

Nuclear Cardiology

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Nuclear Cardiology

- I - A remaining need of a functional information on myocardial perfusion**
- II - The future:**
 - combining functional and anatomic information,
 - new cameras and new images...

Nuclear Cardiology

I - A remaining need of a functional information on myocardial perfusion

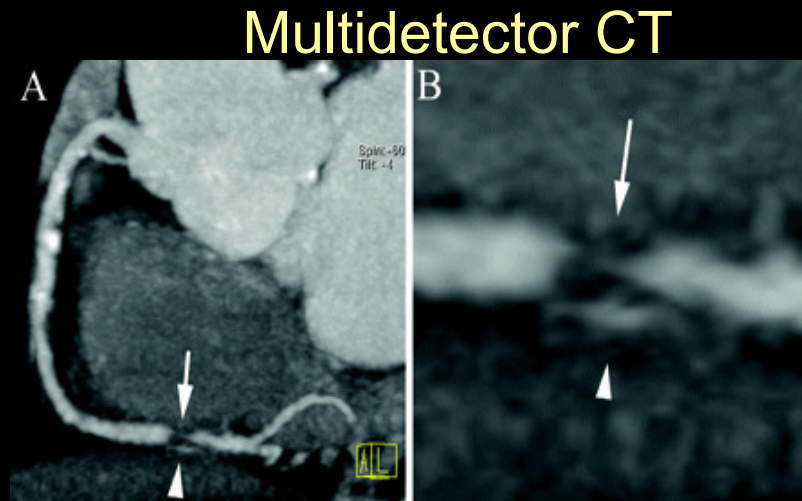
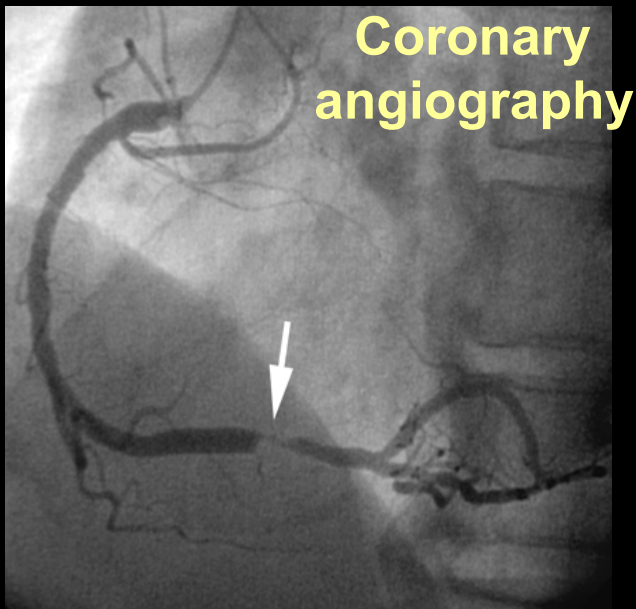
II - The future:

- combining functional and anatomic information,
- new cameras and new images...

I - A remaining need of a functional information on myocardial perfusion

Anatomical information:

- ➡ is not always enough for detecting and assessing CAD,
- ➡ coronary atherosclerosis remains frequently:
 - without ischemia,
 - uncomplicated.

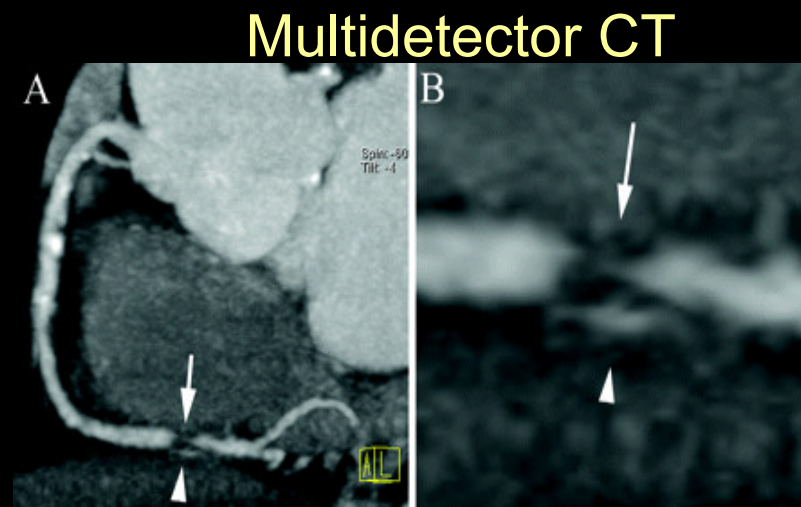
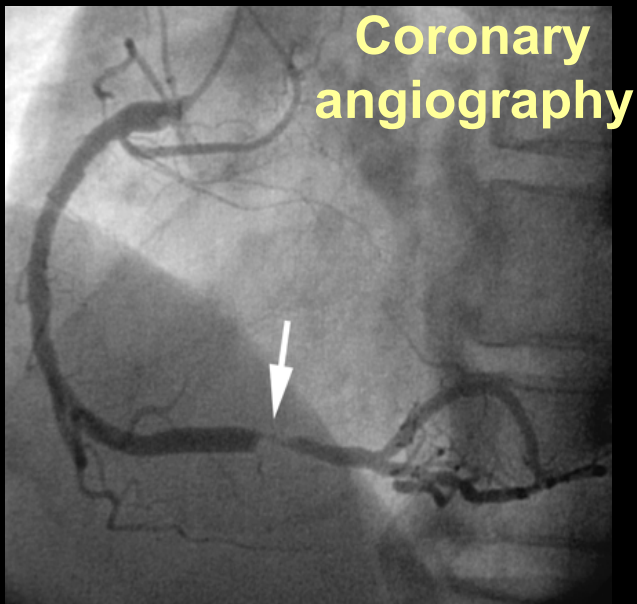


Autopsy studies have determined the rates of high grade coronary atherosclerosis in patients :

- (i) who were without any history of CAD
- (ii) who died because of a non-cardiac cause.

What is this rate in north-american non-diabetic men of 65 years old?

1. less than 40%
2. from 40 to 60%
3. more than 60%

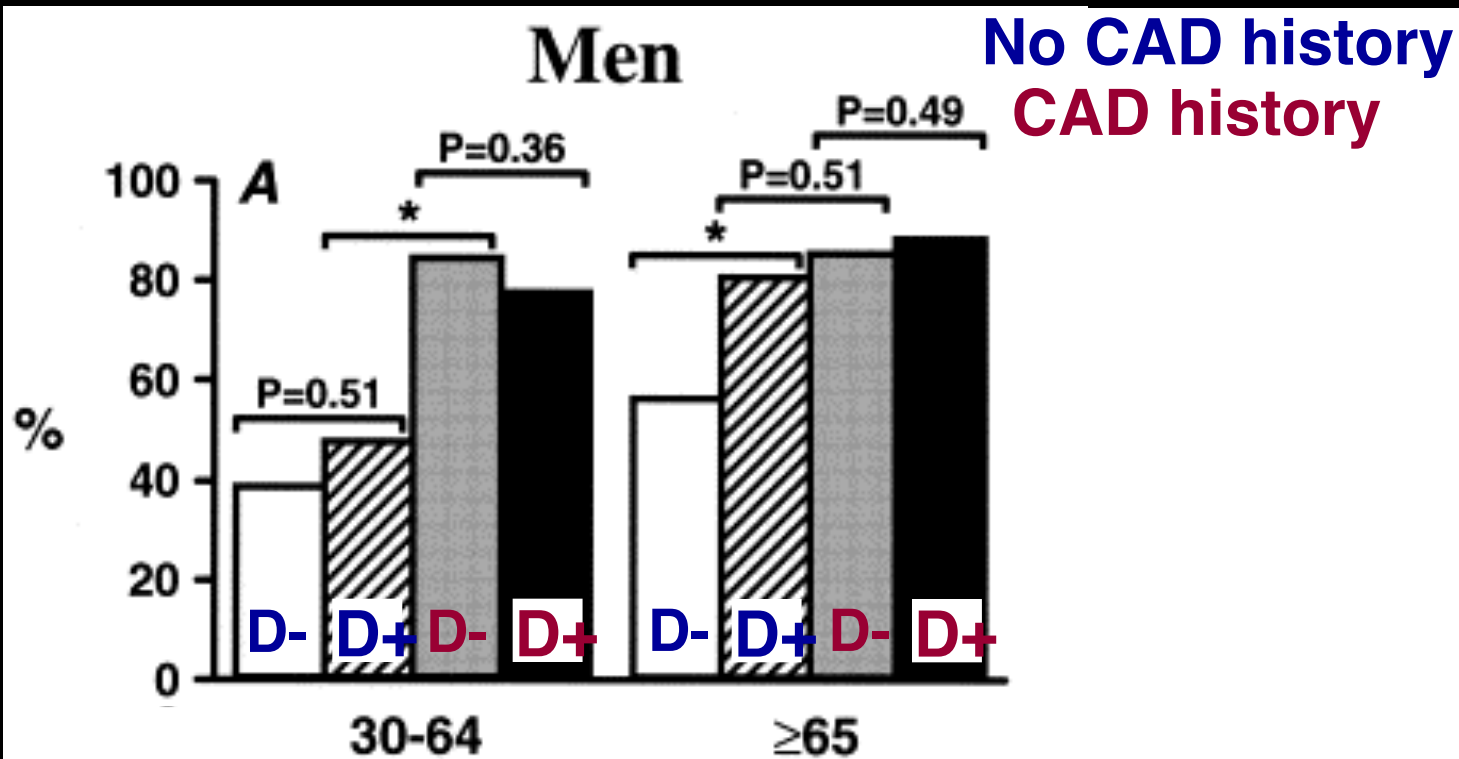


Coronary atherosclerosis in diabetes mellitus

A population-based autopsy study.

Tauqir Y. Goraya et al. J Am Coll Cardiol. 2002;40(5):946-53.

Prevalence of high-grade coronary atherosclerosis at autopsy by diabetes and clinical coronary disease status.



