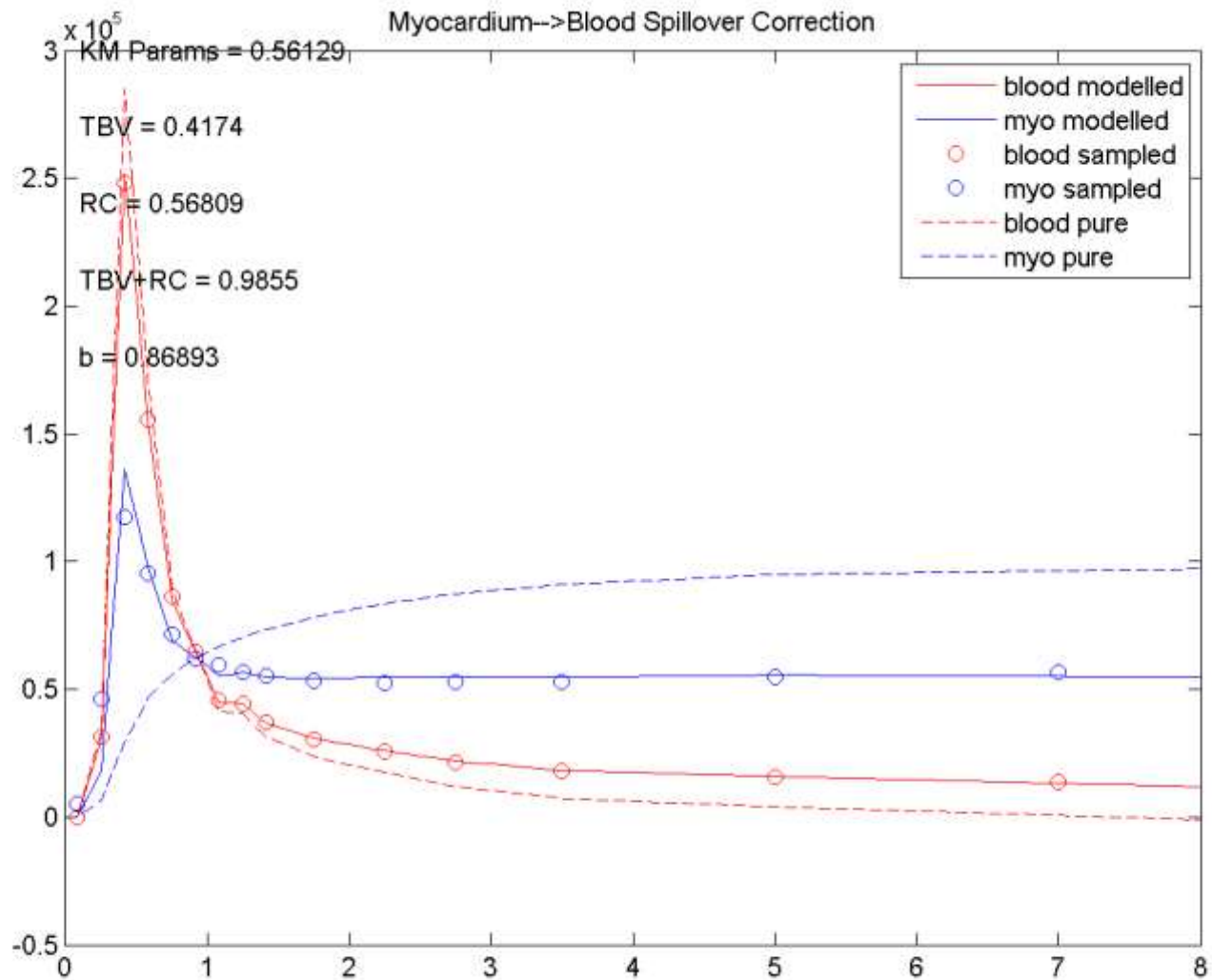
Protocole d'acquisition avec le ^{82}Rb



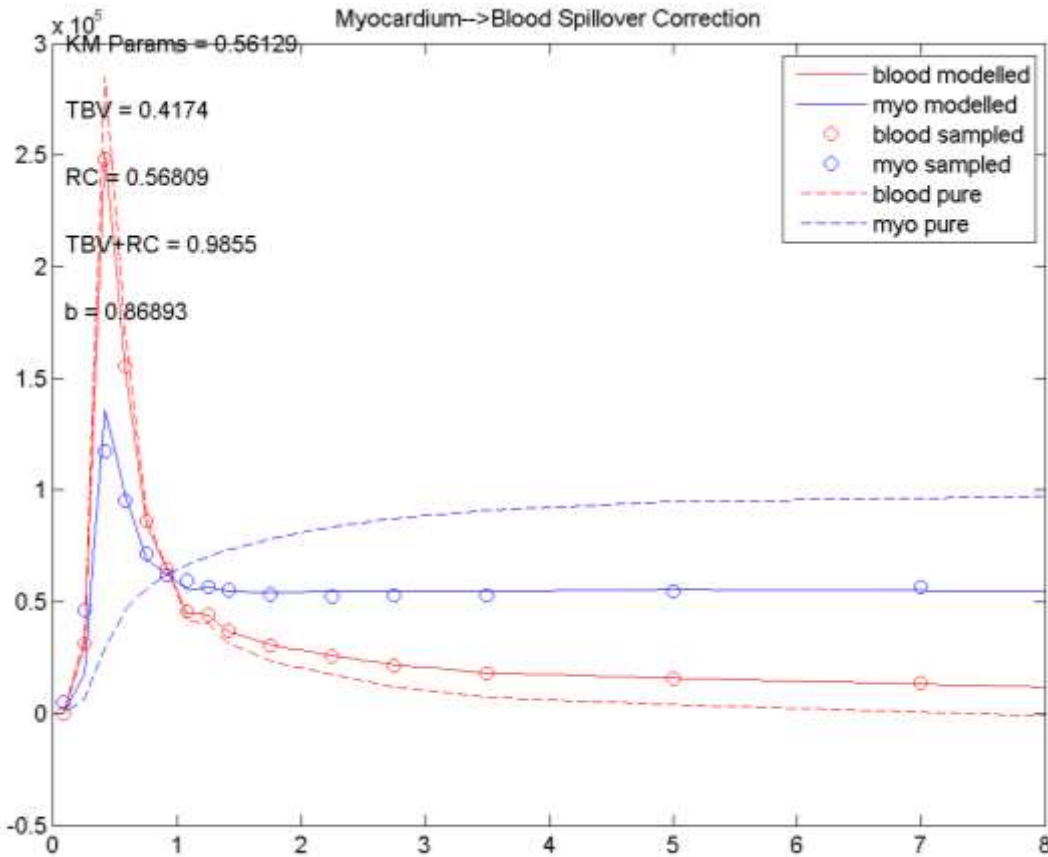
Flow = dynamic acquisition



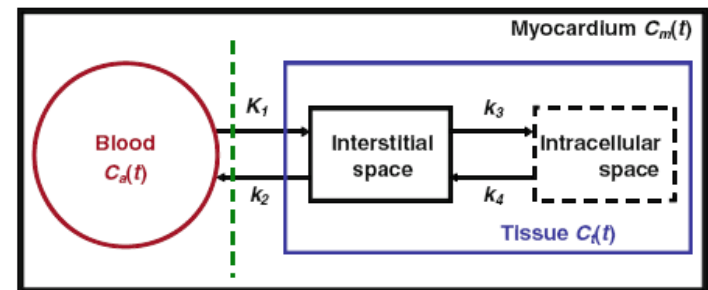
Flow quantification



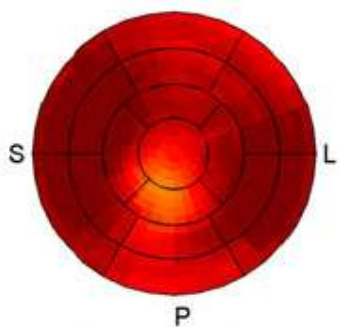
Flow quantification



Compartmental model describing the **dynamic** exchange of activity between arterial blood and myocardial tissue



stressRubidium Uptake

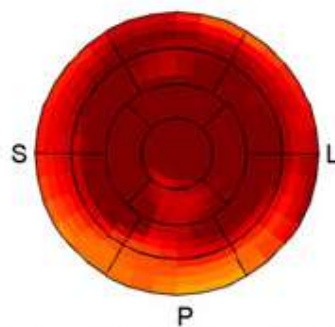


| | LV | LAD | LCX | RCA |
|------|----------|----------|----------|----------|
| Mean | 1.2e+002 | 1.2e+002 | 1.3e+002 | 1.2e+002 |
| %max | 90 | 90 | 94 | 87 |

LowSegment: apical inferior mean 1.1e+002 (78%max)

