Cardiac Radionuclide Fusion Imaging with CT or MR

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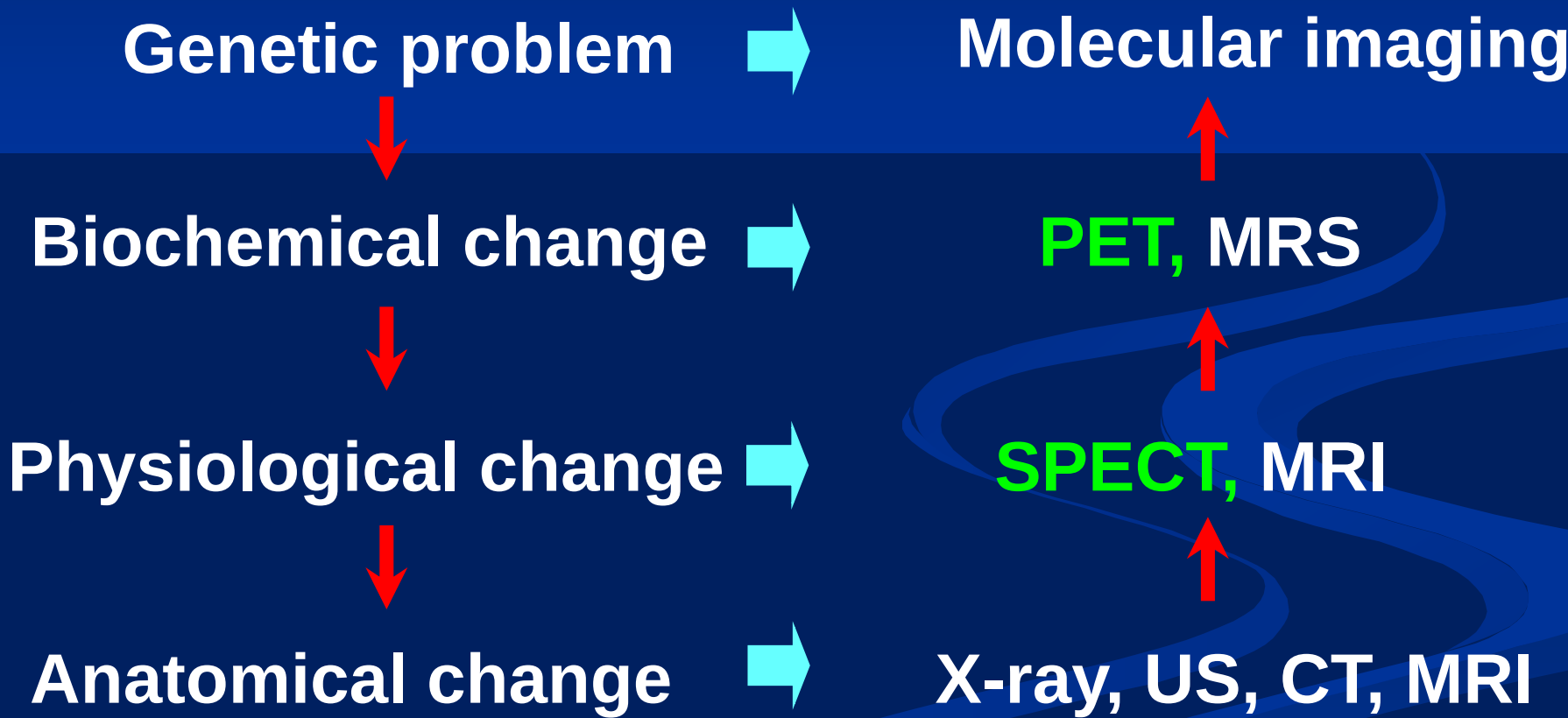
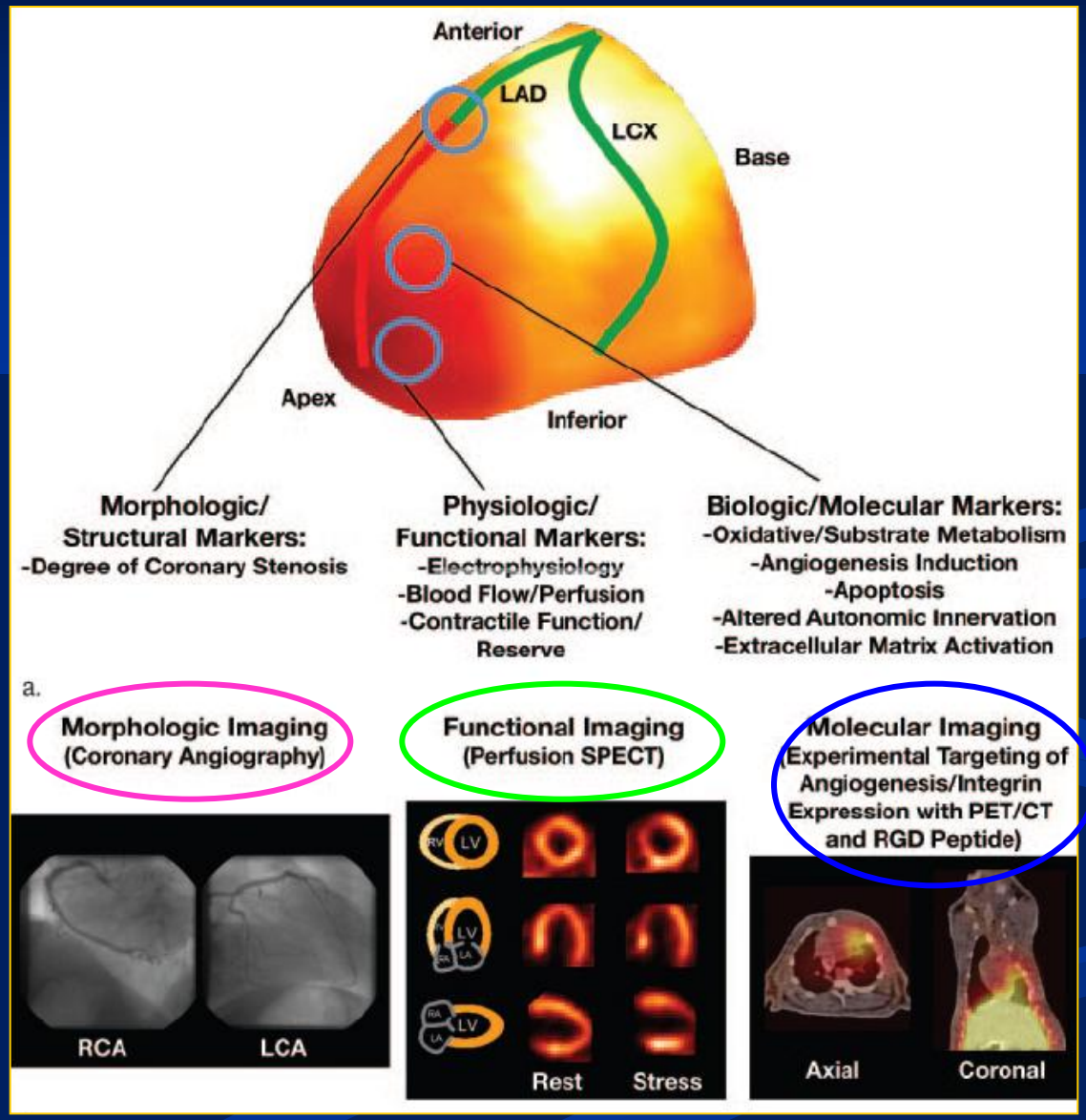
노인보건의료센터