□ Non-diabetic, no antemortem CAD
▨ Diabetic, no antemortem CAD
■ Non-diabetic, antemortem CAD
■ Diabetic, antemortem CAD

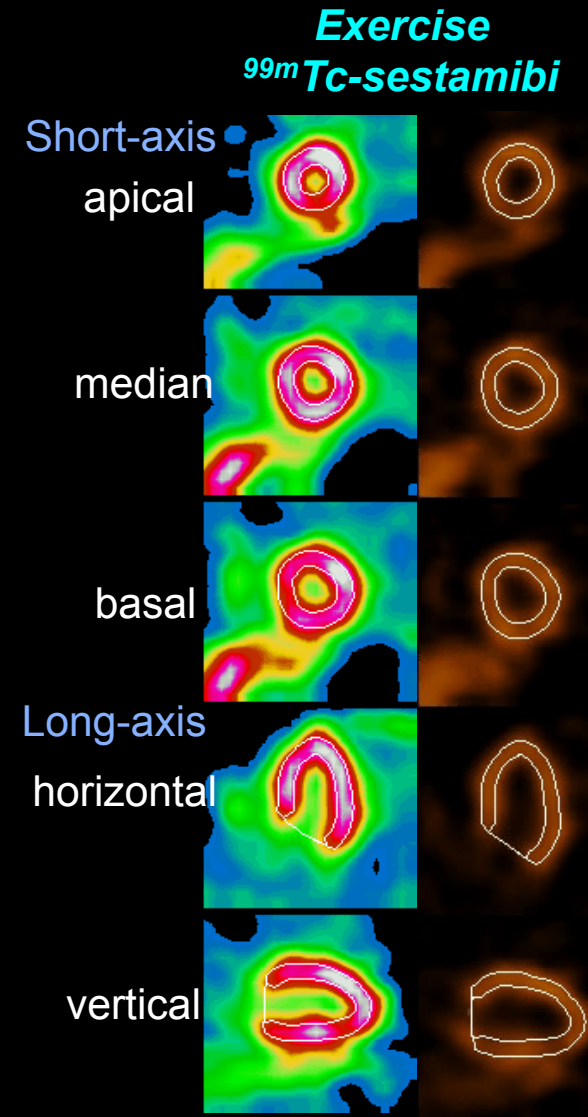
I - A remaining need of a functional information on myocardial perfusion

Severe coronary stenoses are not always associated with severe perfusion abnormalities

Mechanisms:

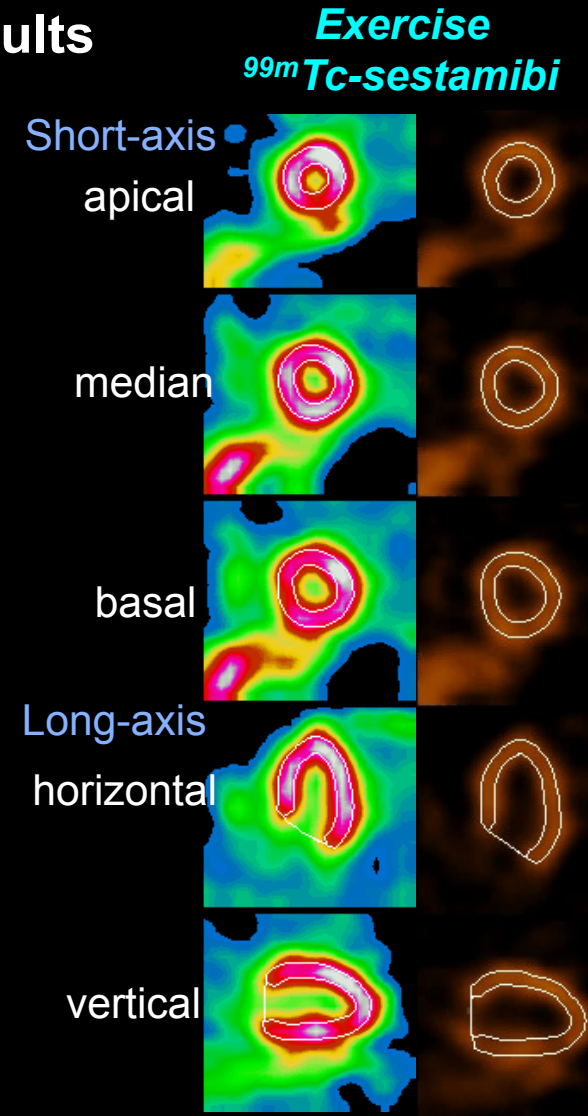
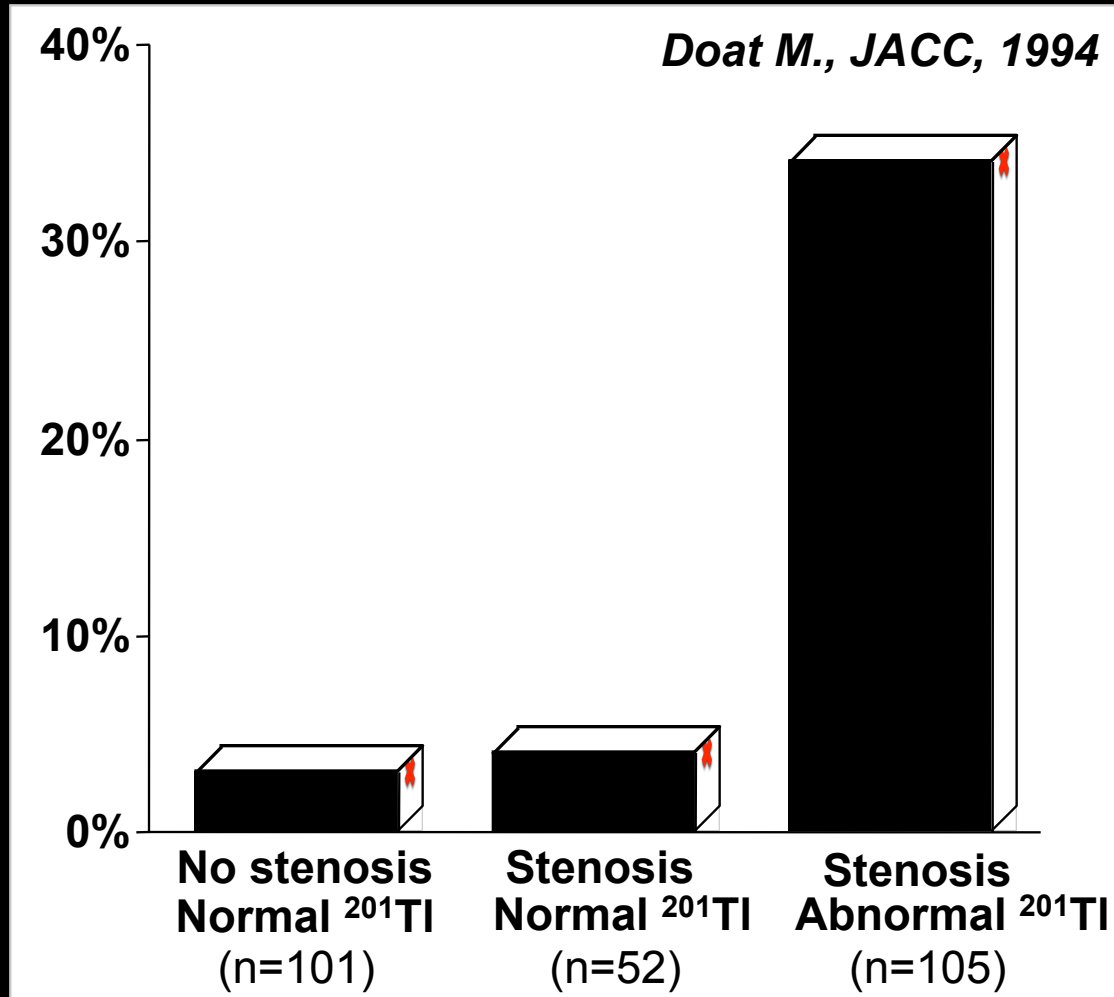
- collaterals,
- antianginal medications.

Patient with a **total occlusion of the right coronary artery**, but with a **normal exercise-SPECT** under beta-blockers



The most serious coronary stenoses are those associated with perfusion abnormalities

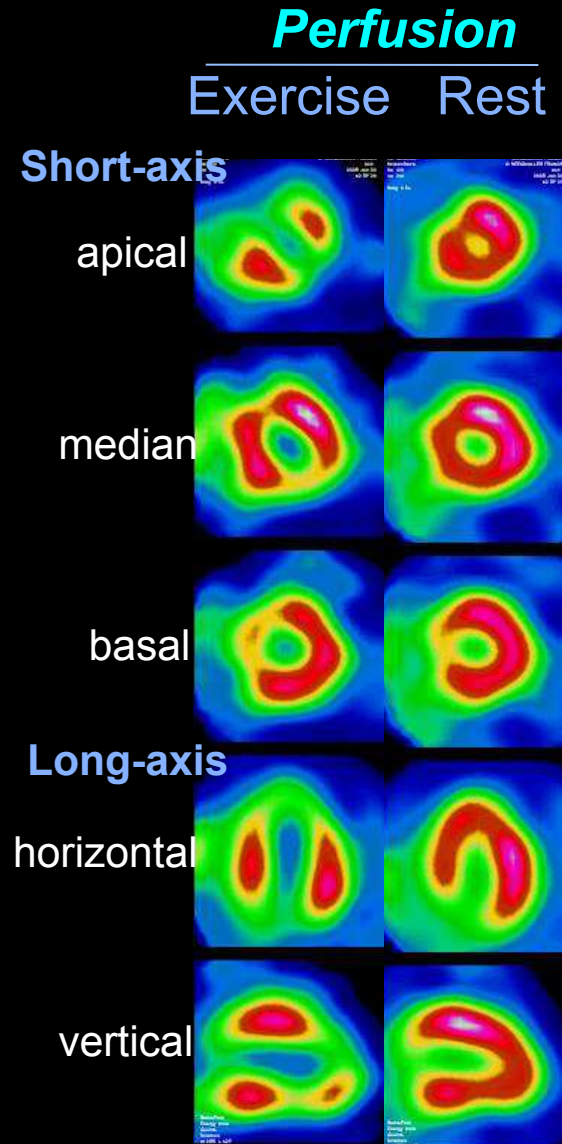
5-year rate of major cardiac events (death or MI) as a function of the stress- ^{201}Tl and angiographic results



Prognostic stratification using exercise MPI

Main parameters:

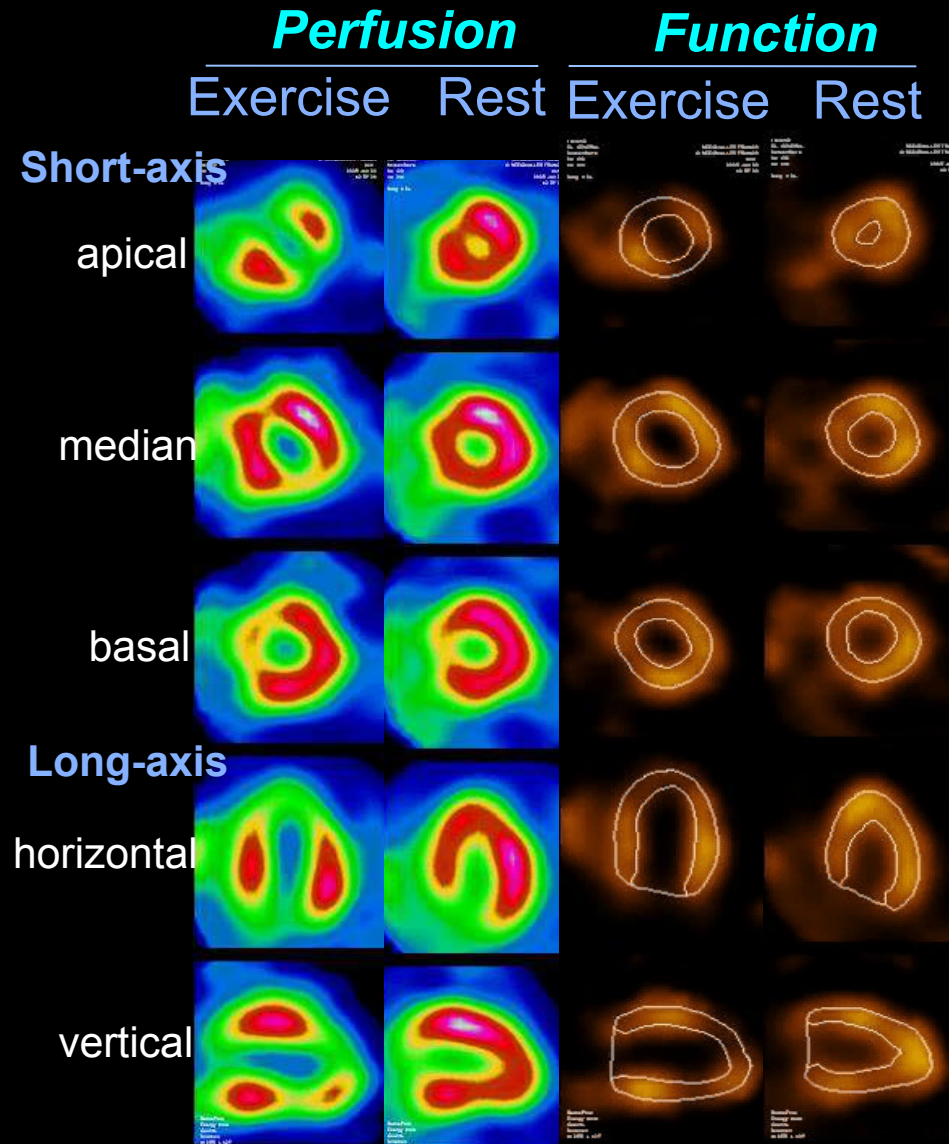
- ✓ Exercise testing parameters (maximal work load and heart rate, positive test)
- ✓ Normal stress-SPECT
- ✓ Extent of stress defects
- ✓ Extent of reversible stress defects



Prognostic stratification using exercise MPI

Main parameters:

- ✓ Exercise testing parameters (maximal work load and heart rate, positive test)
- ✓ Normal stress-SPECT
- ✓ Extent of stress defects
- ✓ Extent of reversible stress defects
- ✓ Post-stress LV ejection fraction (<45%) and end-systolic volume (>70 mL)
- ✓ Reversible wall motion abnormalities



Myocardial Perfusion Tomoscintigraphy

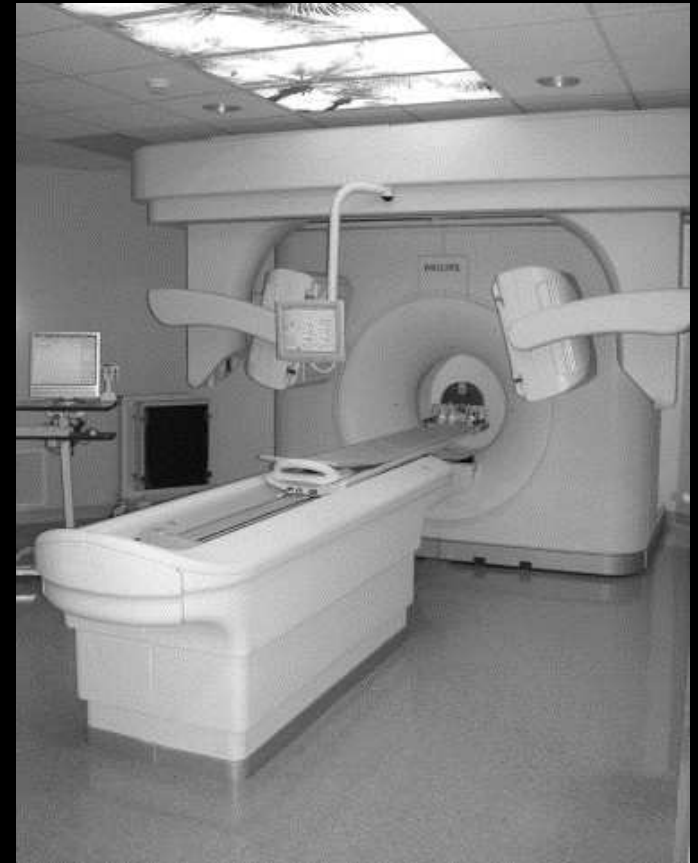
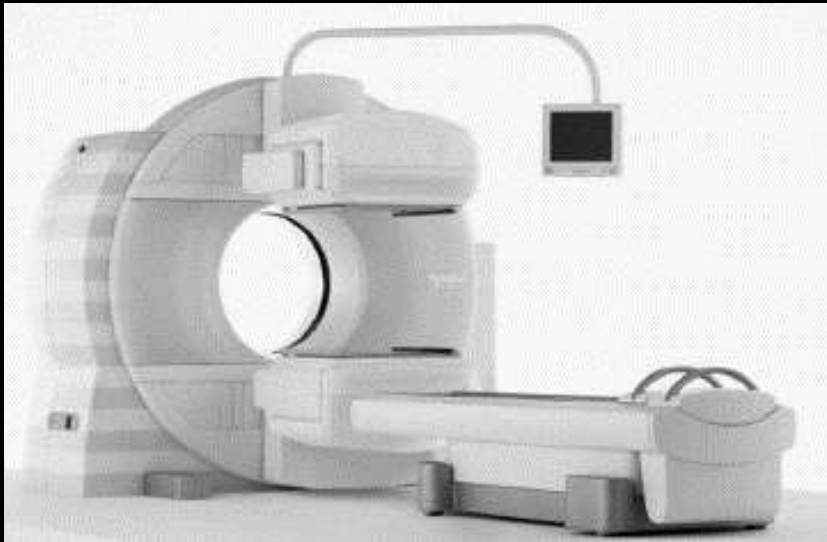
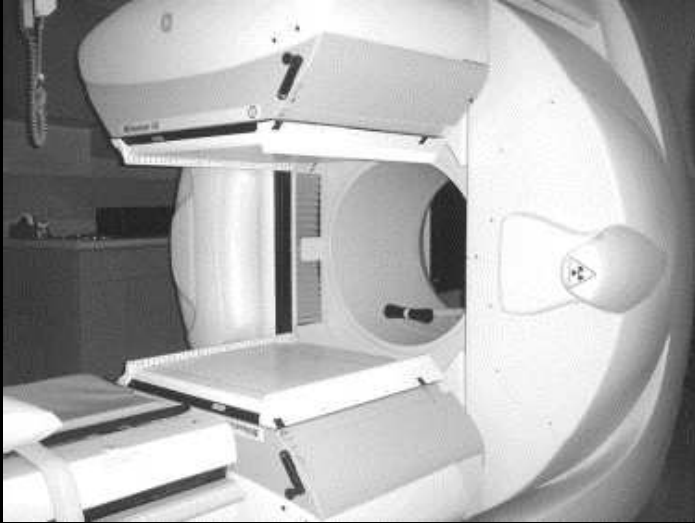
I - A remaining need of a functional information on myocardial perfusion

II - The future:

- combining functional and anatomic information,**
- new cameras and new images...**

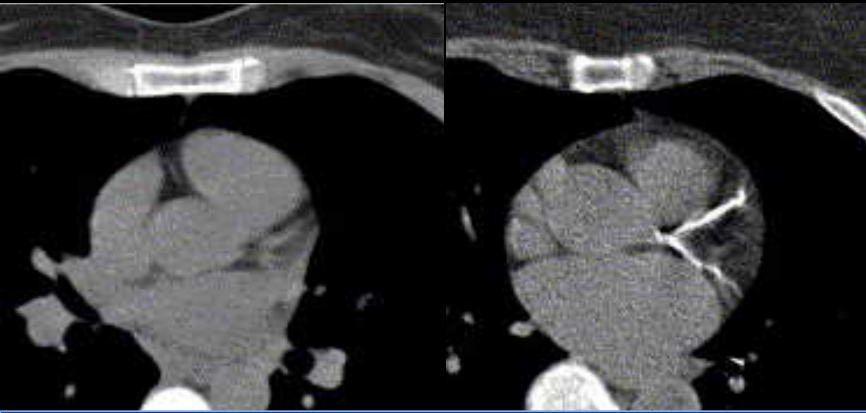
Combining functional and anatomic information

Hybrid SPECT/CT scanners



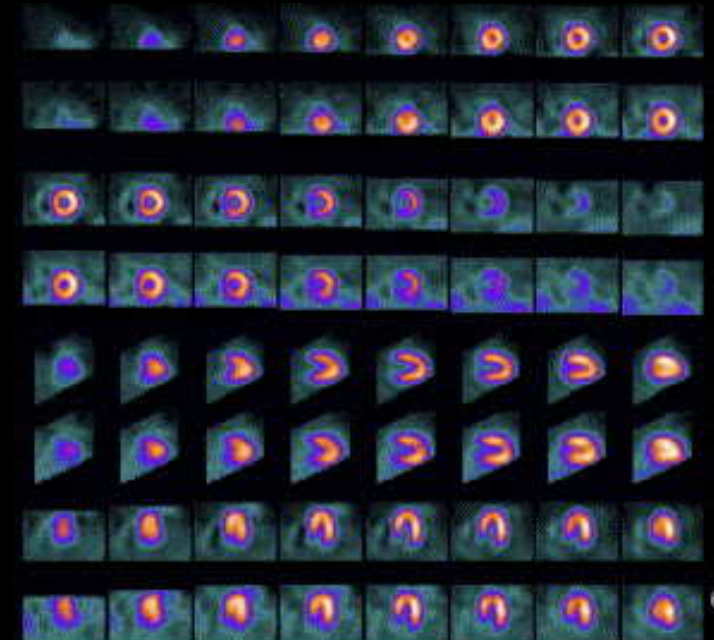
Combining functional and anatomic information

Hybrid SPECT/CT scanners for coronary calcium scoring



Thompson RC, and Coll.
Clinical utility of coronary calcium scoring after nonischemic myocardial perfusion imaging. J Nucl Cardiol. 2005;12:392-400.