kBq/cc

stressRubidium Flow

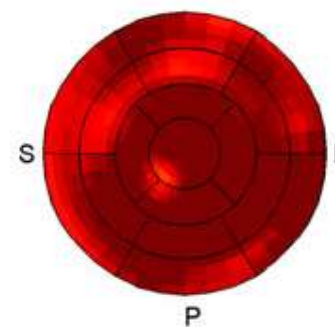


| | LV | LAD | LCX | RCA |
|------|----|-----|-----|-----|
| Mean | 4 | 4.2 | 4 | 3.7 |
| %max | 84 | 89 | 83 | 77 |

LowSegment: basal inferior mean 3.1 (65%max)

mL/min/g

stressRubidium / restRubidium

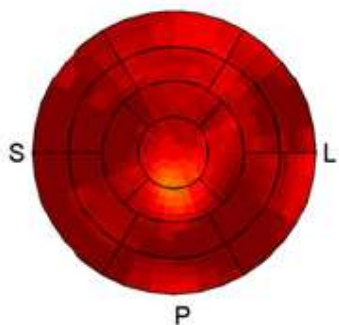


| | LV | LAD | LCX | RCA |
|------|-----|-----|-----|-----|
| Mean | 4.1 | 4 | 4.2 | 4.1 |
| %max | 90 | 89 | 92 | 91 |

LowSegment: mid anteroseptal mean 3.6 (79%max)

mL/min/g

restRubidium Uptake

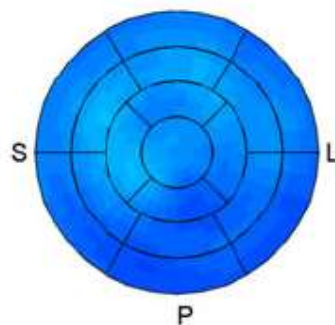


| | LV | LAD | LCX | RCA |
|------|----|-----|-----|-----|
| Mean | 76 | 75 | 77 | 77 |
| %max | 93 | 92 | 94 | 93 |