Progress of Disease and Imaging

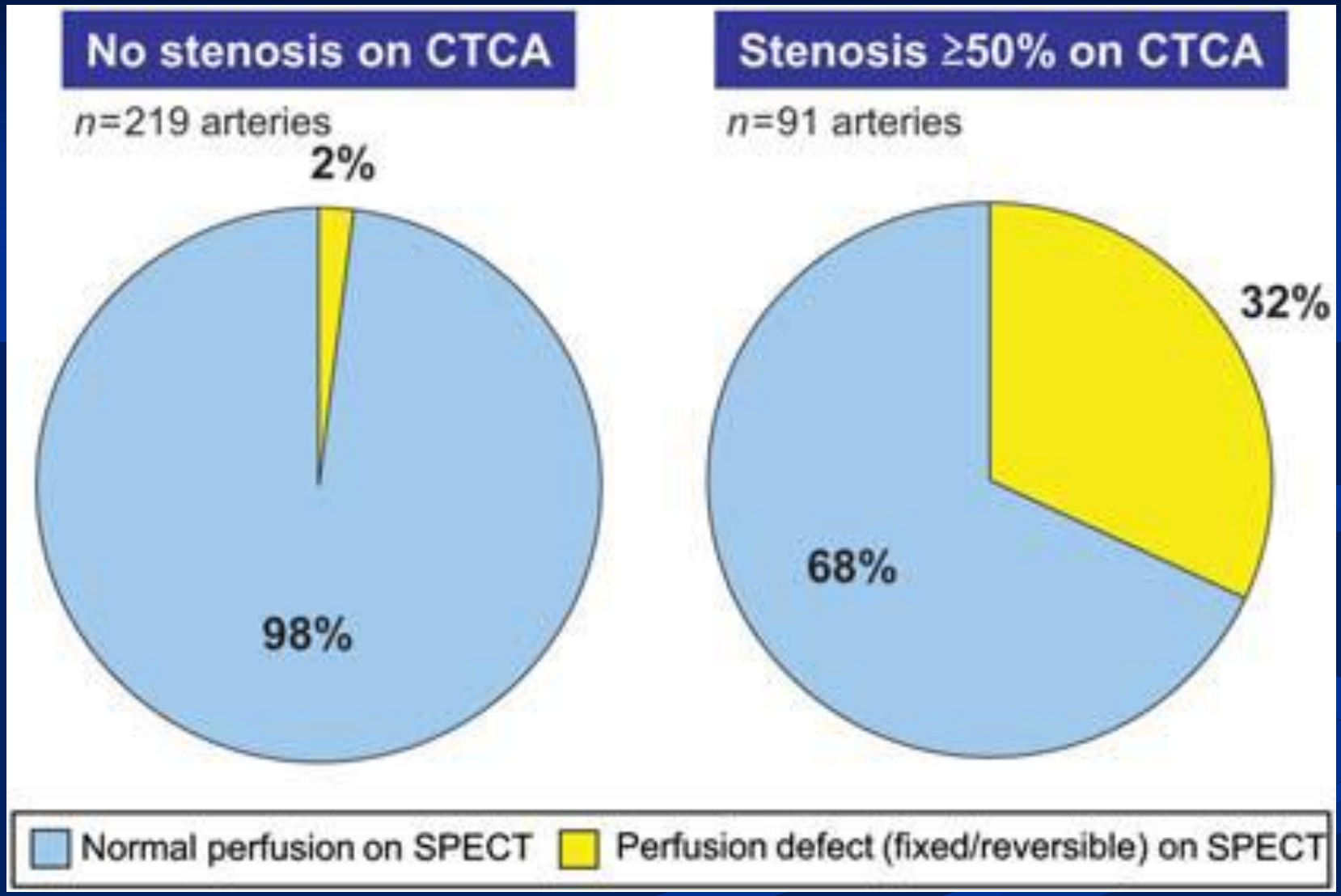


Imaging of myocardial ischemia

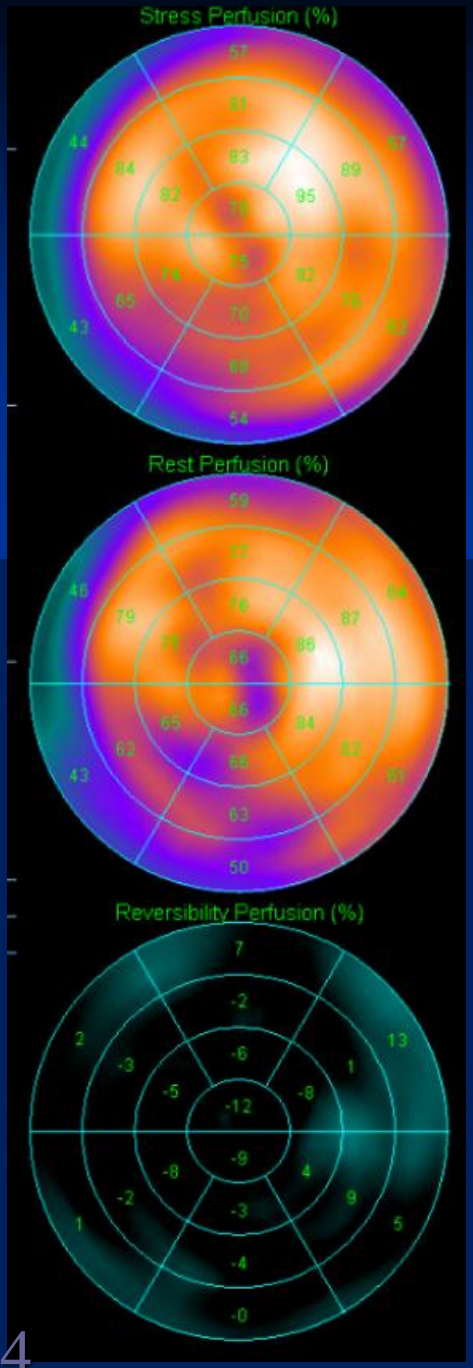


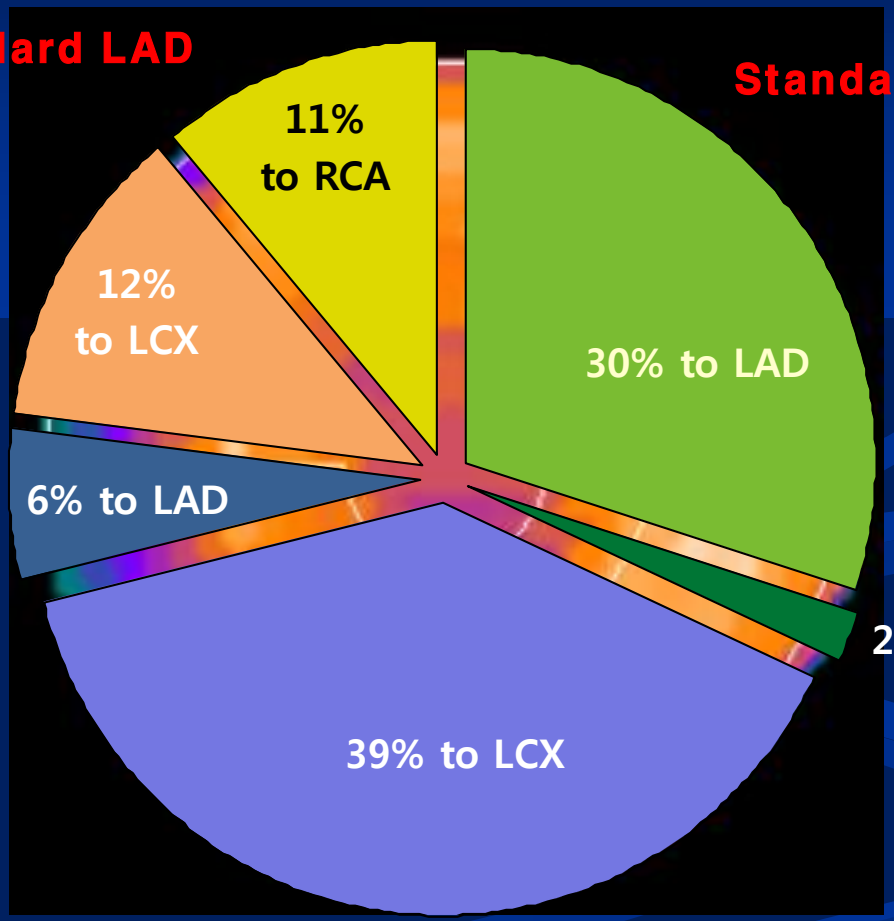
CTA

Radiology 2007;244:337–355



Eur Heart J 2011;32:2100–2108





Eur Heart J 2011;32:2100-2108

Cardiac Hybrid Imaging

- Comprehensive imaging of cardiac function with anatomical co-registration

=> Coronary anatomy and quantitative perfusion can be studied in a single session

- There are important limitations to myocardial perfusion imaging and CTA alone
- There is added value in the integrated approach

Myocardial Perfusion Imaging

- Strengths
  - Very high success rate
  - Relative and absolute perfusion
  - Stress and rest function
  - Proved cost-effective
  - Robust risk stratification/patient management algorithms

- Weaknesses
  - Can underestimate extent of CAD
  - Anatomic information only “ inferential”

CT angiography

- Strengths
  - Can visualize anatomy/ performed very quickly
  - High NPV for significant CAD

- Weaknesses
  - Calcium, stents
  - Need for regular rhythm and slow heart rate
  - Subjective evaluation
  - Distal vessels, side-branches
  - Poor quality in large patients

Value Added of the fusion imaging Approach for Diagnosis of CAD

- MPI contribution to diagnosis
  - Improved CAD detection in vessels < 2mm (mid to distal segs, and side branches)
  - Assessment of physiologic significance
- CT contribution to diagnosis
  - Assessment of multivessel CAD
- Fusion imaging contribution to diagnosis
  - Identification of culprit coronary stenosis for targeted interventions

Value Added of the fusion imaging Approach for Risk Assessment

- MPI contribution to diagnosis
  - Ischemic burden
- CT contribution to diagnosis
  - Multi-VD
  - Subclinical atherosclerosis

Cardiac Hybrid Imaging

- Myocardial perfusion SPECT + CTA
- N-13 ammonia or Rb-82 PET + CTA
- F-18 FDG PET + CTA

- CardIQ Fusion software
  - Advantage workstation 4.4; GE Healthcare

CardIQ Fusion process (GE healthcare)

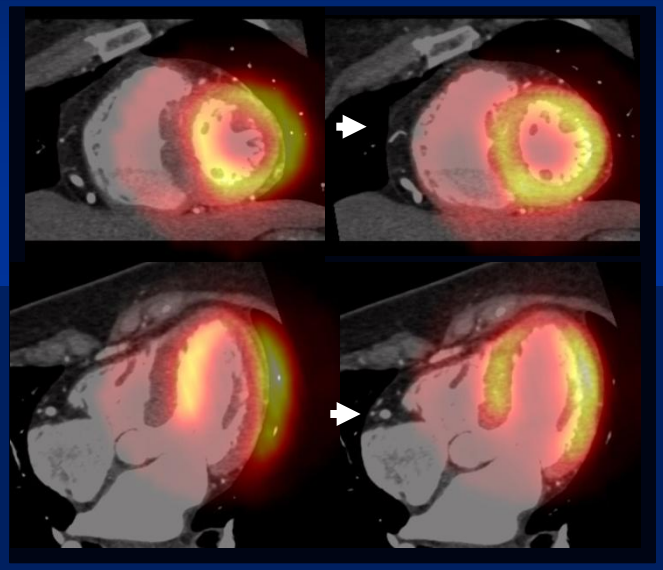
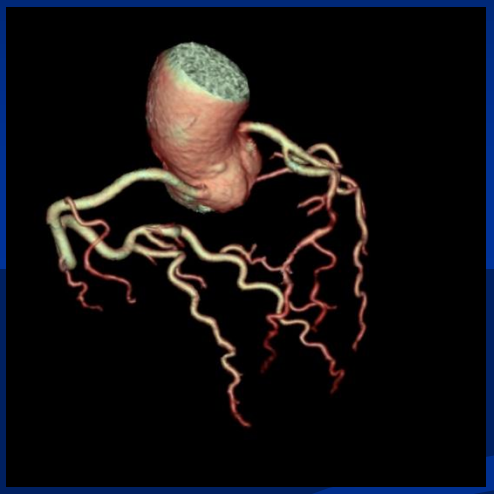
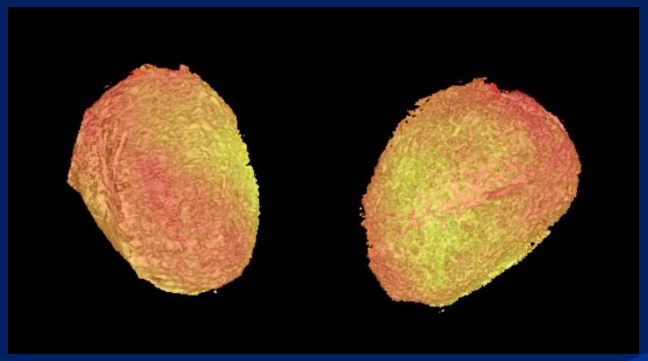