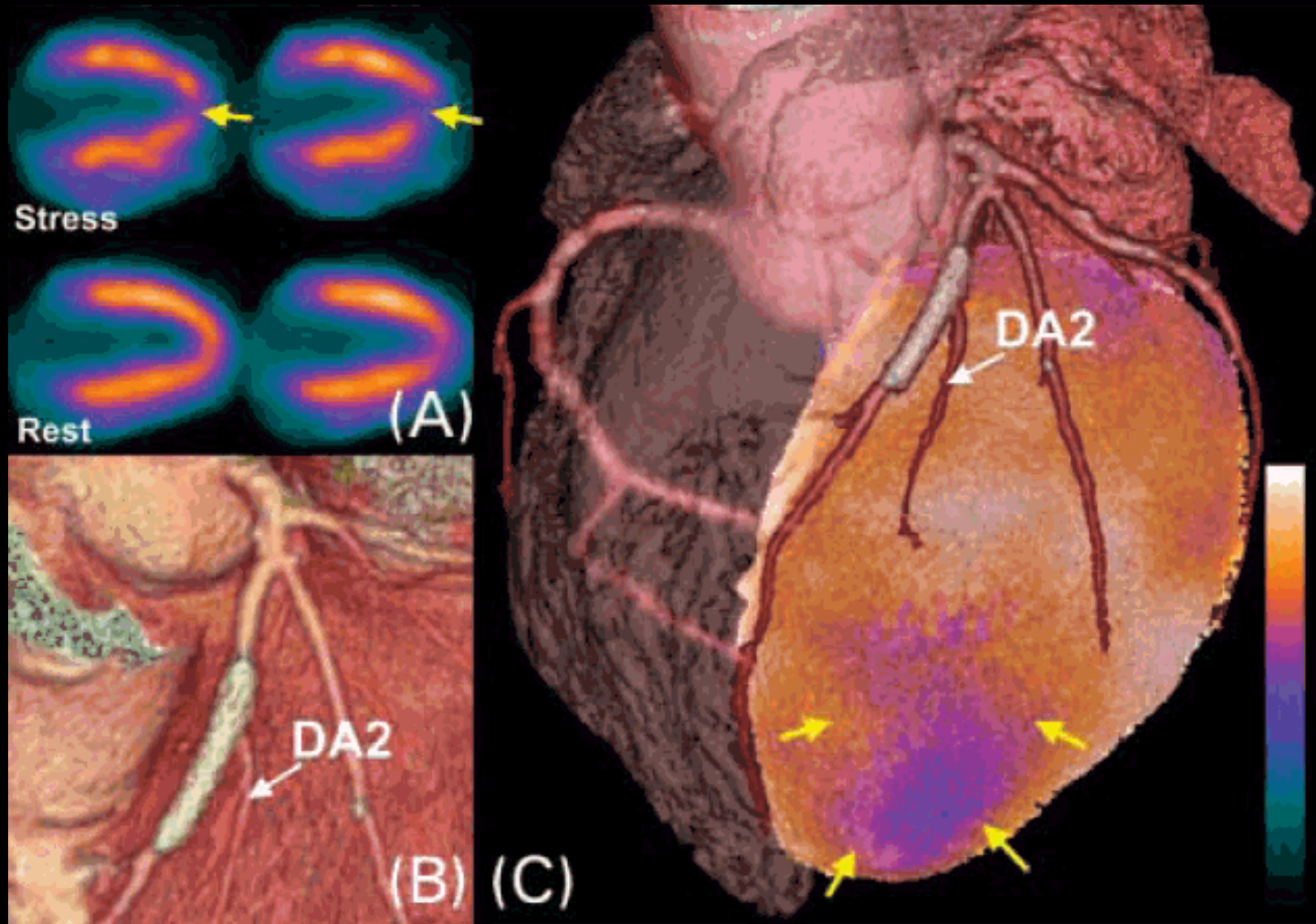
Shaw LJ, Berman DS.
Redefining the low-risk patient with significant atherosclerotic disease. J Nucl Cardiol. 2005;12:375-7.



In case of normal MPI, **CT measurements of coronary calcium** might allow subclinical atherosclerosis to be detected

Combining functional and anatomic information

Hybrid SPECT/CT scanners for CT coronary angiography



Gamma-cameras with semiconductors

Cadmium zinc telluride (CZT) solid-state detectors

- much higher myocardial count rate
- much higher energy resolution
- higher spatial resolution
- smaller size

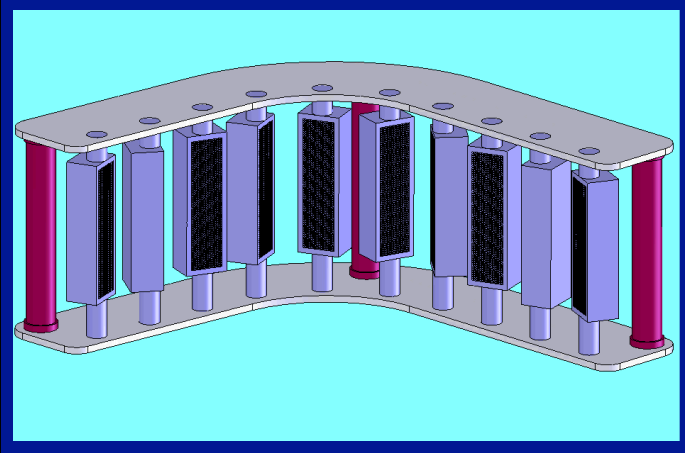


GE Medical Systems



Spectrum Dynamics

Gamma-cameras with semiconductors



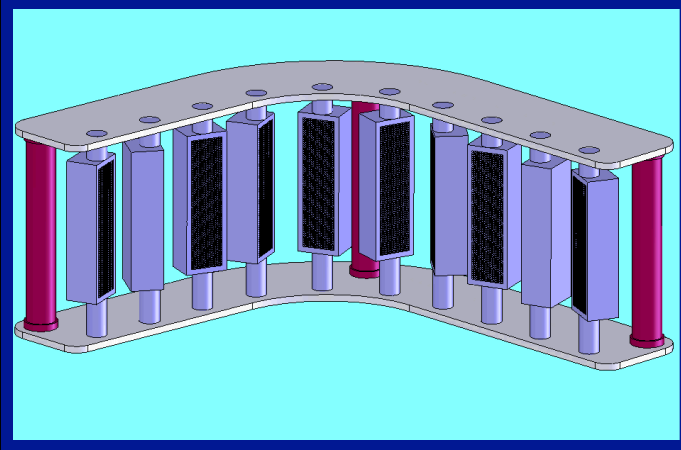
Camera head = 9 rotating detectors with

- large tungsten collimators,
- pixelized CZT detectors (2.5 mm).



Spectrum Dynamics

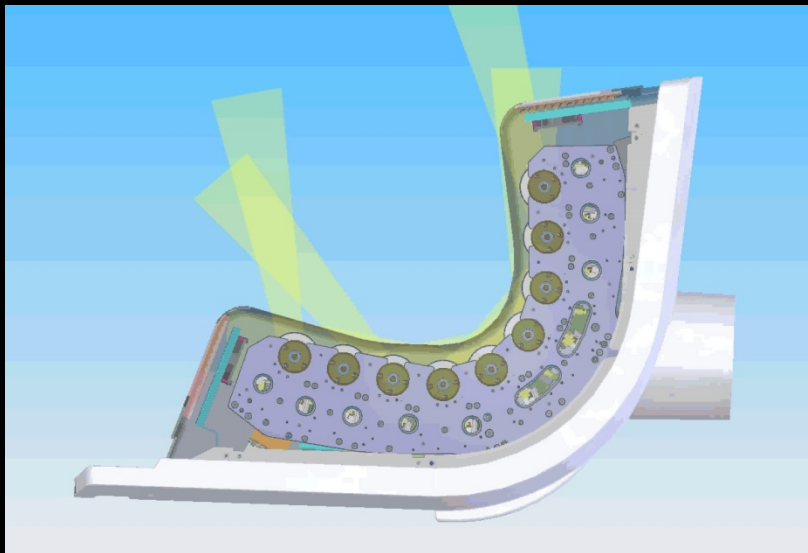
Gamma-cameras with semiconductors



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‘Region-centric’ acquisition maximizing the recording time in the heart area



Spectrum Dynamics

Gamma-cameras with semiconductors

Cadmium zinc telluride (CZT) solid-state detectors

- much higher myocardial count rate



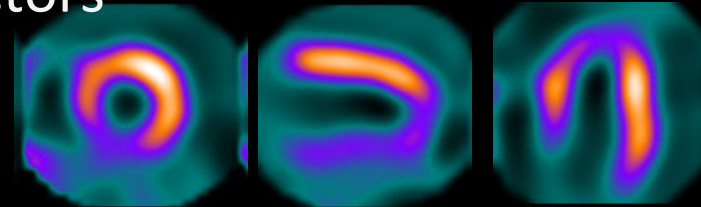
Allows shortening acquisition time, up to:
- 2 min for high injected ^{99m}Tc activities,
- 3 to 4 min for low injected ^{99m}Tc activities and ^{201}Tl .