LowSegment: apical inferior mean 69 (85%max)

kBq/cc

restRubidium Flow

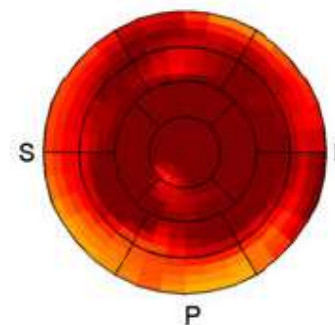


| | LV | LAD | LCX | RCA |
|------|------|-----|------|------|
| Mean | 0.98 | 1.1 | 0.94 | 0.88 |
| %max | 87 | 93 | 83 | 78 |

LowSegment: basal inferior mean 0.79 (70%max)

mL/min/g

stressRubidium - restRubidium



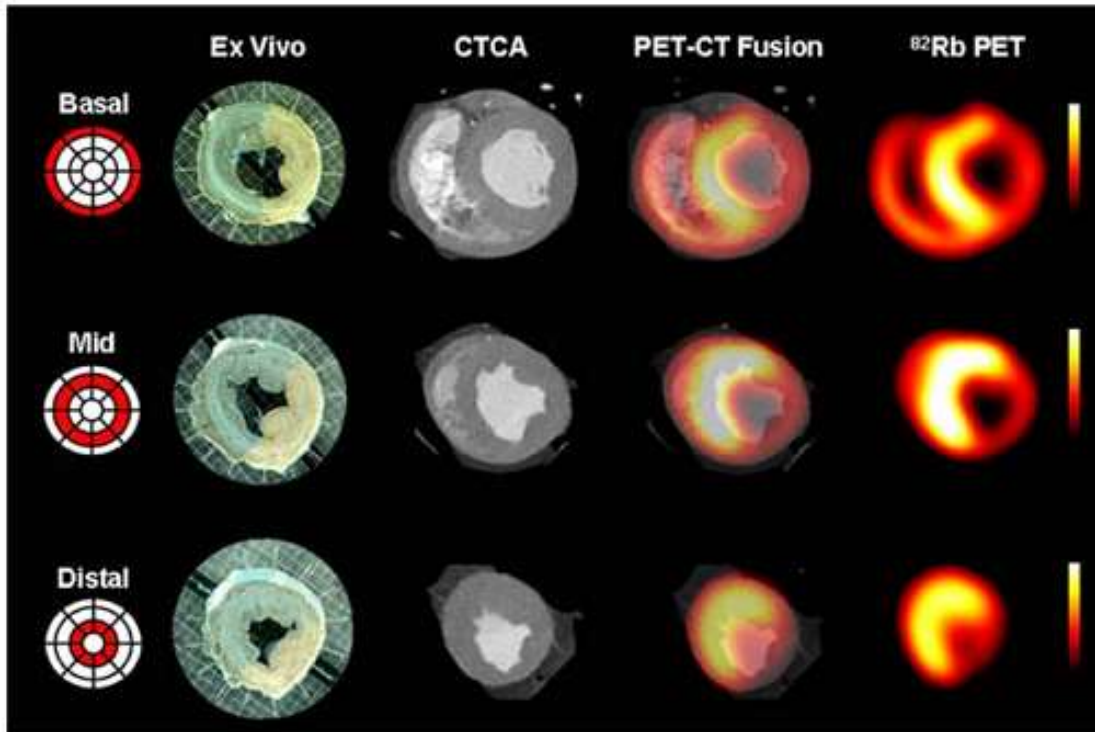
| | LV | LAD | LCX | RCA |
|------|----|-----|-----|-----|
| Mean | 3 | 3.2 | 3 | 2.8 |
| %max | 84 | 88 | 83 | 76 |

LowSegment: basal inferior mean 2.3 (63%max)