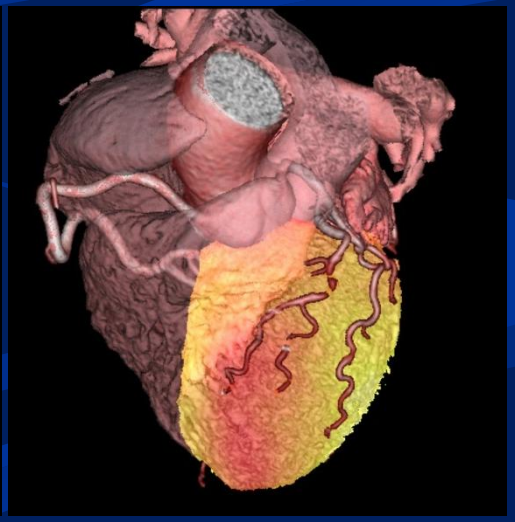
Image coregistration



Coronary artery segmentation



Epicardial segmentation



3-demensional volume rendered fusion

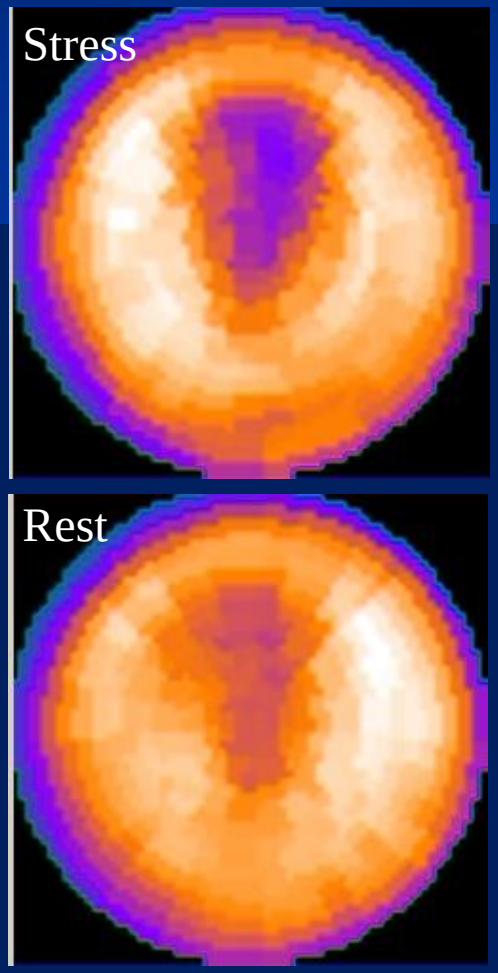
Added value of 3D cardiac SPECT/CTA fusion imaging in patients with reversible perfusion defect on MPS (CIFKoMS)

3D cardiac SPECT/CTA fusion imaging	vs	MPS
Sensitivity : 82.5%		Sensitivity : 68.8%
Specificity : 80.3%		Specificity : 65.6%

1) Confirmed hemodynamic significance in many lesions
2) Added new lesions including left main disease
3) Excluded equivocal defects
4) Corrected corresponding arteries to their allocated defects
5) Localized culprit segments