*Herzog BA et al.
J Nucl Med. 2010;51:46-51.*

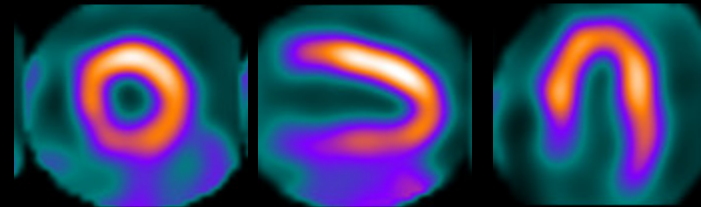
**inferior wall & apical
ischemia**

Semi-conductors

Stress
2 min

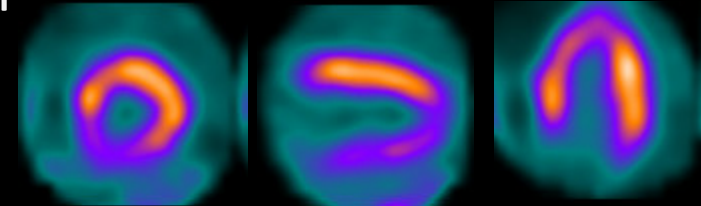


Rest
4 min

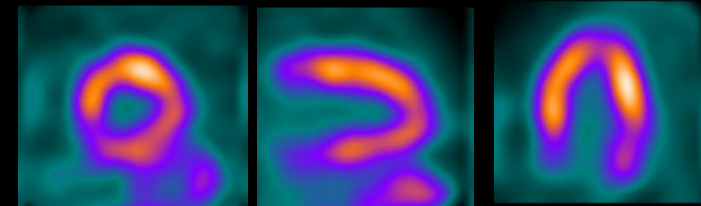


Conventional

Stress
11.5 min



Rest
14 min



Gamma-cameras with semiconductors

Cadmium zinc telluride (CZT) solid-state detectors

- much higher myocardial count rate ('centric'

acquisition)

➡ Might also allow:

- **reducing injected activities**, up to ➡ Clinical validation studies in progress
 - . 100 MBq for ^{99m}Tc tracers,
 - . 50 to 75 MBq for ^{201}Tl .

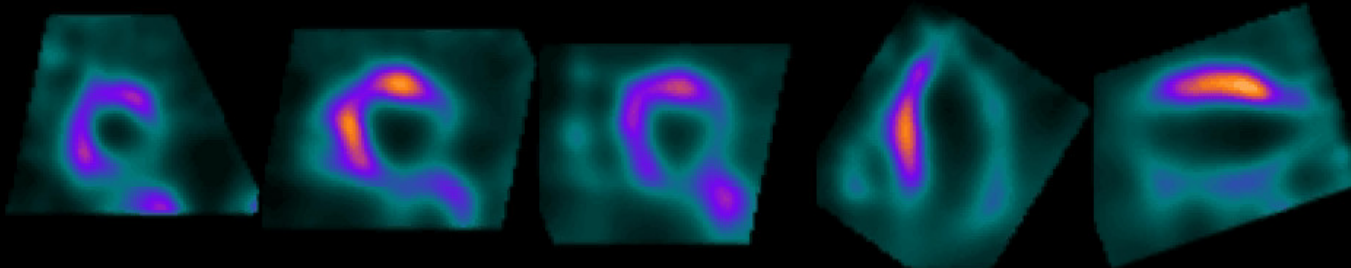
Gamma-cameras with semiconductors

Cadmium zinc telluride (CZT) solid-state detectors

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➡ Might also allow:

- **reducing injected activities**, up to ➡ Clinical validation studies in progress
 - . 100 MBq for ^{99m}Tc tracers,
 - . 50 to 75 MBq for ^{201}Tl .
- **or maximizing spatial and/or temporal resolutions**



Sestamibi (400 MBq)
4 min recording time
16 frames / cycle
Voxels of 30 mm³

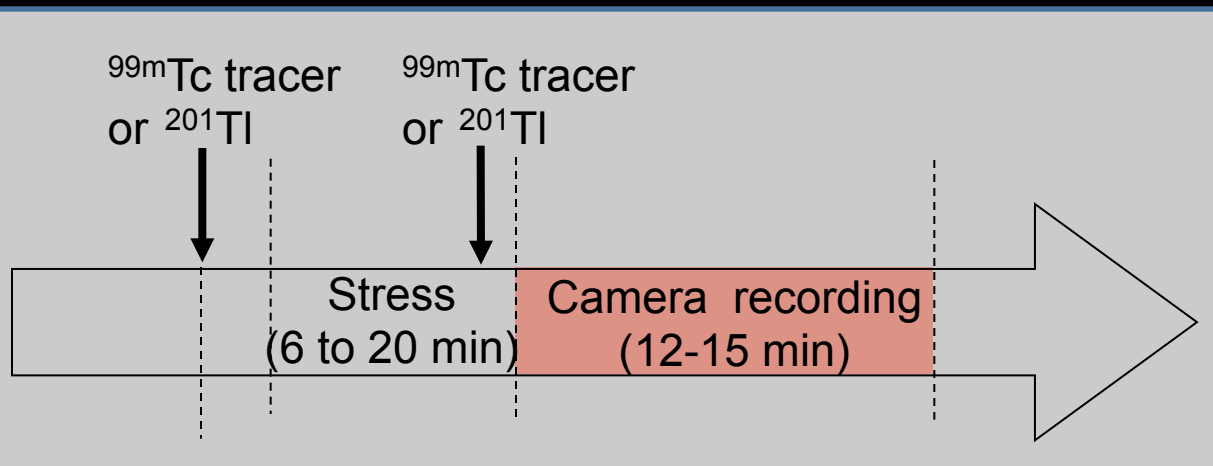
Gamma-cameras with semiconductors

Cadmium zinc telluride (CZT) solid-state detectors

- much higher myocardial count rate,
- much higher energy resolution

➔ Dual energy recording

- ✓ 3-7 mCi of ^{99m}Tc tracer and 1.5-2.5 mCi of ^{201}Tl ,
- ✓ limited irradiation exposure (10-15 mSv)
- ✓ only 1 positioning scan
- ✓ scatter correction (20-30% ^{99m}Tc scatter in ^{201}Tl peak)



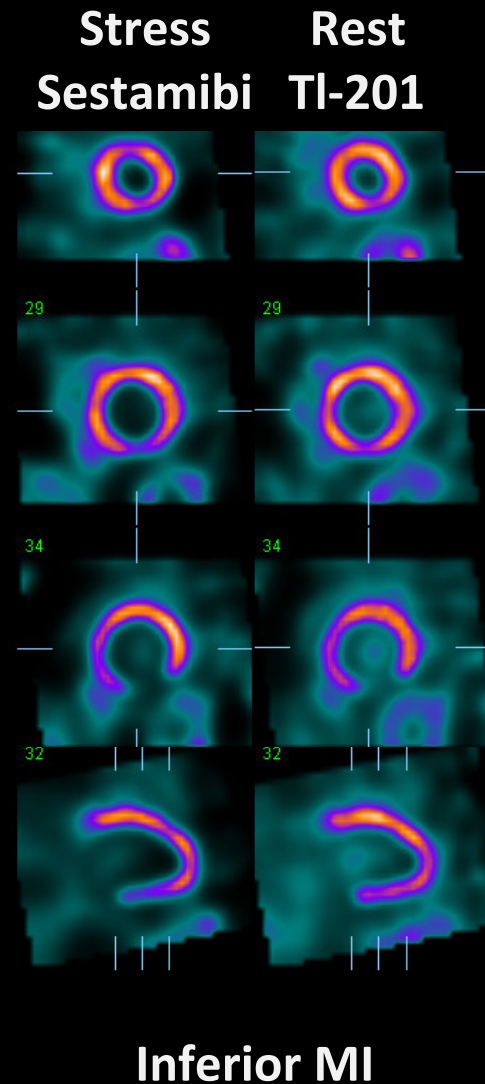
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^{99m}Tc tracer
or ^{201}Tl

^{99m}Tc tracer
or ^{201}Tl

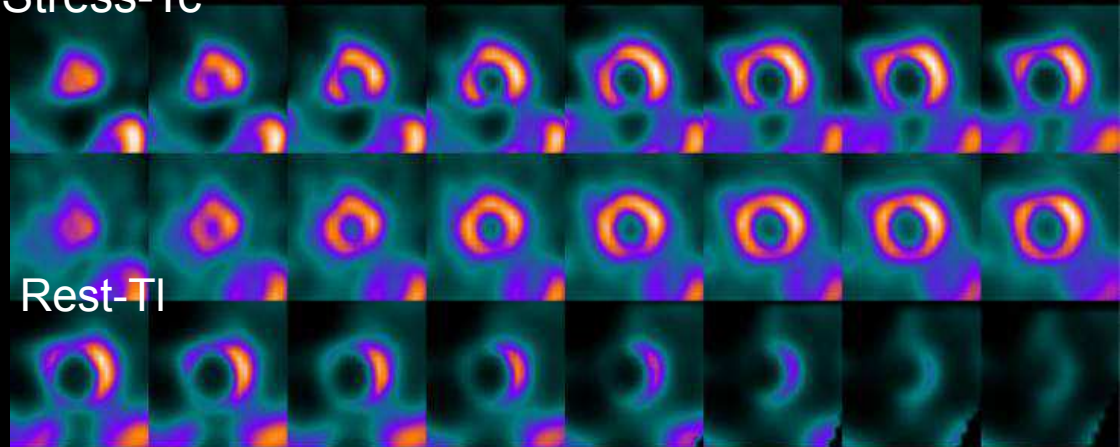
Stress
(6 to 20 min)

Camera recording
(12-15 min)

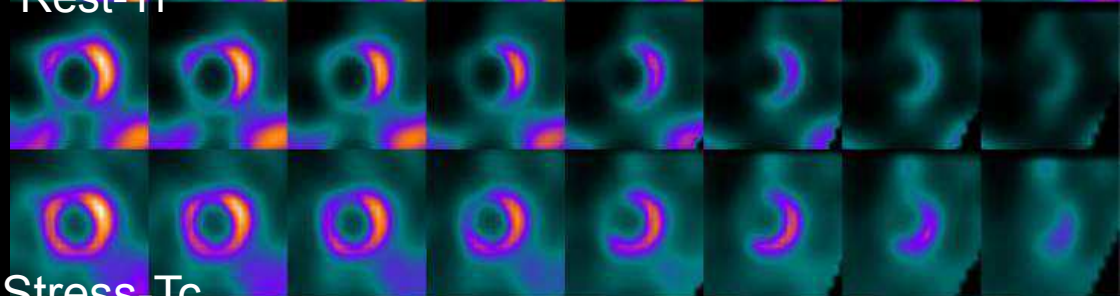
Simultaneous rest-Tl/stress-Tc recording with CZT

➡ Yes, this is definitely a reversible defect!