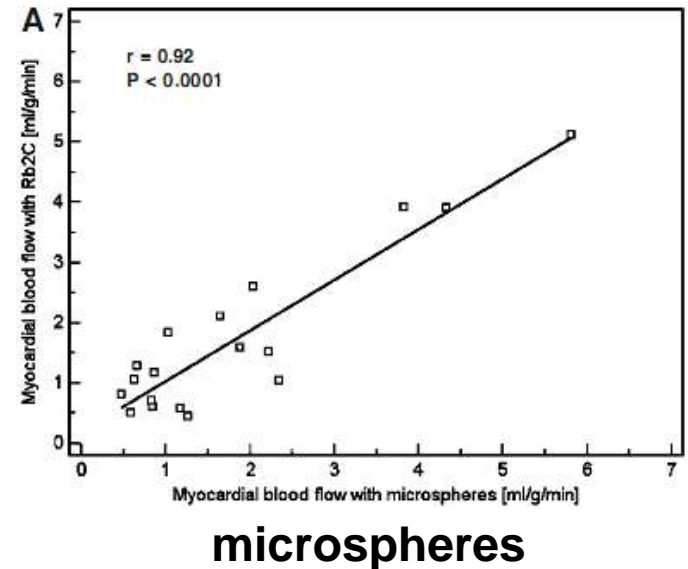
mL/min/g

Perfusion: PET agents

Absolute quantification of blood flow with PET

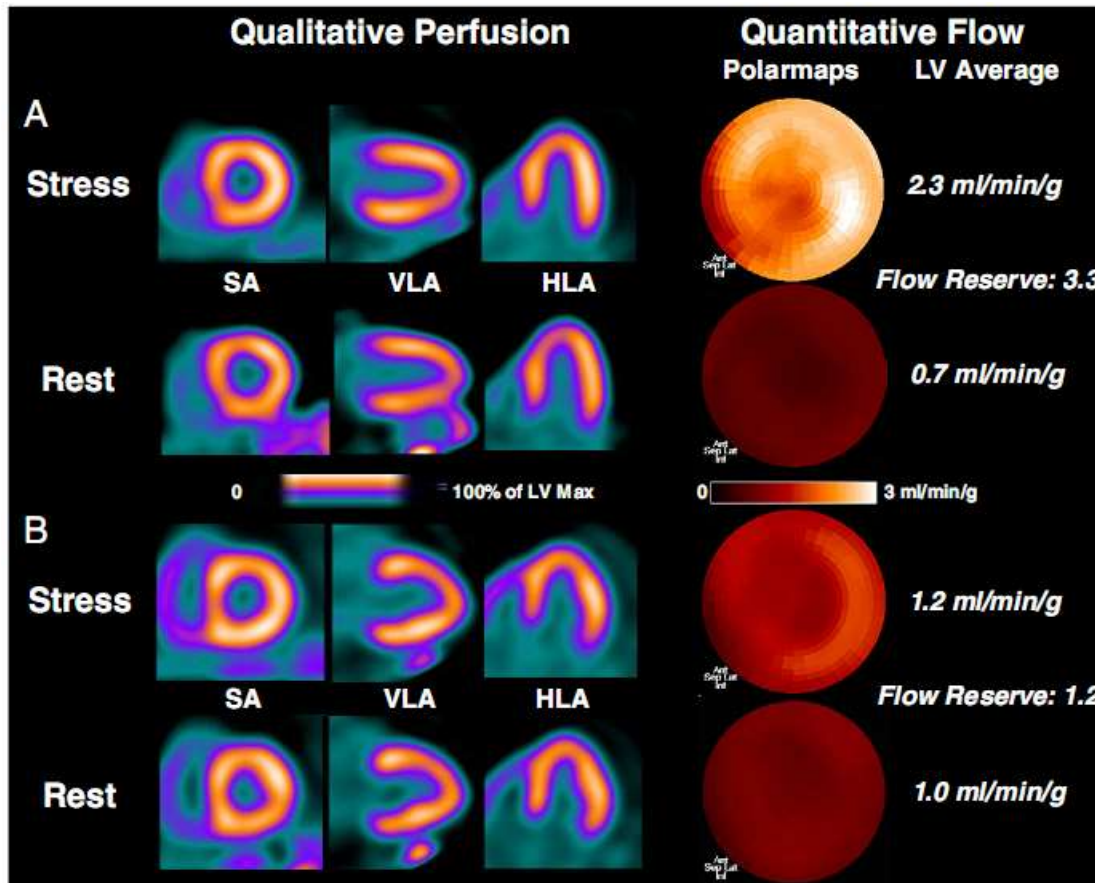


^{82}Rb uptake



Perfusion: PET agents

Absolute quantification of blood flow with PET

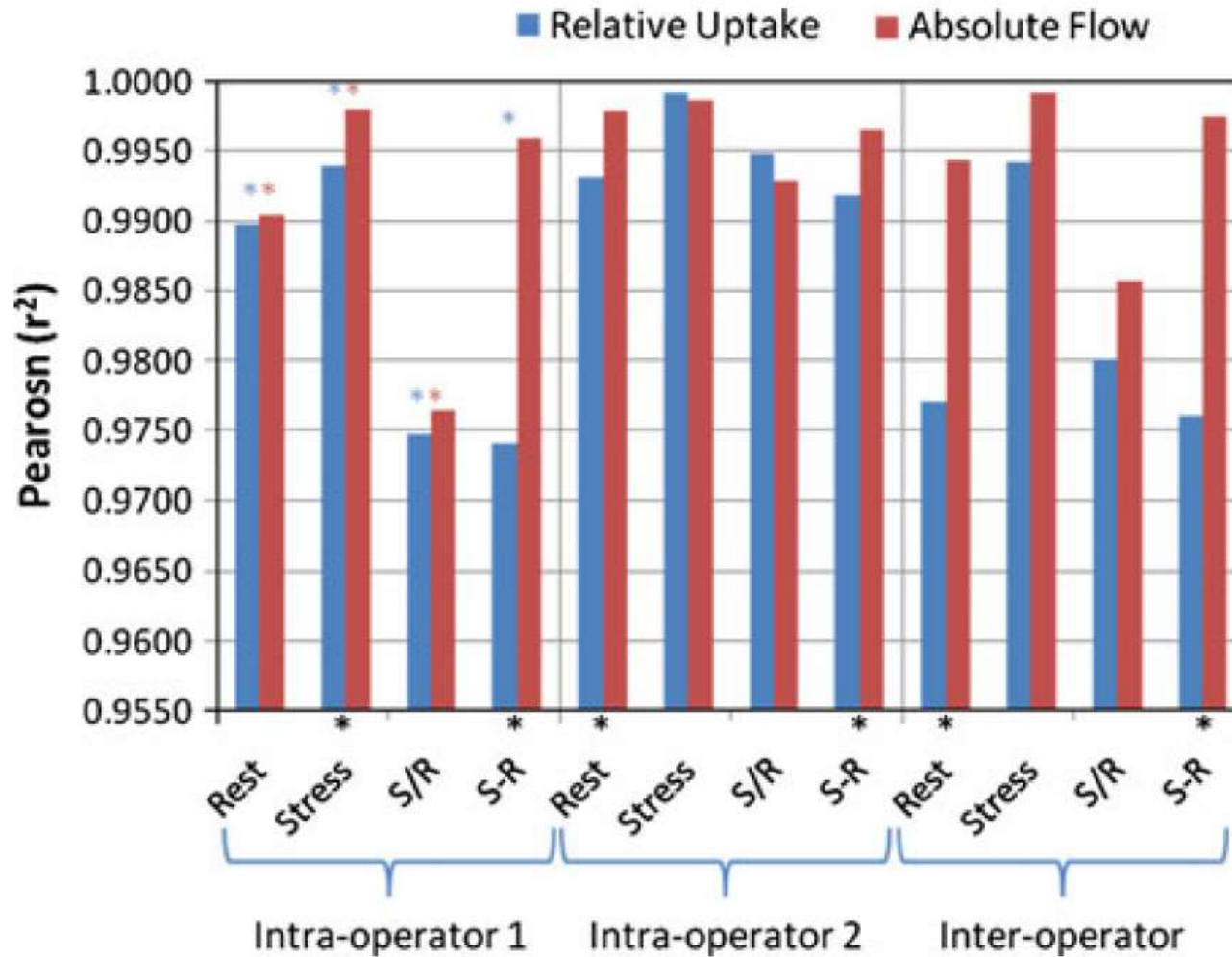


Normal

Balanced ischemia

^{82}Rb

Reproductibilité

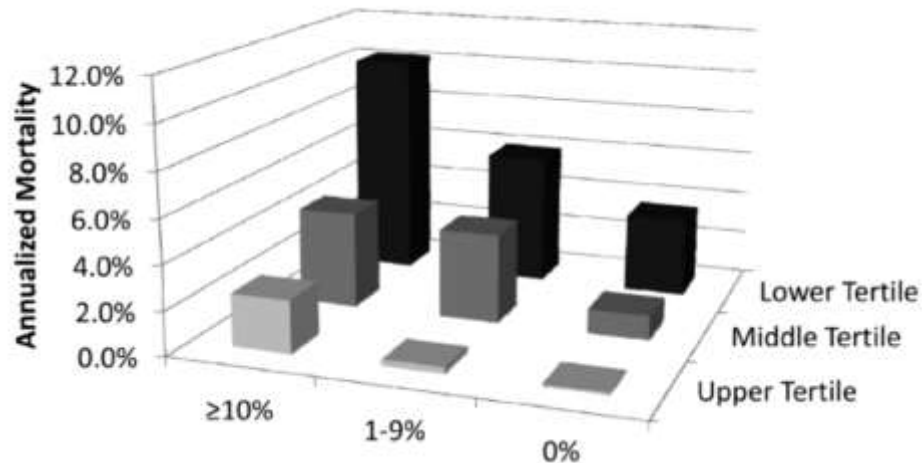