EJ Kong et al. SNM, 2009

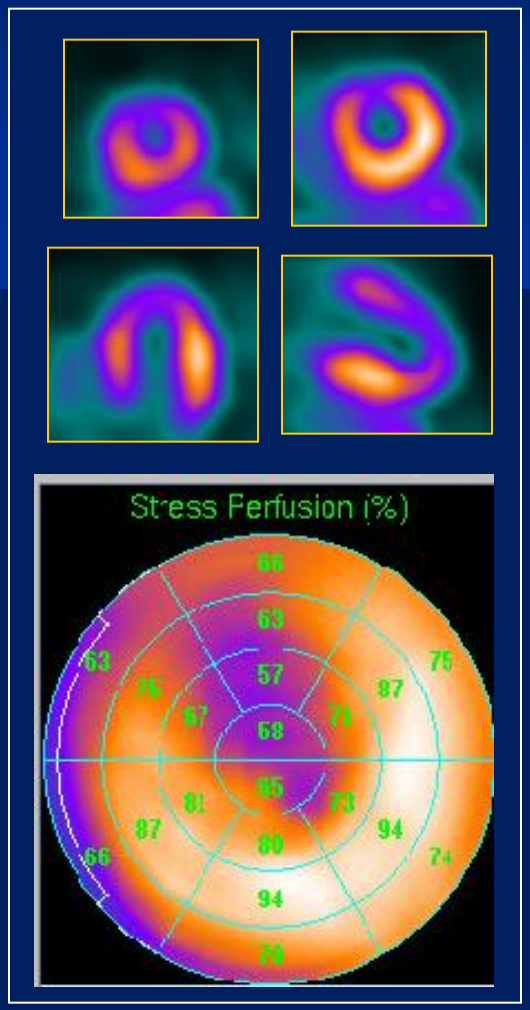
Added left main disease



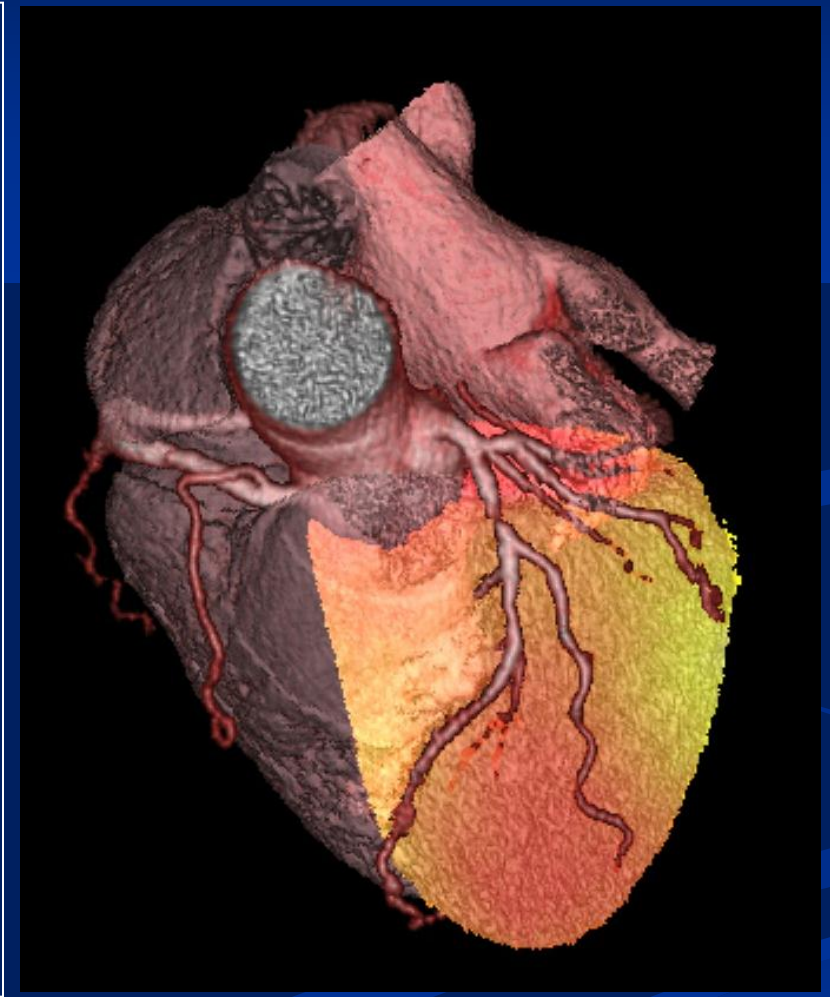
Tc-99m MIBI MPS

Cardiac MPS/CTA fusion imaging

LAD stenosis: corresponding ischemia

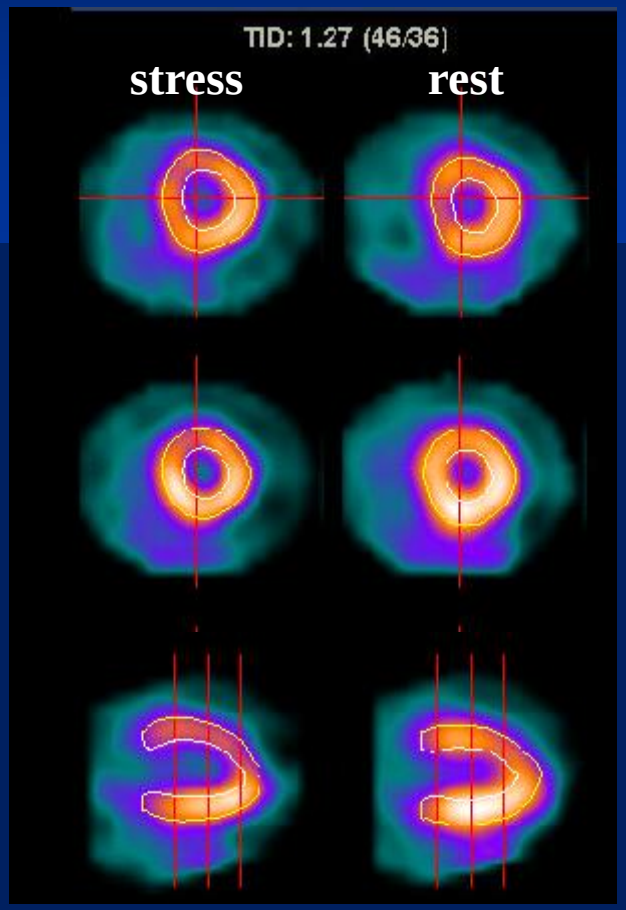


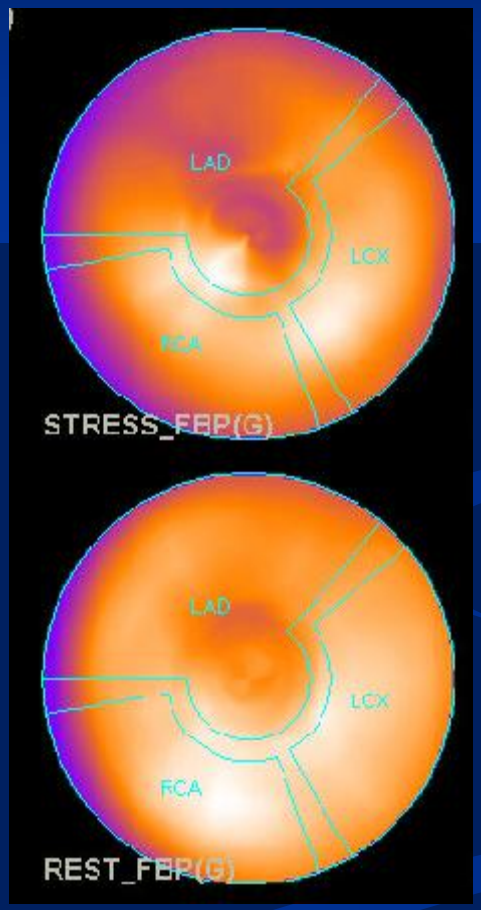
Tc-99m MIBI MPS

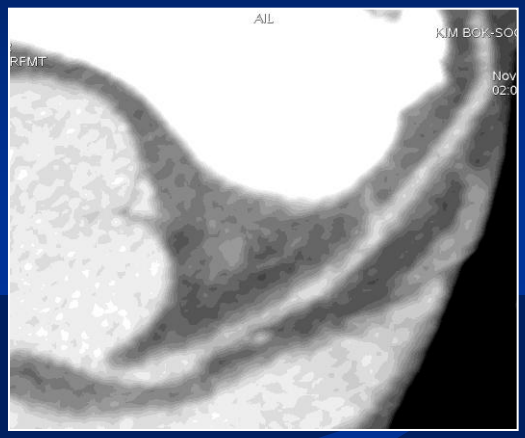


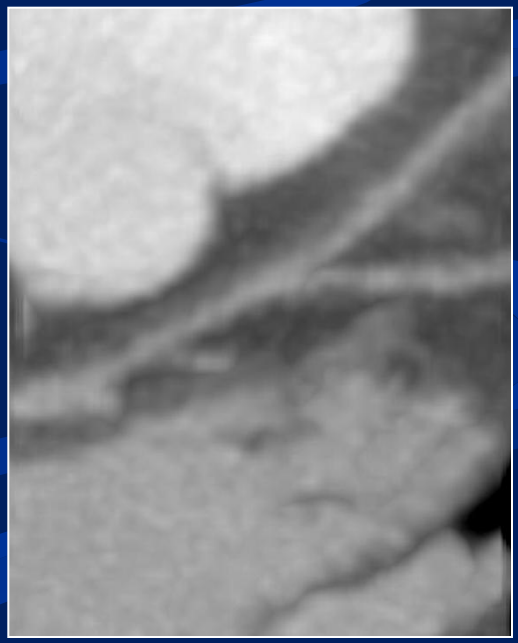
Cardiac MPS/CTA fusion imaging

LAD stenosis: corresponding ischemia



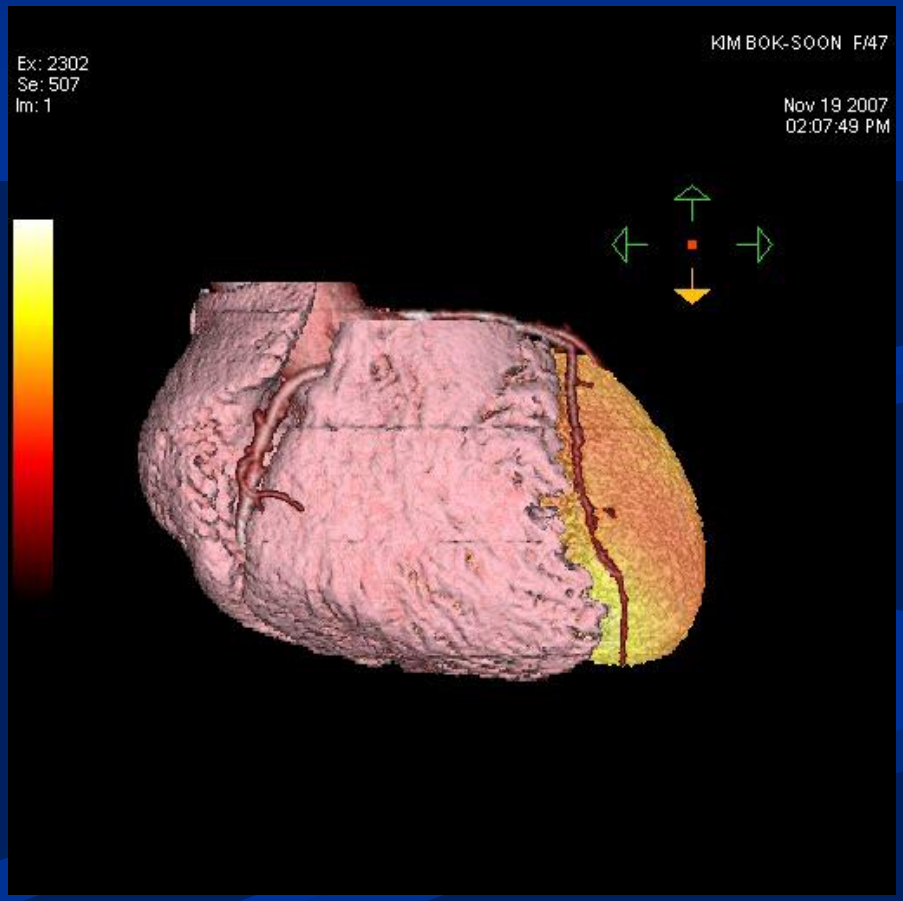






Tc-99m MIBI MPS

Cardiac MPS/CTA fusion image

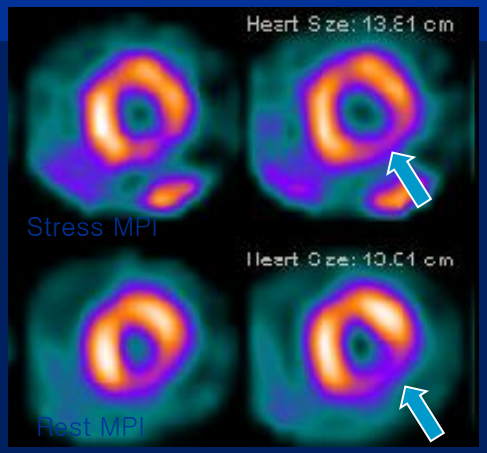


Ischemia due to RI

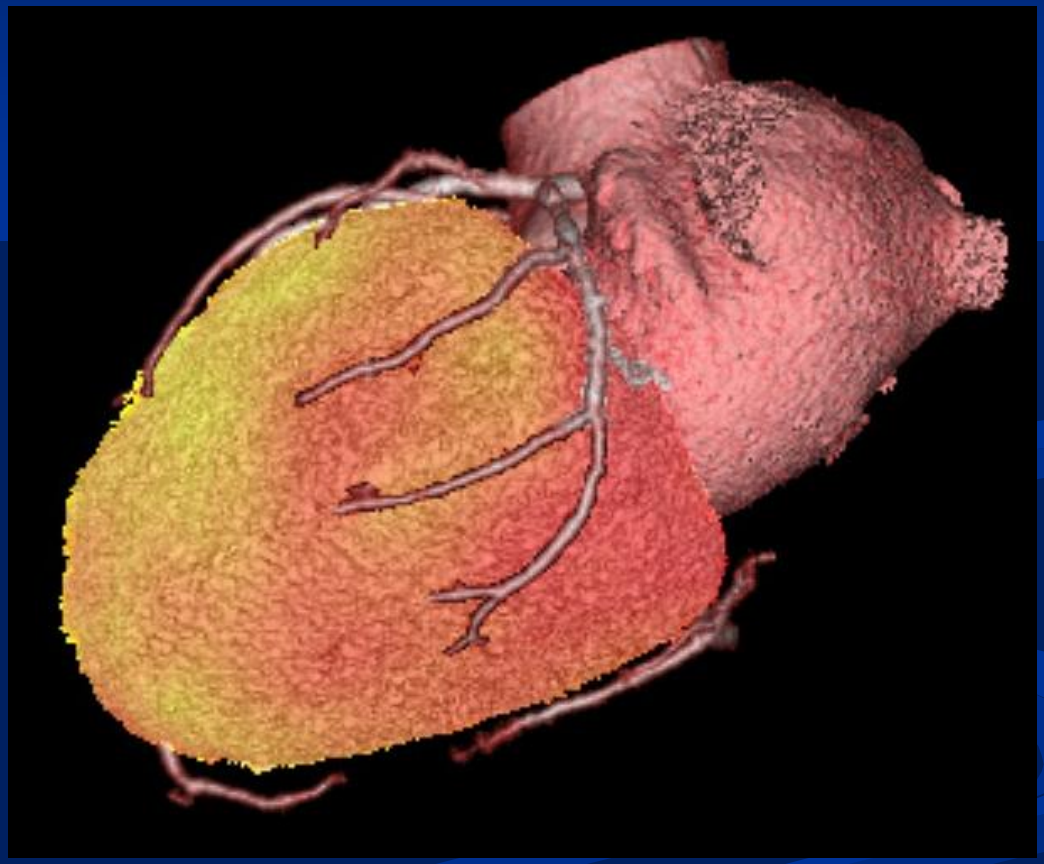
Tc-99m MIBI MPS

Cardiac MPS/CTA fusion imaging