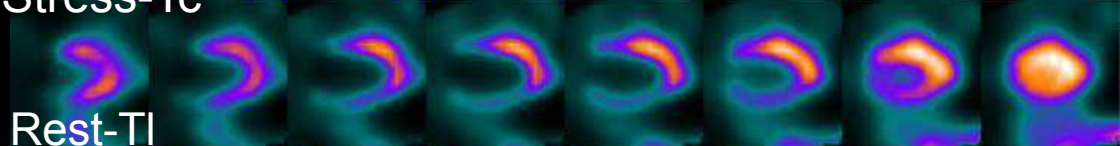
Stress-Tc



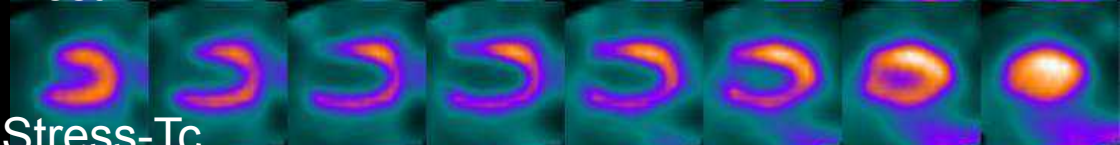
Rest-Tl



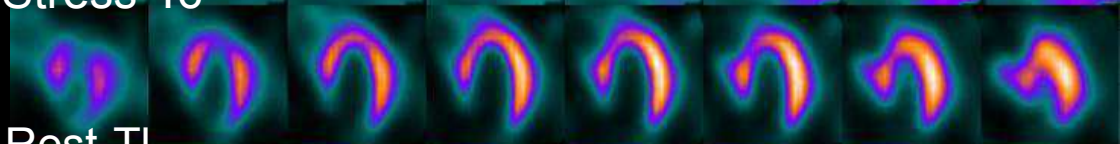
Stress-Tc



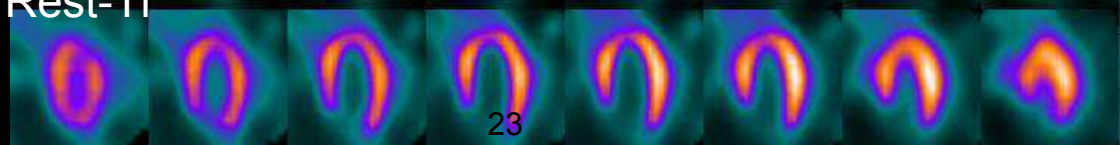
Rest-Tl



Stress-Tc



Rest-Tl



Stress-Tc



Rest-Tl



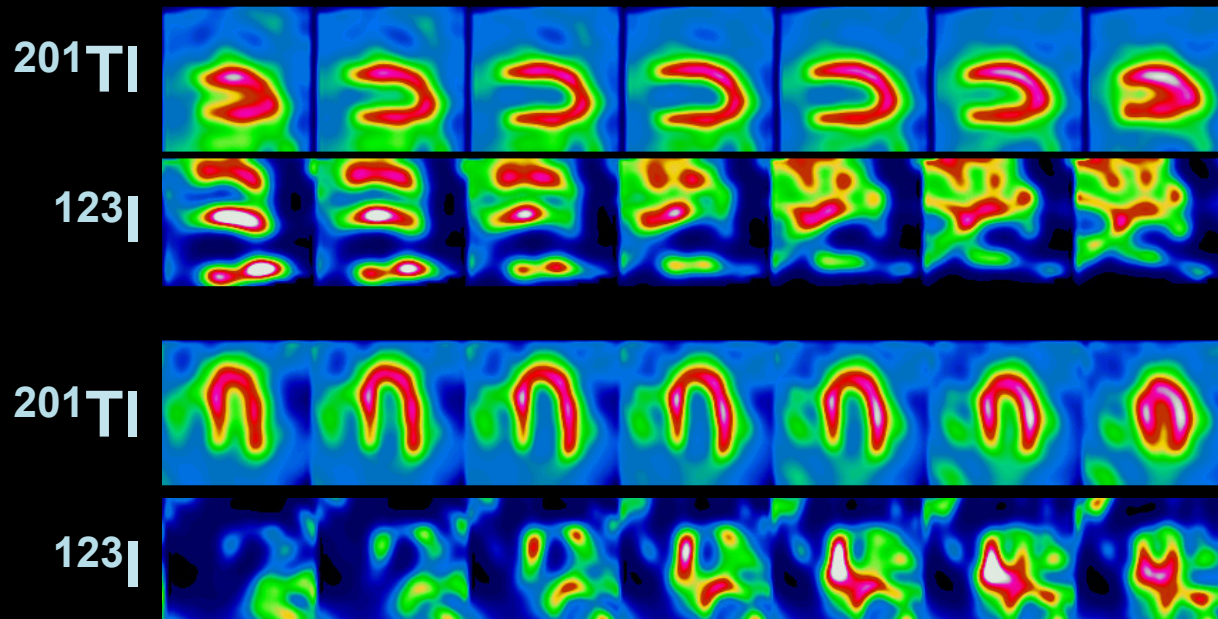
Gamma-cameras with semiconductors

Cadmium zinc telluride (CZT) solid-state detectors

- much higher myocardial count rate,
- much higher energy resolution

➔ Dual energy recording with other tracers:

Exemple of dual $^{201}\text{Tl}/^{123}\text{I}$ -MIBG in severe diabetes

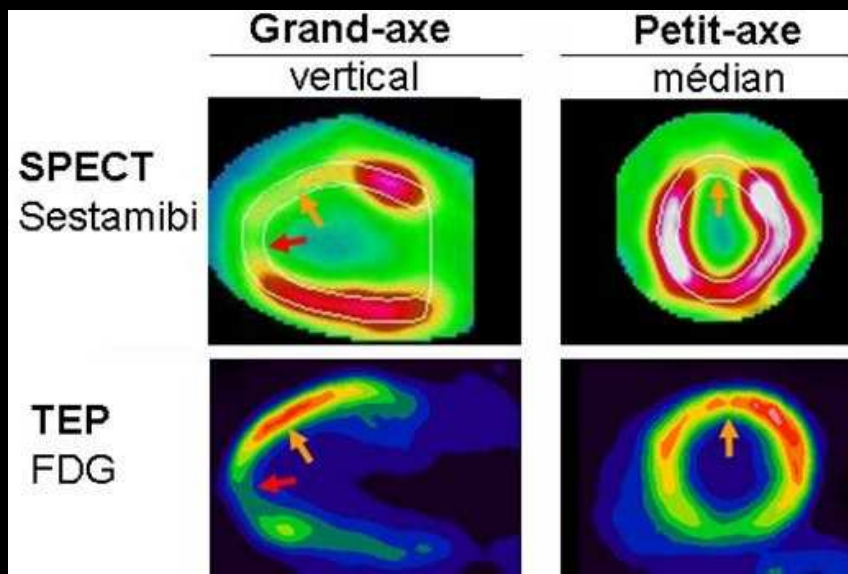


Étude de la viabilité myocardique avec le ^{18}F -FDG

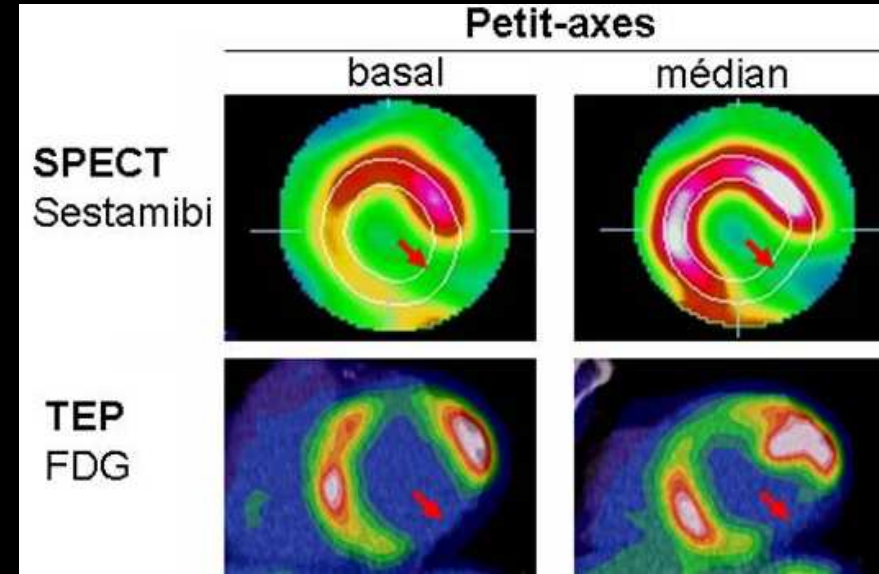
Encore considérée comme la référence, en particulier :

- pour la détection du **myocarde hibernant**,
- en cas de **dysfonction VG sévère**.