MBF: large-scale validation

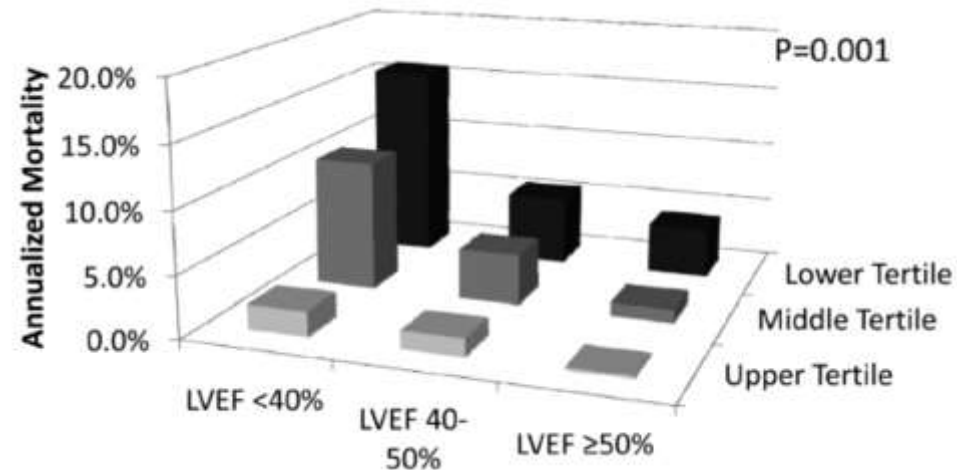
Hypothesis: incremental prognostic value of coronary flow reserve (CFR), beyond clinical risk factors and semi-quantitative assessment of myocardial ischemia and left ventricular function.

- Single-centre, non-randomized, observational study
- 2783 consecutive patients
- Perfusion analysis: ⁸²Rubidium PET
- Median follow-up: 1.4 years [0.7 – 3.2]