Allocation of ischemia due to LCX

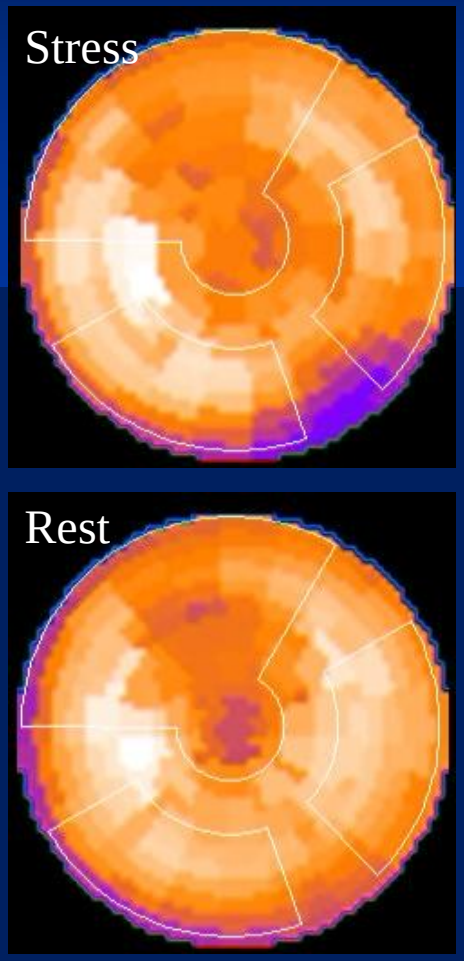


Tc-99m MIBI MPS

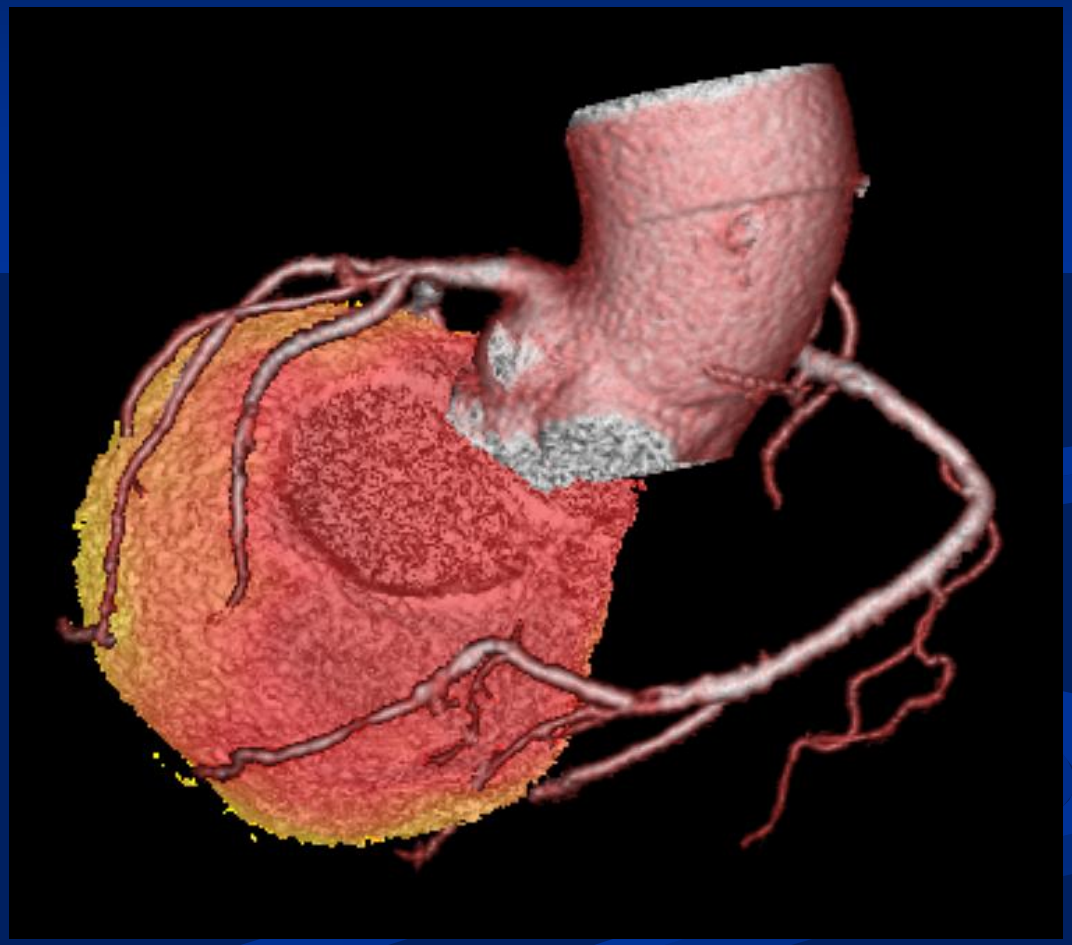


Cardiac MPS/CTA fusion imaging

Allocation of ischemia due to PLB

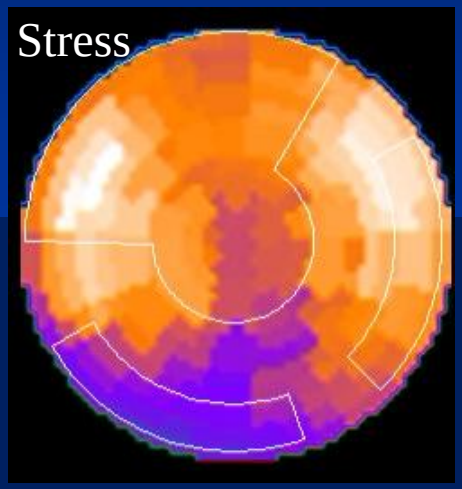


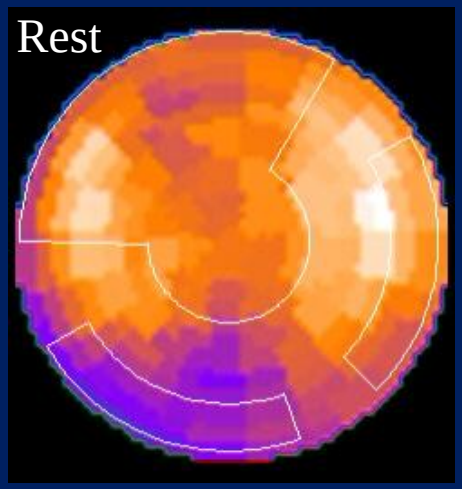
Tc-99m MIBI MPS



Cardiac MPS/CTA fusion imaging

Allocation of ischemia due to LCX - Left dominant

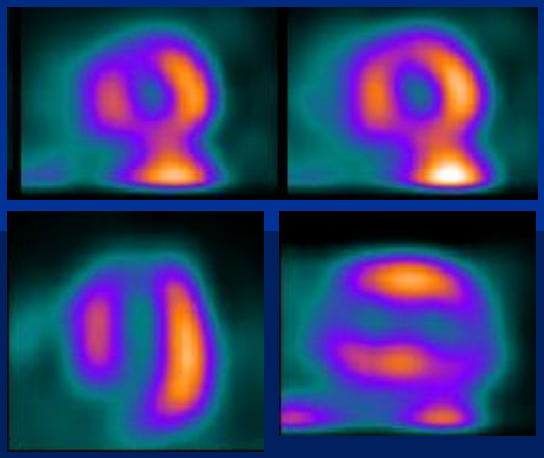


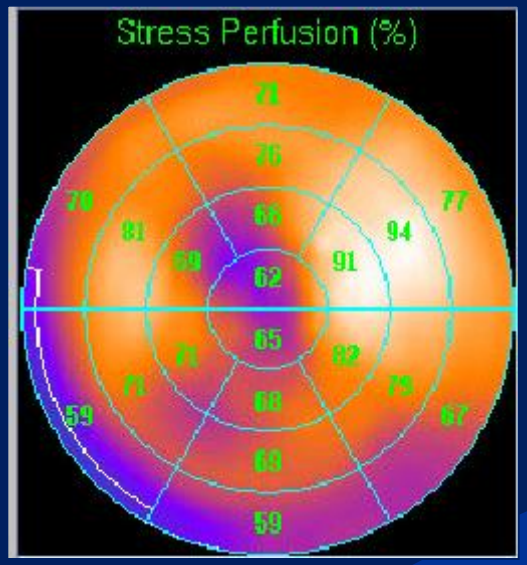


Tc-99m MIBI MPS

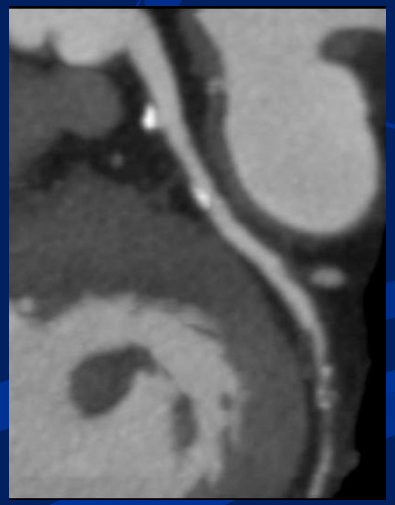
Cardiac MPS/CTA fusion imaging

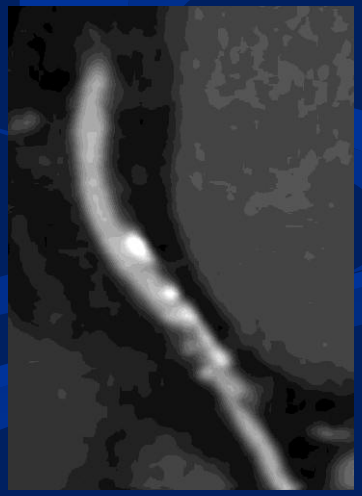
MPS/CTA fusion imaging: most helpful in multi-vessel disease with intermediate lesion severity