Mismatch

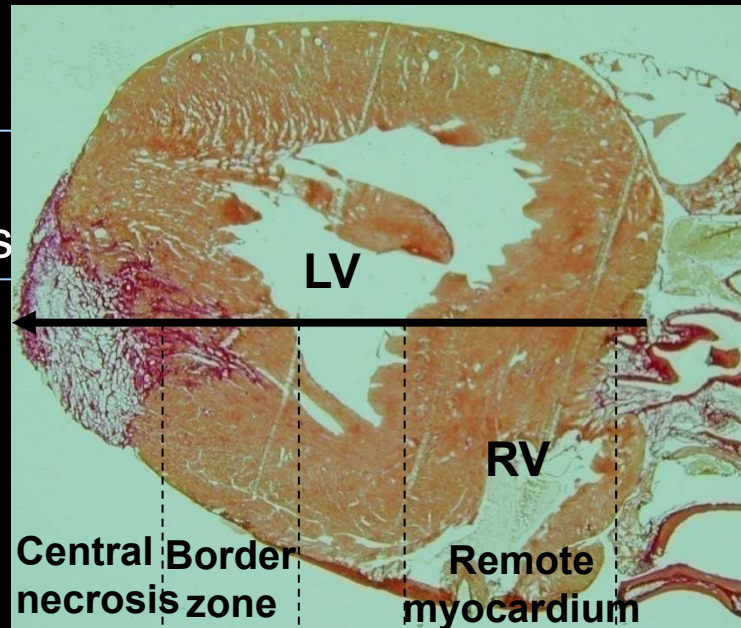


Match

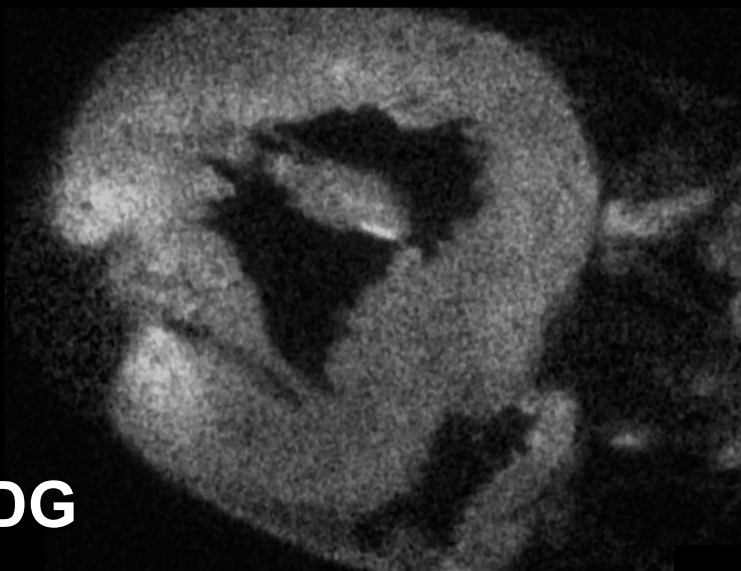
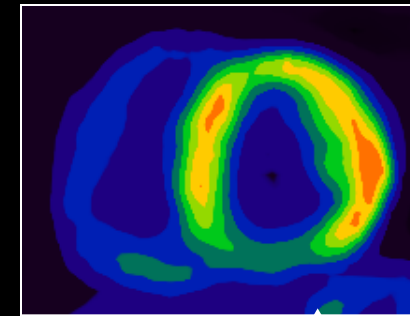


Necrotic areas exhibit a dramatic decrease in metabolic activity decrease in FDG uptake

Sirius red
Collagen fibrosis



2-months after coronary occlusion in rats
Maskali F. J Nucl Cardiol 2005



^{18}F -FDG

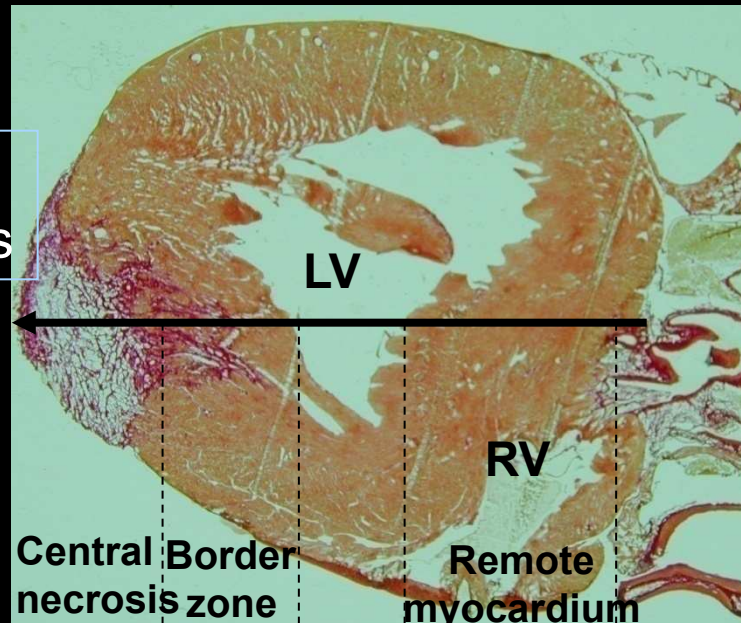
Injection before sacrifice of

- ^{111}In -DTPA
- $^{99\text{m}}\text{Tc}$ -Sestamibi
- ^{18}F -FDG

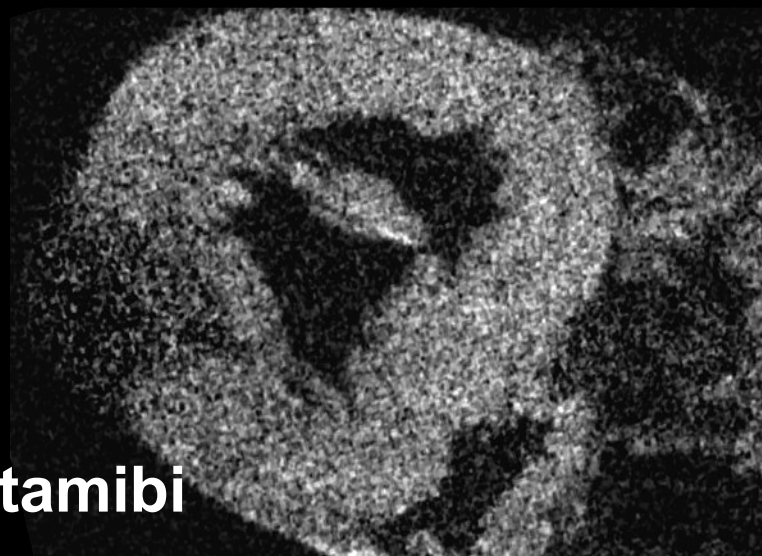
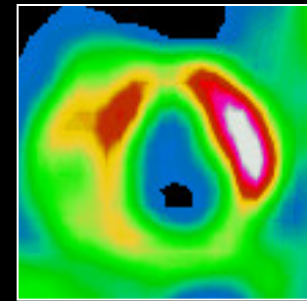
μ -imager

Necrotic areas exhibit a dramatic decrease in myocardial perfusion (decrease in Sestamibi uptake)

Sirius red
Collagen fibrosis



2-months after coronary occlusion in rats
Maskali F. J Nucl Cardiol 2005



^{99m}Tc -Sestamibi

Injection before sacrifice of

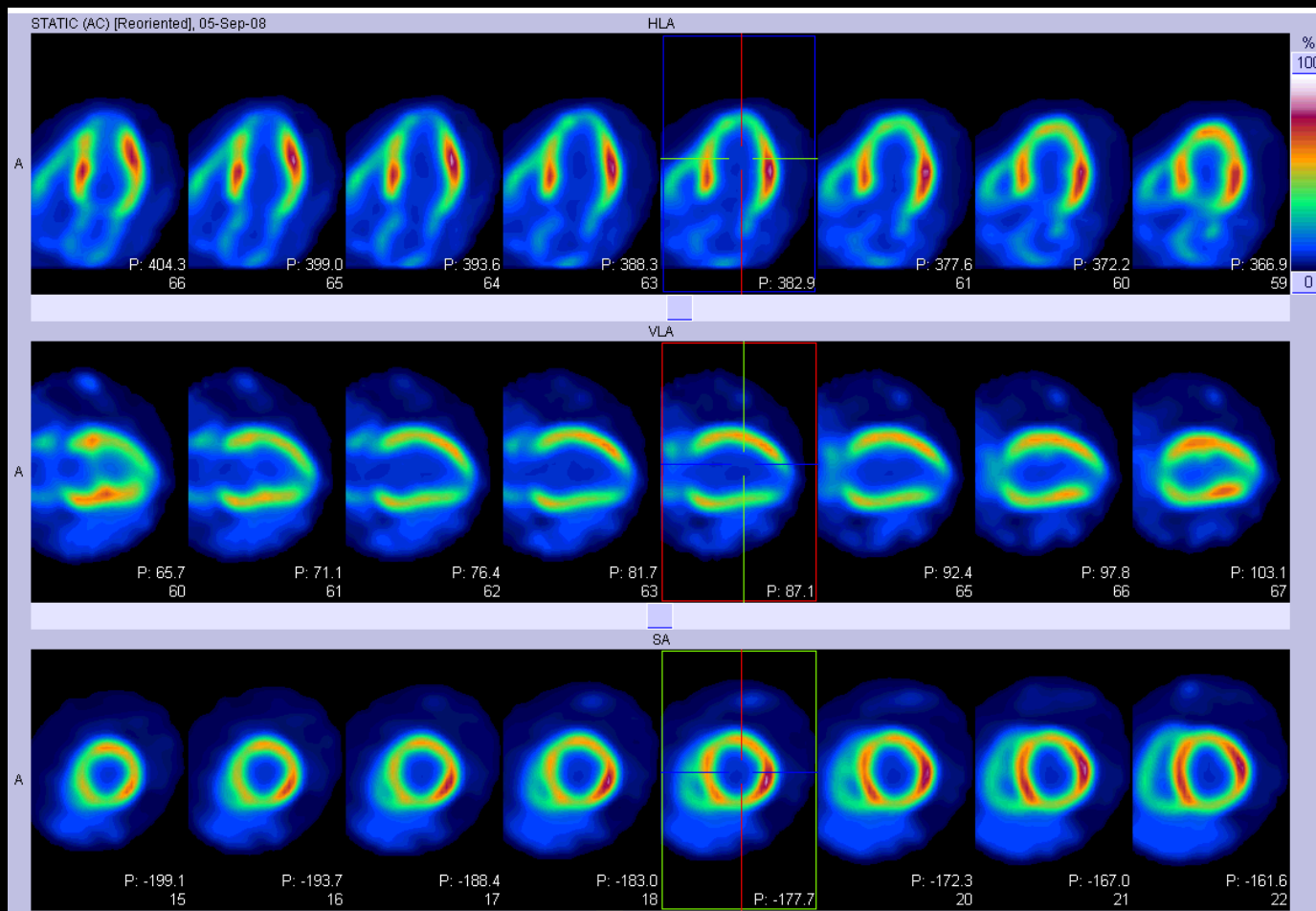
- ^{111}In -DTPA
- ^{99m}Tc -Sestamibi
- ^{18}F -FDG

μ -imager

Étude de la viabilité myocardique avec le ^{18}F -FDG

Amélioration de la qualité d'images :

- nouvelles caméras TEP
- prémédication par acide nicotinique ($\downarrow$ AG circulants),