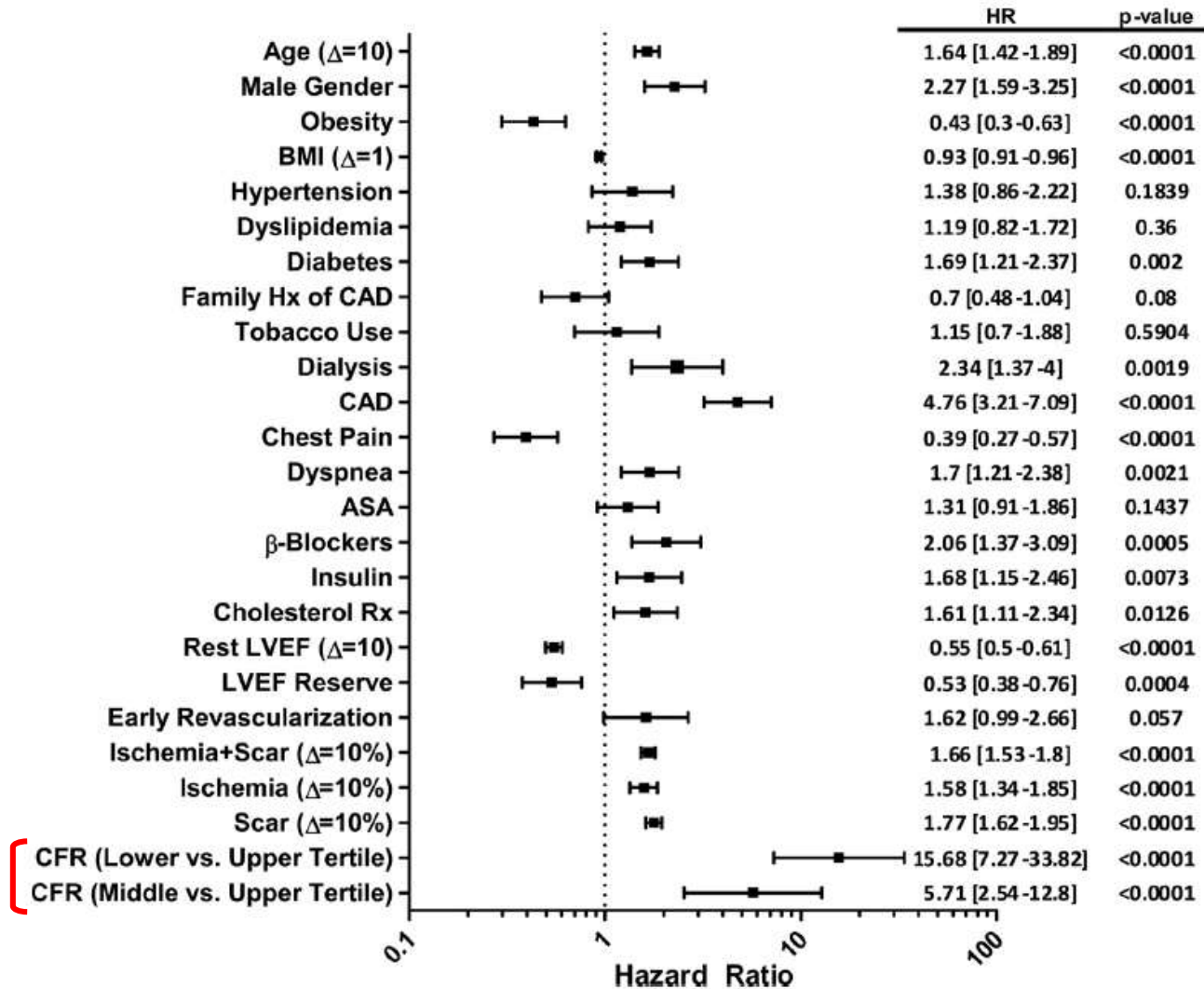
Extent of ischemia + scar



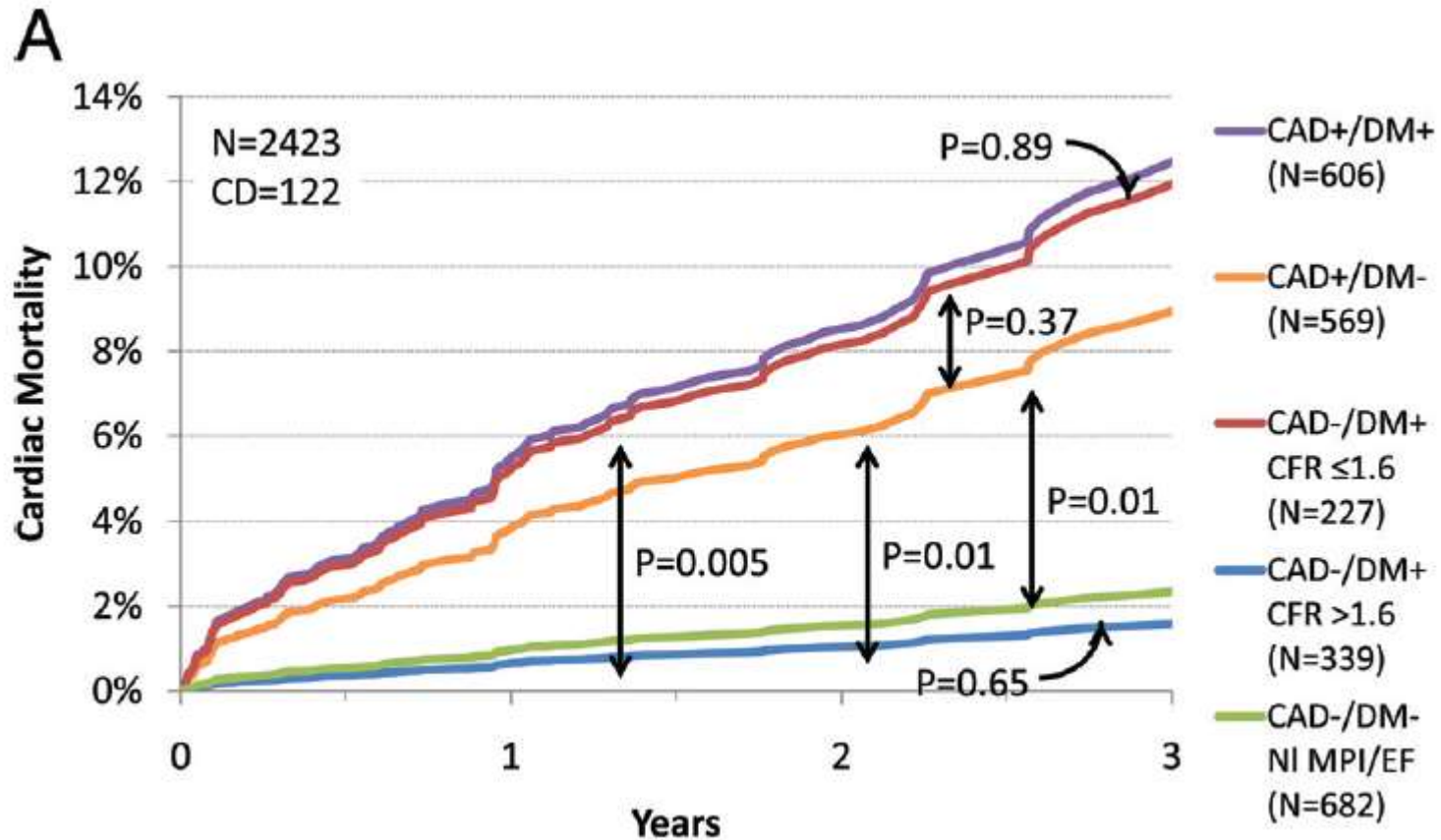
Left ventricular ejection fraction



MBF: integration of risk profile