Tc-99m MIBI MPS





Cardiac MPS/CTA fusion image

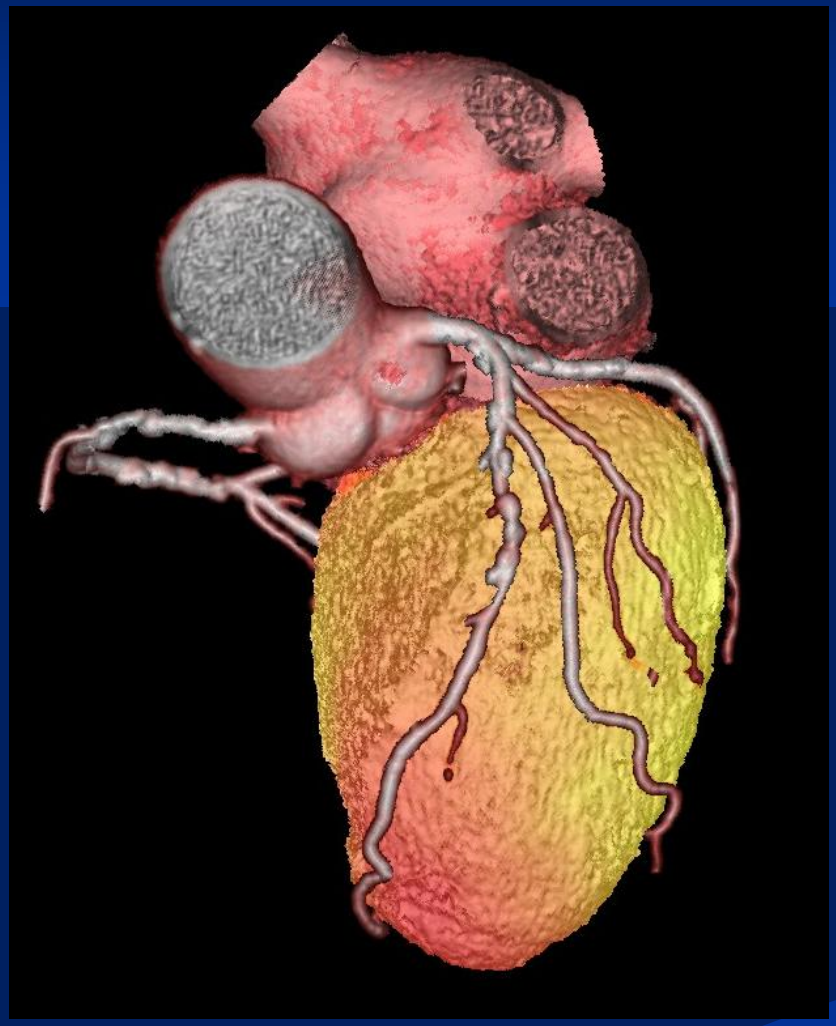


Table 1 Diagnostic accuracy of cardiac hybrid imaging (SPECT/CTCA and PET/CTCA) (Vessel-based analysis)

Author	Hybrid system	*n*	Gold standard (definition of significant CAD)	Sens	Spec	PPV	NPV
Namdar *et al.*[42]	$^{13}N-NH_3$ PET/4-slice CTCA	25	Flow-limiting coronary stenoses requiring revascularization (ICA + PET)	90	98	82	99
Rispler *et al.*[43]	SPECT/16-slice CTCA	56	Flow-limiting coronary stenoses (>50% stenosis on ICA + SPECT pos.)	96	95	77	99
Groves *et al.*[44]	^{82}Rb PET/64-slice CTCA	33	>50% stenosis on ICA	88	100	97	99
Sato *et al.*[45]	SPECT/64-slice CTCA[a]	130	>50% stenosis on ICA	94	92	85	97
Kajander *et al.*[46]	$^{15}O-H_2O$ PET/64-slice CTCA	107	Flow-limiting coronary stenosis (>50% stenosis of ICA + FFR)	93	99	96	99

n denotes the number of patients in each study; SPECT, single photon emission computed tomography; CTCA, CT coronary angiography; PET, positron emission tomography; CAD, coronary artery disease; Sens, sensitivity; Spec, specificity; PPV, positive predictive value; NPV, negative predictive value; ICA, invasive coronary angiography; FFR, fractional flow reserve.

[a]Hybrid SPECT/CTCA only applied for non-evaluable arteries on CTCA (14%).

Table 2 Incremental clinical value of fused hybrid imaging compared to the side-by-side analysis

Author	Hybrid system	Patient population	Incremental value of fused hybrid imaging
Gaemperli *et al.*[47]	SPECT/64-slice CTCA and 3D image fusion	38 patients with ≥1 SPECT defects	Modification of initial interpretation in 29% of patients In equivocal lesions, haemodynamic relevance could be confirmed in 35% and excluded in 25%
Santana *et al.*[48]	16- and 64-slice CTCA and MPI (SPECT or ^{82}Rb PET)	50 patients with suspected CAD	Modification of initial interpretation in 28% of patients Trend towards increased sensitivity (by 17%) in patients with multivessel disease
Slomka *et al.*[49]	Motion-frozen SPECT/64-slice CTCA (automatic coregistration)	35 patients with suspected CAD	Improved diagnostic performance in RCA- and LCX-territories

SPECT denotes single photon emission computed tomography; CTCA, CT coronary angiography; MPI, myocardial perfusion imaging; PET, positron emission tomography; CAD, coronary artery disease.

Table 3 Incremental clinical value of hybrid imaging in the diagnosis of coronary artery disease

Improved diagnostic performance to detect CAD compared with SPECT of CTCA alone
Allows to identify flow-limiting coronary lesions ('culprit lesions') requiring revascularization (particularly in the RCA- and LCX-territory and with multivessel disease)
Adds diagnostic information in approximately one-third of patients
Provides independent prognostic information through combination of morphological and functional criteria

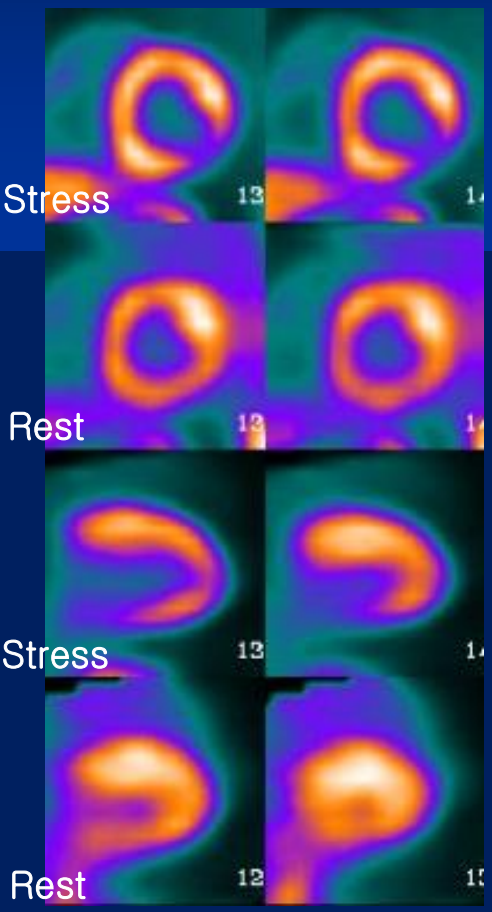
Eur Heart J 2011;32:2100–2108

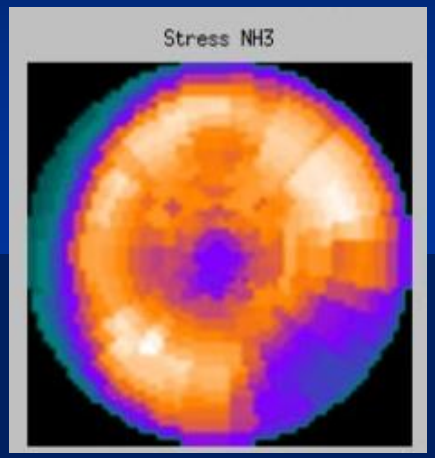
Cardiac Hybrid Imaging

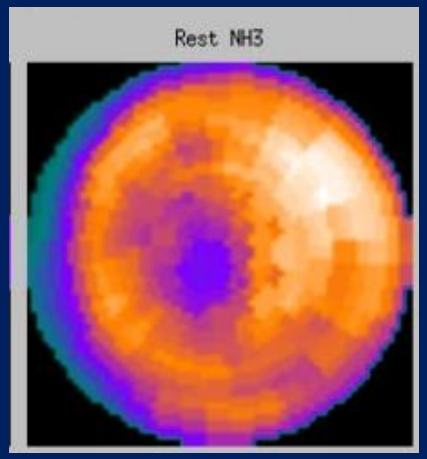
- Myocardial perfusion SPECT + CTA
- N-13 ammonia PET + CTA
- F-18 FDG PET + CTA
- CardIQ Fusion software
  - Advantage workstation 4.4; GE Healthcare