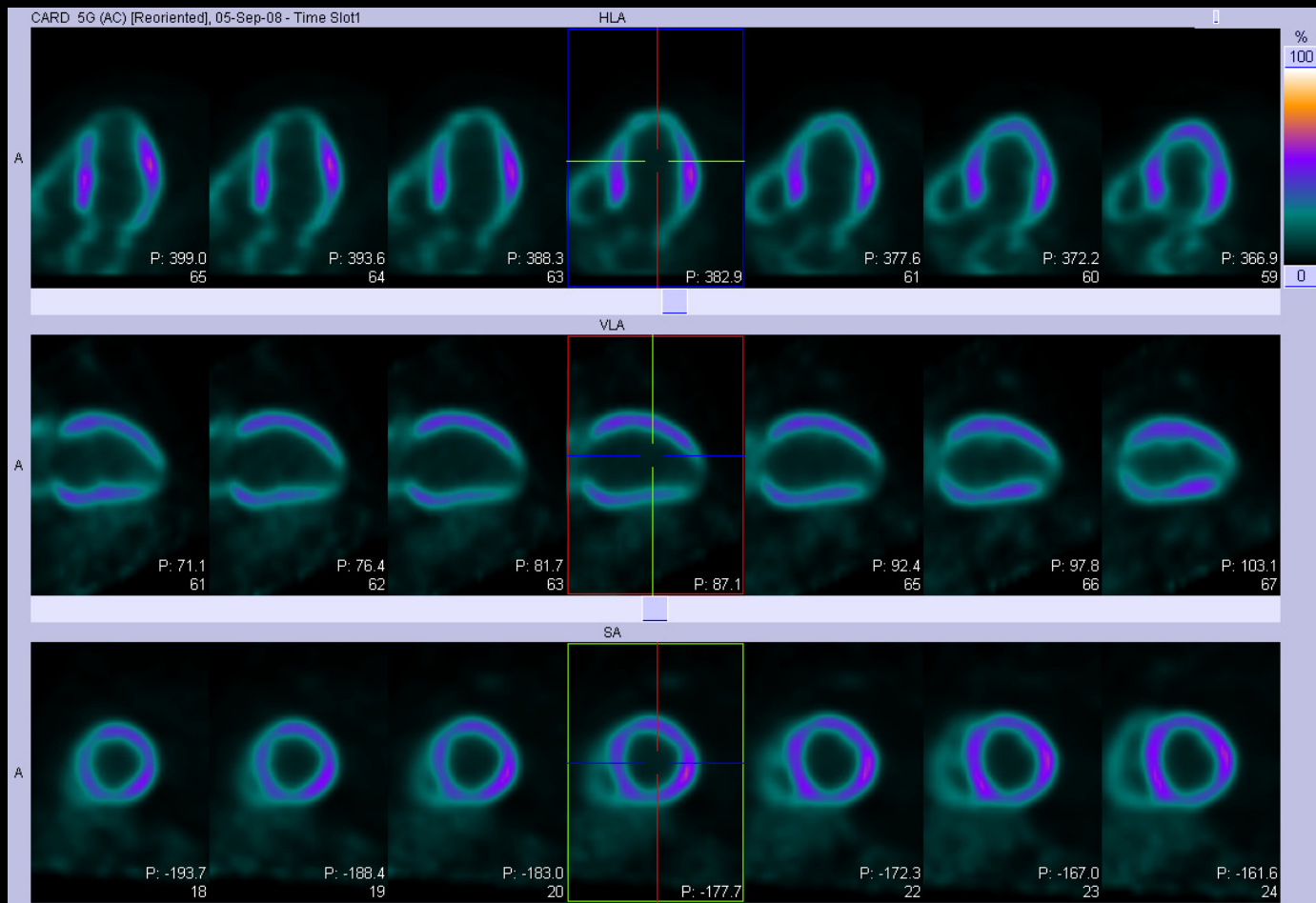


FDG-TEP
+Acipimox
Homme avec
IDM apical

Étude de la viabilité myocardique avec le ^{18}F -FDG

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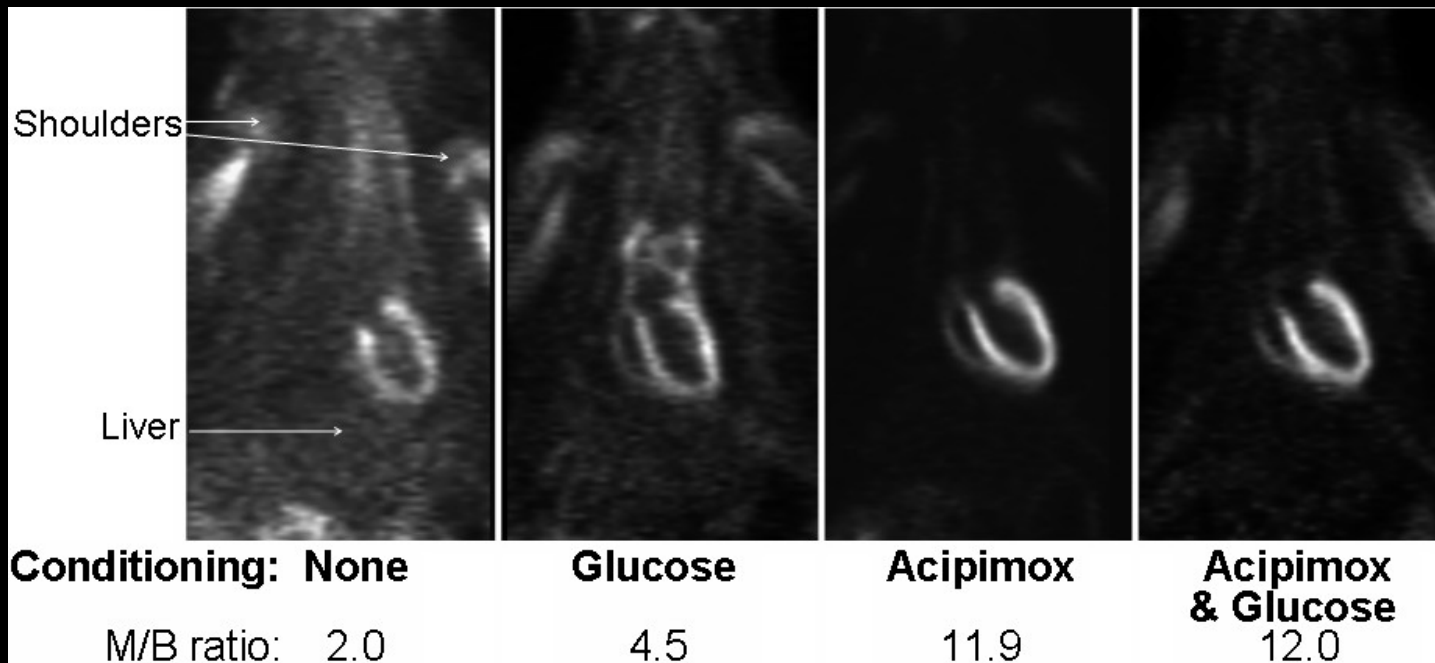


FDG-TEP
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- prémédication par acide nicotinique ($\downarrow$ AG circulants),



Prémédication par acide nicotinique (Acipimox) chez le rat.
Poussier S. Eur J Nucl Med 2010



New PET tracers for myocardial perfusion imaging

Nekolla SG, and coll. **Evaluation of the Novel Myocardial Perfusion PET Tracer ^{18}F -BMS-747158-02 Comparison to ^{13}N -Ammonia and Validation With Microspheres in a Pig Model.** *Circulation* 2009;119: 2333-42

New cationic lipophilic tracers, labeled with ^{18}F :

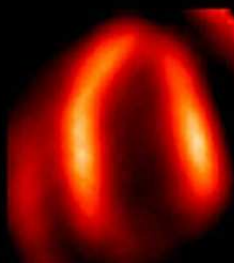
- high rates of myocardial extraction (>90%) and retention
- better « flow tracer » than current SPECT and PET tracers,
- very high image quality,

N-13 NH3

Rest



Stress



F-18 BMS

Rest



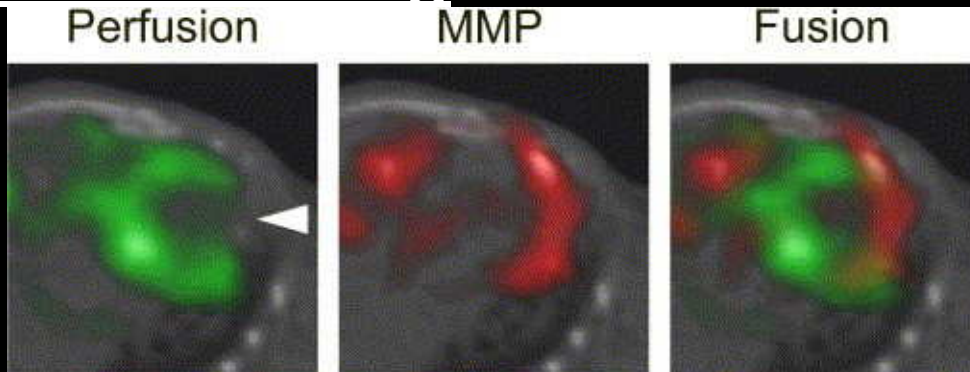
Stress



Molecular Imaging

New tracers developed for cardiologic and oncologic indications

Remodeling

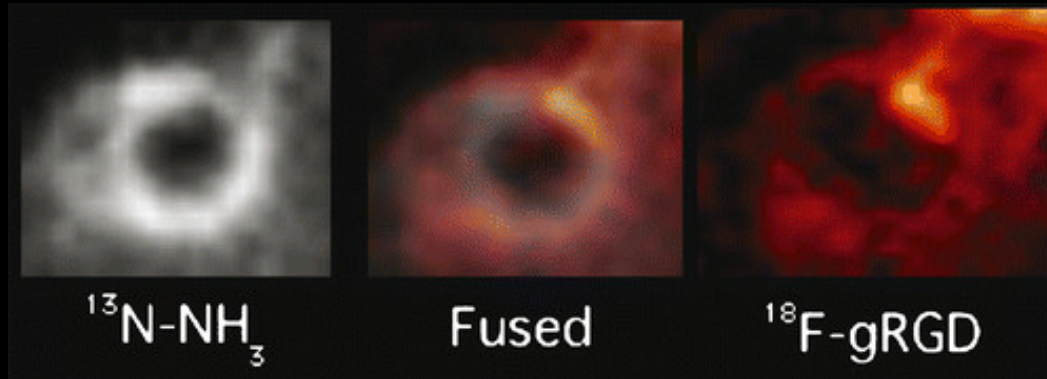


Imaging of matrix metalloproteinase (MMP) activity in a mouse heart infarct.
Sinusas A. Yale University School of Medicine

Molecular Imaging

New tracers developed for cardiologic and oncologic indications

Remodeling



Angiogenesis

Imaging of $\alpha\text{v}\beta 3$ integrin expression using ^{18}F -galacto-RGD in a rat heart infarct

- for characterisation of angiogenesis in vivo
- for monitoring therapeutic effects.

Higuchi T, et al. Eur J Nucl Med Mol Imaging. 2007;34:S9-19.