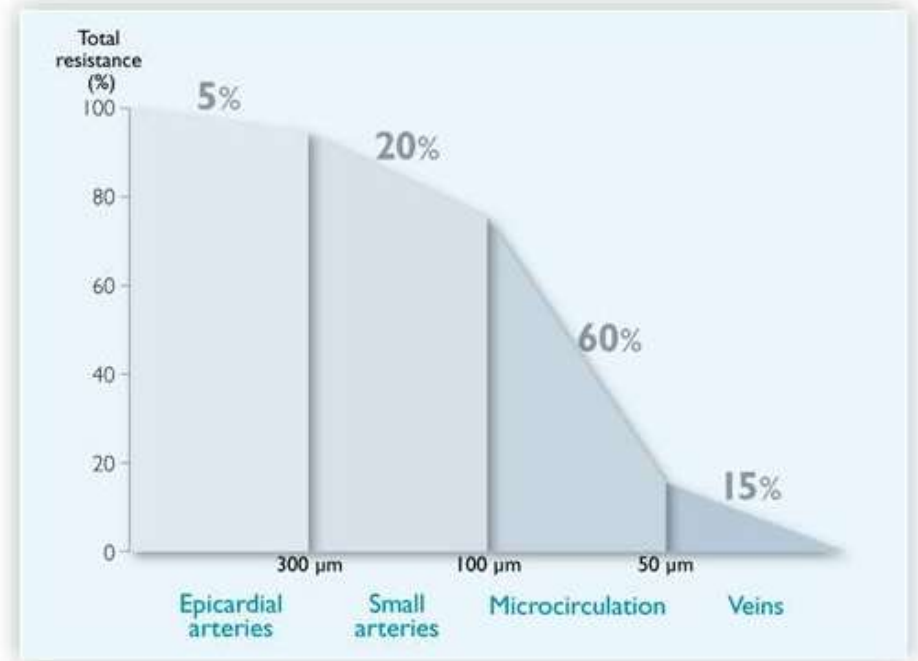
MBF: integration of risk profile



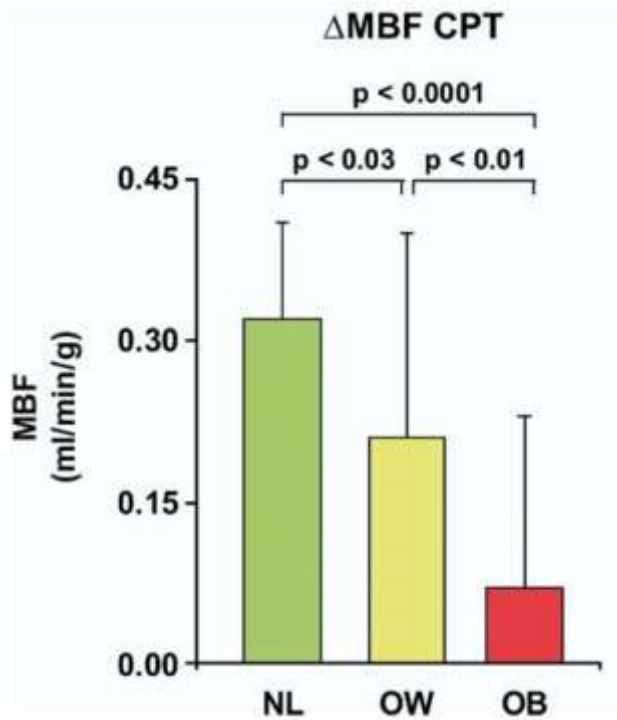
CAD = coronary artery disease
DM = diabetes mellitus

Myocardial blood flow (MBF)