N-13 ammonia PET/CTA fusion imaging : allocation of ischemia due to LCX

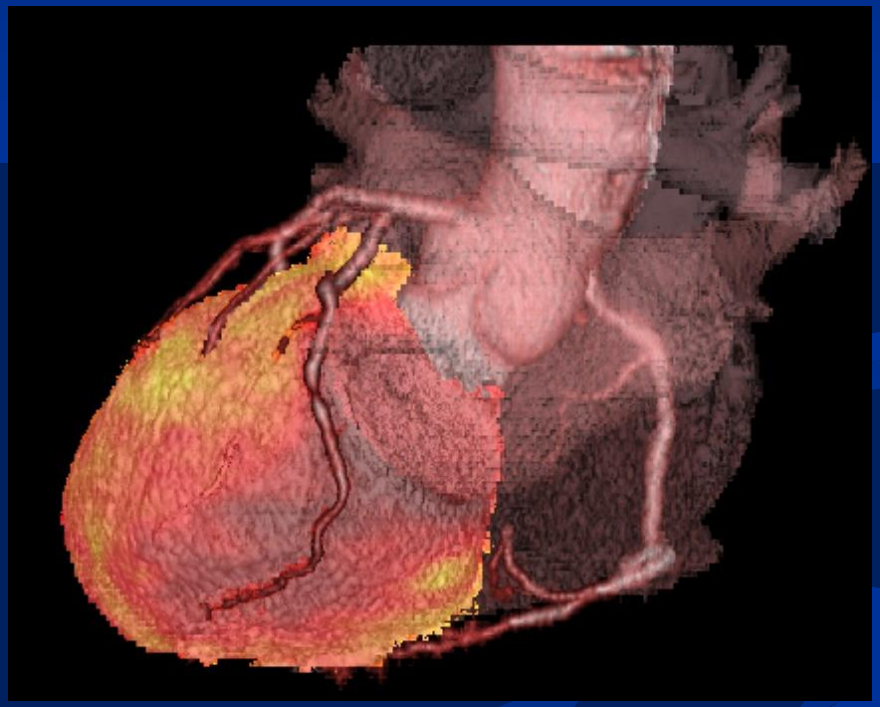
51/ M





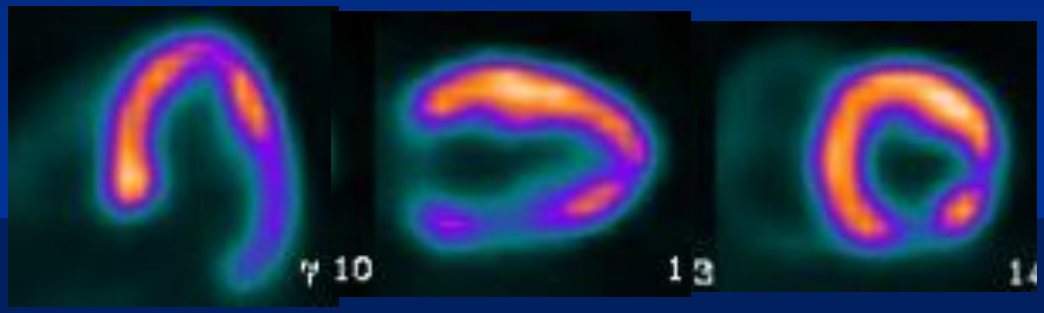


Adenosine stress/rest N-13 ammonia PET



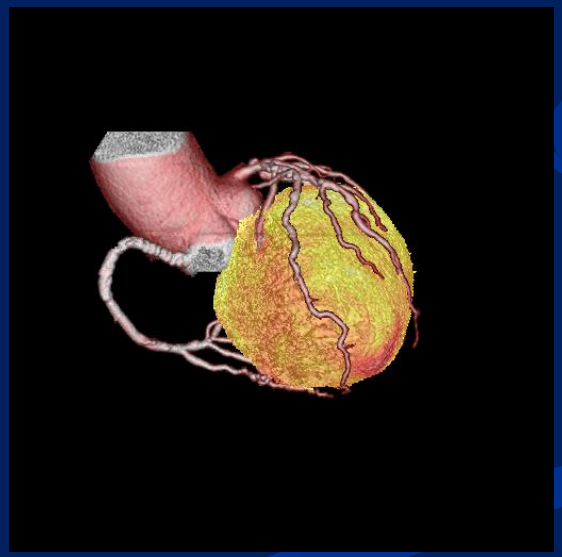
3D cardiac N-13 ammonia/CTA fusion imaging