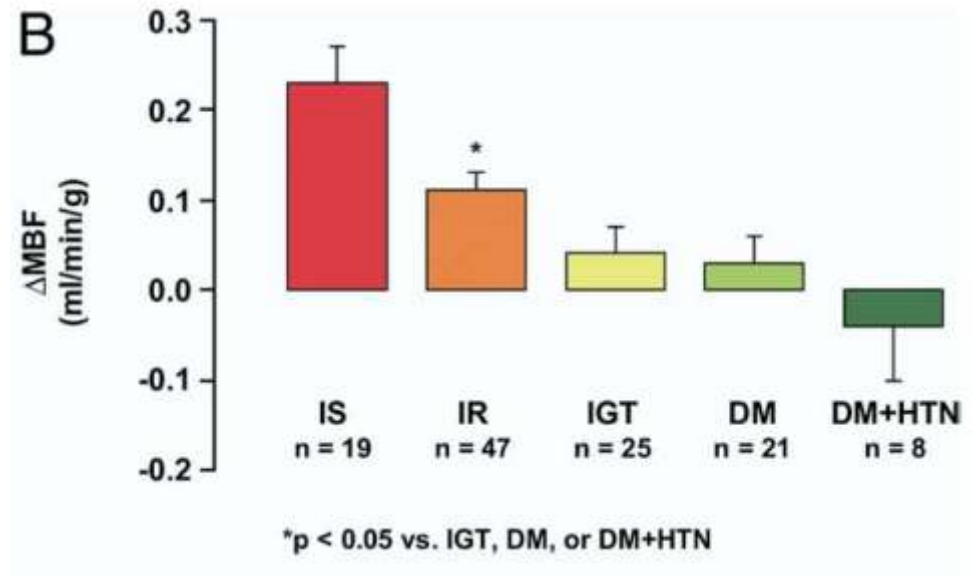
Microcirculation



Microvascular dysfunction and risk factors



Weight



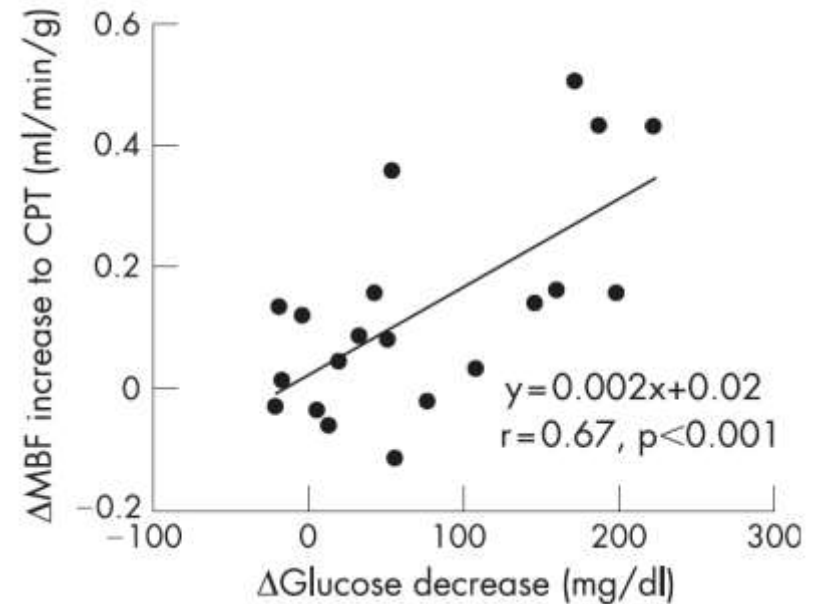
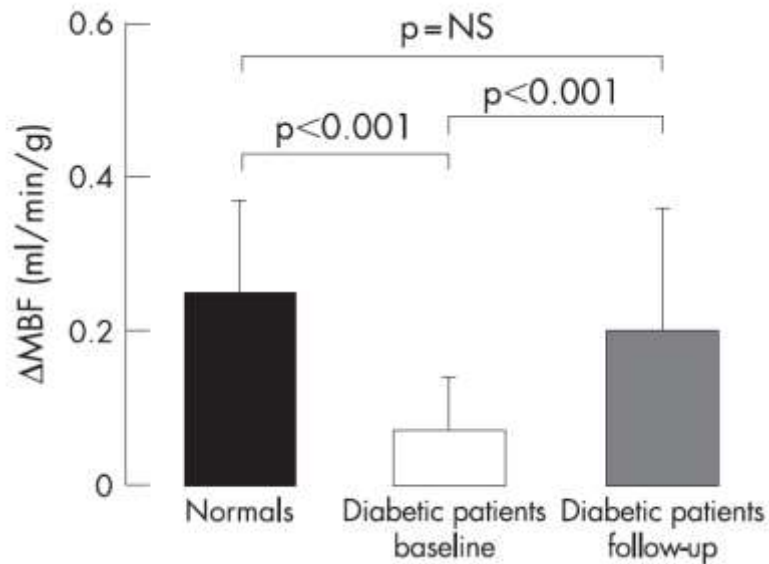
Diabetes / Hypertension

OW = overweight; OB = obese;

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

Microvascular dysfunction and risk factors

20 patients DM2, 18 matched controls



Conclusions

La SMP est un examen parfaitement validé en routine pour

- le diagnostic de l'insuffisance coronaire
- l'évaluation de la viabilité myocardique
- le pronostic des cardiopathies ischémiques

Caméras de nouvelle génération : meilleure sensibilité

Perspectives : TEP de perfusion myocardique

- Correction d'atténuation (patients obèses)
- Quantification absolue du flux sanguin myocardique : intérêt en clinique et en recherche