3D cardiac FDG/CTA fusion imaging

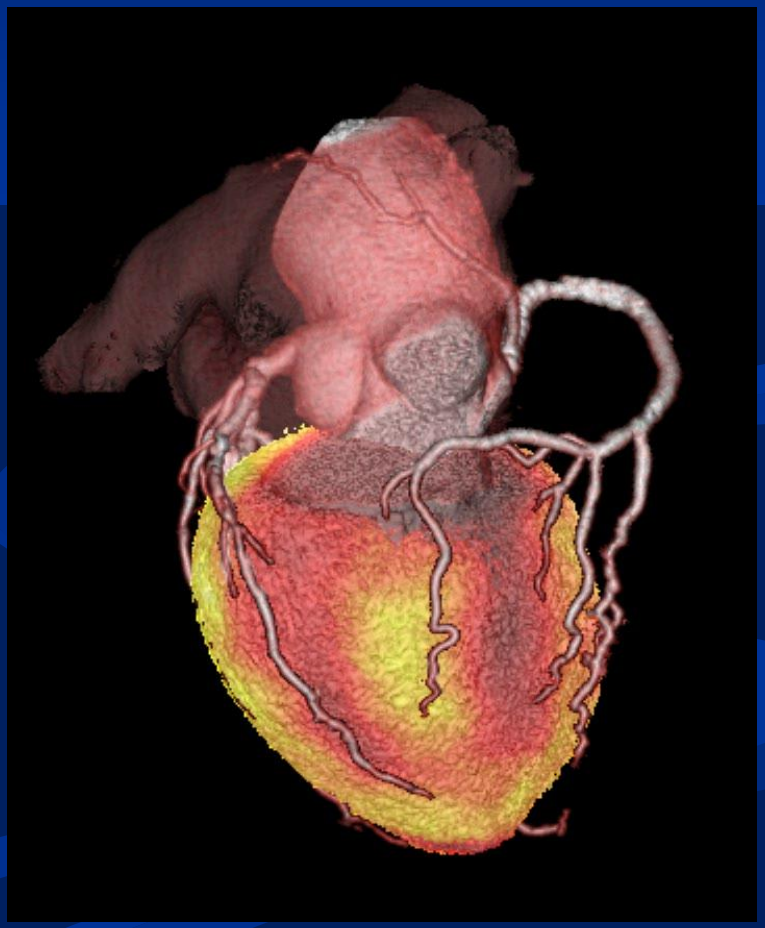


F-18 FDG myocardial PET

Polar map of FDG PET

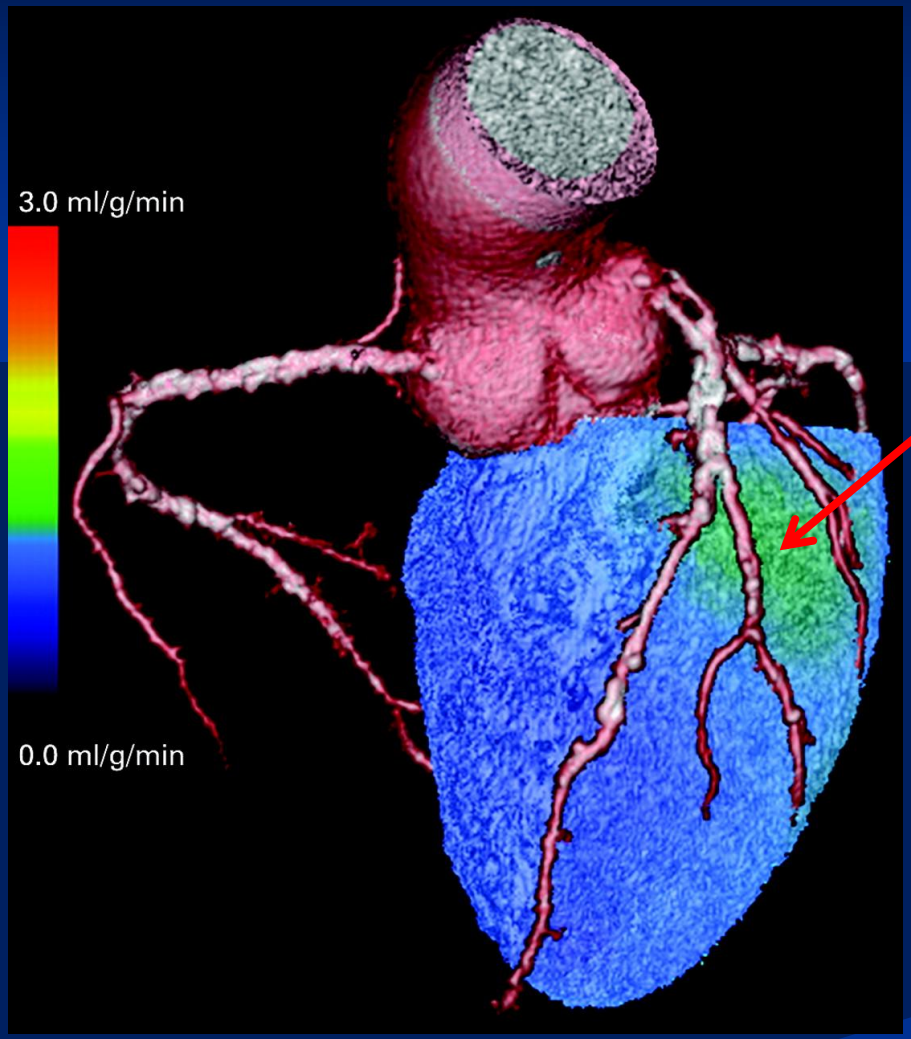


3D-Cardiac FDG/CTA fusion image



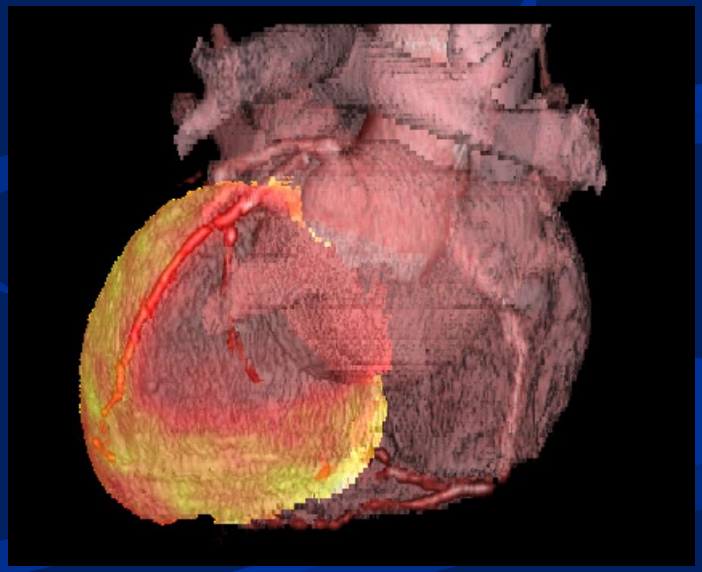
Clinical application of PET/CT

^{15}O-water parametric PET/CT hybrid image



CTA + adenosine stress Perfusion

MBF
1.3 ml/g/min



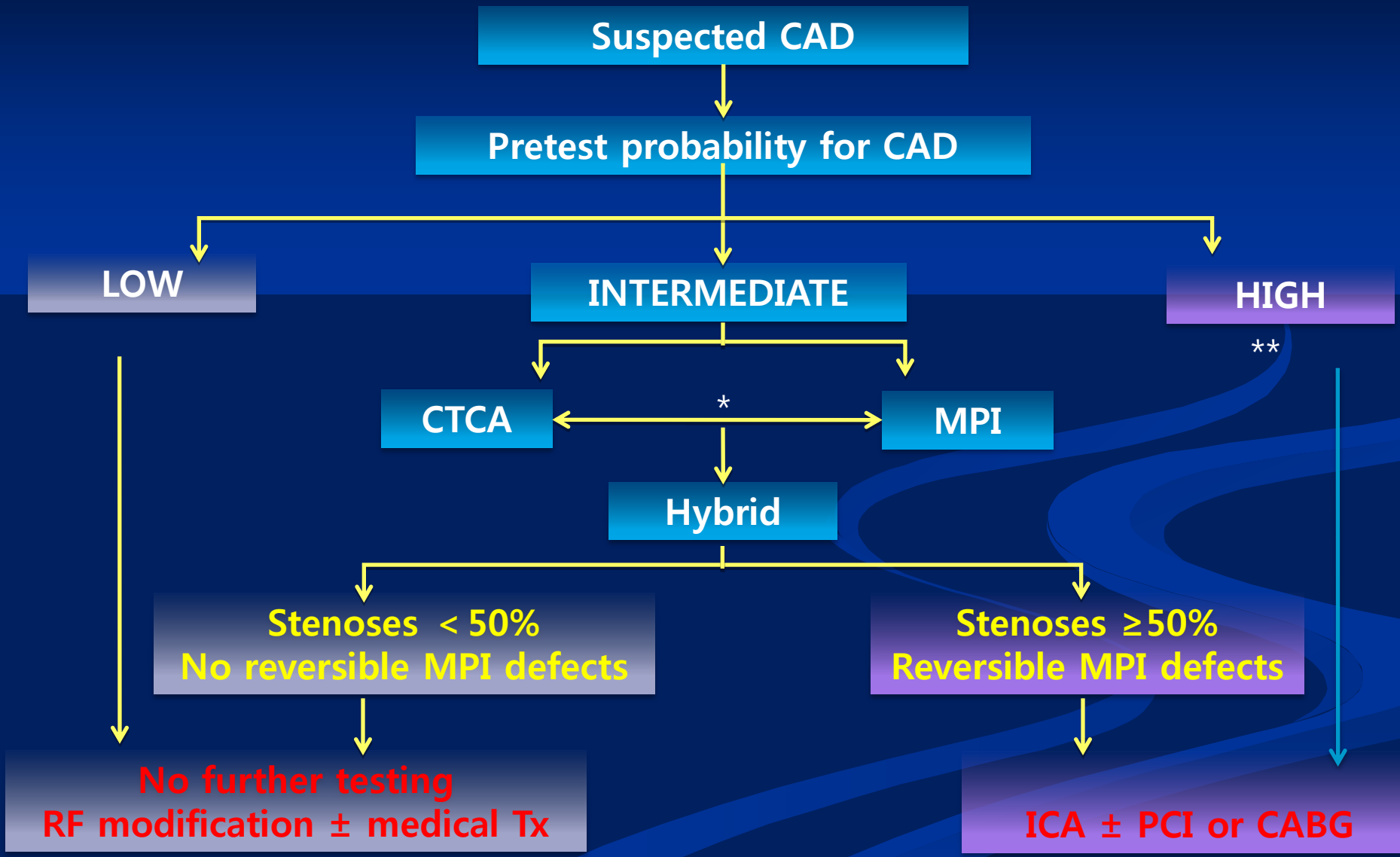
$^{13}NH_3$ PET/CT hybrid image

Knuuti J , Bengel F M Heart 2008;94:360-367

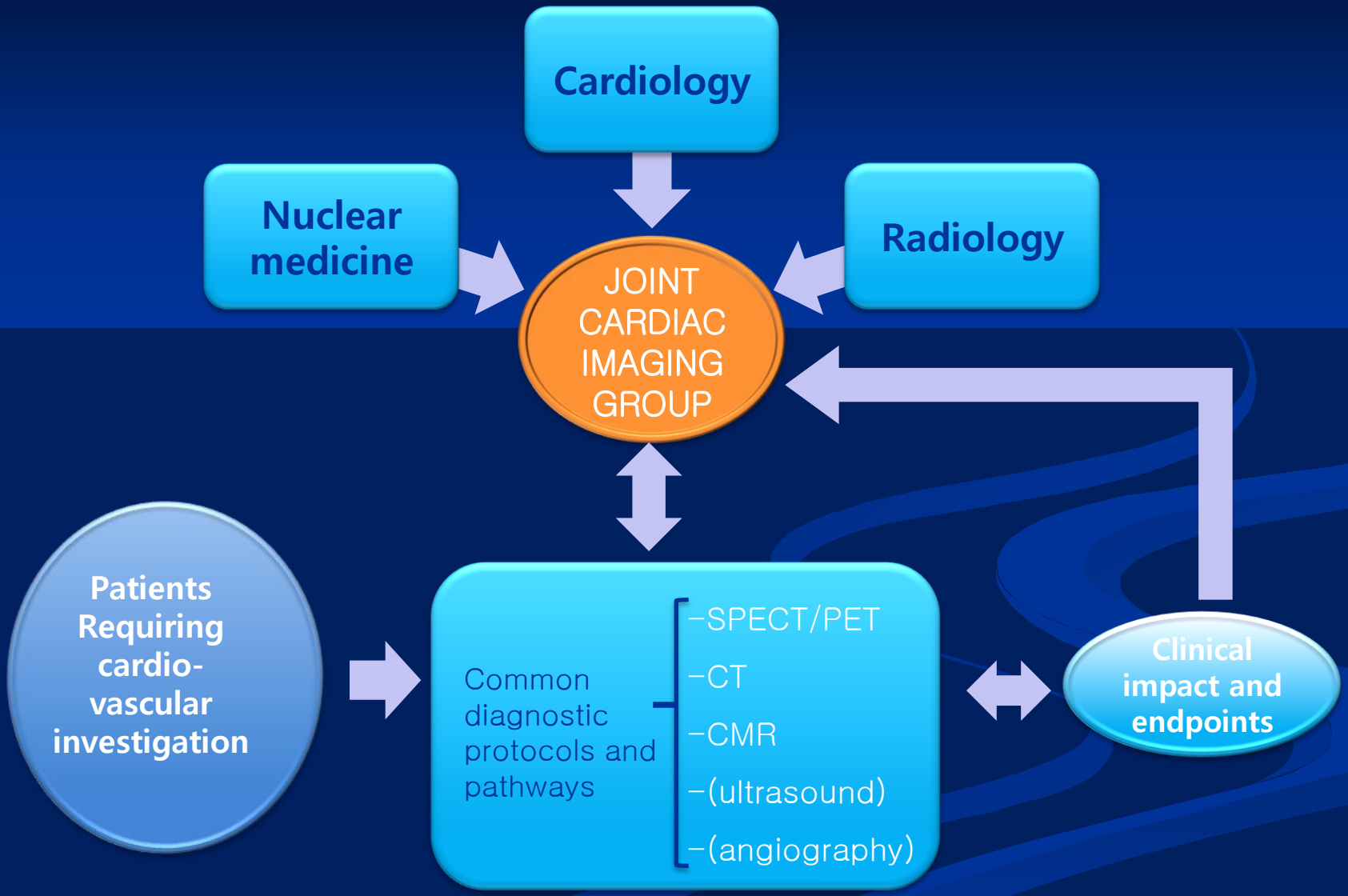
Advances in Cardiac Imaging

- Anatomic assessment
  - Plaque morphology
- Physiologic assessment
  - Flow quantification
  - Biologic properties of pathologic processes
- **Together, HYBRID IMAGING, very exciting new developments in coronary imaging**

Clinical algorithm for the use of hybrid imaging



Eur J Heart 2011;32:2100-8
Eur J Nucl Med Mol Imaging 2011;38:2101-212



Eur J Heart 2011;32:2100-8
J Nucl Cardiol 2010;17:4-7

Thank you very much for your attention

발표자료 준비에 많은 도움을 주신 영남의대 조인호 교수님과
심장핵의학연구회 회원님들께 깊은 감사를 드립니다.

Table 4 Estimated effective radiation dose from cardiac diagnostic imaging

Protocol	Injected activity (MBq)[a]	Effective dose (mSv)
^{99m}Tc sestamibi 1-day stress/rest	350/1000	11.3
^{99m}Tc sestamibi 2-day stress/rest	950/950	15.7
^{99m}Tc tetrofosmin 1-day stress/rest	320/960	9.3
^{99m}Tc tetrofosmin 2-day stress/rest	950/950	12.8
^{201}Tl stress/redistribution	130	22.0
^{201}Tl stress/reinjection	55/110	31.4
^{82}Rb stress/rest[72]	1850/1850	4.6
^{13}N–NH_3 stress/rest	550/550	2.4
^{15}O–H_2O stress/rest	1100/1100	2.5
^{18}F-fluorodeoxyglucose (viability)	350	7.0
CAC-scan (prospective ECG-triggering)[73]		1.0
CAC-scan (retrospective ECG-triggering)[73]		3.0
4-slice CTCA (without tube current modulation)		6.7–13.0
4-slice CTCA (with tube current modulation)		2.5–6.2
16-slice CTCA (without tube current modulation)		4.9–20.6
16-slice CTCA (with tube current modulation)		4.3–8.1
64-slice CTCA (without tube current modulation)		8.0–21.4
64-slice CTCA (with tube current modulation)		7.0–14.0
64-slice CTCA (prospective ECG-triggering)[30]		2.1
320-slice CTCA (prospective ECG-triggering)[74]		6.8
2 × 128-slice (dual source), high pitch spiral-CTCA[58]		0.9
Diagnostic coronary angiography		2.3–22.7