Nuclear Cardiology
Advances and Perspectives

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I have no conflict of interest to declare
Physiologically assessing coronary stenosis


12 dogs, diatrizoate, LCx occlusion
$^{99m}$Tc-macroaggregates

Dynamic exercise
Vasodilators
Dobutamine
Myocardial SPECT imaging in diagnosis


- Values derived from "unselected" populations

- Sensitivity: Overall 89%, Adenosine 99mTc-MIBI 92%
- Specificity: Overall 74%, Adenosine 99mTc-MIBI 85%
- Normalcy: Overall 89%, Adenosine 99mTc-MIBI 85%

- Overall: 51st, 9954 pts
- Adenosine: 99mTc-MIBI, 3rd, 274 pts
Non-invasive cardiac imaging in diagnosis

Gated SPECT - Attenuation Correction

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
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<tbody>
<tr>
<td>Ficaro</td>
<td>1996</td>
<td>46%</td>
<td>82%</td>
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<tr>
<td>Gallowitsh</td>
<td>1998</td>
<td>69%</td>
<td>84%</td>
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<td>Links</td>
<td>2000</td>
<td>69%</td>
<td>92%</td>
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<td>Hendel</td>
<td>2002</td>
<td>44%</td>
<td>50%</td>
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</table>
Myocardial SPECT in risk stratification

Russell RR, Zaret BL. Curr Probl Cardiol 2006;31:557-629

Annual event rate (%)

- Exercise
- Adenosine
- CAD+
- DM+
- Normal
- Mildly abnl
- Moderately
- Severely

Normal
Myocardial SPECT in clinical decision making

In the COURAGE nuclear substudies, SPECT ischemia did not predict adverse events and did not alter treatment effectiveness.
Ischemia driven outcomes in DM

SPECT ischemia in suspected CAD 1991-2009


39,515 diagnostic tests
Fractional Flow Reserve guided PCI

Tonino PM, et al. NEJM 2009;360:213-224


20 sites, 1005 pts, 1 yr f-u
Death, MI, repeat revascularization

28 sites, 1220 pts, stopped <1 yr
Death, MI, urgent revascularization
SPECT ischemia-guided revascularization, particularly with PCI, decreased the risk of repeat revascularization in MVD
Outcomes in inducible ischemia & LV dysfunction


Cardiac death in 399 STICH patients
Hibernating myocardium identifies which patients may accrue a survival benefit with revascularization versus medical therapy.
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Recommendation</th>
<th>Issuing body</th>
<th>Class</th>
<th>LE</th>
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<tr>
<td>Stable chest pain</td>
<td>Diagnosis of CAD in patients with intermediated pre-test likelihood of CAD:</td>
<td>ACC/AHA ESC</td>
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<td>B</td>
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<td>- unable to exercise-abnormal resting ECG</td>
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<td></td>
<td>Identification of target coronary lesions</td>
<td>ACC/AHA ESC</td>
<td>I</td>
<td>B</td>
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<td>Assessment of haemodynamic significance of coronary stenosis</td>
<td>ACC/AHA ESC</td>
<td>I</td>
<td>B</td>
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<td>Evaluation post-PCI or CABG</td>
<td>ACC/AHA ESC</td>
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<td>B</td>
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<tr>
<td>Acute chest pain</td>
<td>Detection of resting ischaemia</td>
<td>ACC/AHA ESC</td>
<td>IIa</td>
<td>IIb</td>
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<tr>
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<td>Detection of ischaemia in patients with uncertain diagnosis</td>
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<td>I</td>
<td>A</td>
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<td>Detection of ischemia in low-intermediate risk patients after UA/NSTEMI</td>
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<td>B</td>
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<td>Assessment of infarct size and myocardium at risk after STEMI</td>
<td>ACC/AHA ESC</td>
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<td>Preoperative risk</td>
<td>Risk stratification before elective non-cardiac surgery</td>
<td>ACC/AHA</td>
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<td>assessment</td>
<td></td>
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<td>Heart failure</td>
<td>Assessment for ischaemia and viability</td>
<td>ACC/AHA ESC</td>
<td>IIa</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>Diagnosis of CAD</td>
<td>ACC/AHA</td>
<td>IIb</td>
<td>C</td>
</tr>
</tbody>
</table>

Myocardial SPECT in Guidelines

Appropriate myocardial SPECT use in Greece

3,032 pts, 4 centers

- Asymptomatic patients <2yrs after PCI: 39%
- Suspected CAD in low risk patients: 29%
- Preoperative assessment in patients achieving >4 METS: 14%

Inappropriate studies
Stress testing and catheterization after stenting


n=247,052
656 institutions
9%-66% tests (2 yrs f-u)

Higher testing rates after stenting
• were not associated with lower risk for MI or death
• but higher rates of repeat revascularization
Repeat revascularization in silent ischemia (SPECT)


769 patients
115 revascular

Asymptomatic patients with inducible ischemia on SPECT realize no survival benefit from repeat revascularization
Exercise ECG and SPECT in prognosis


- suspected CAD, low-risk patients, Exerc. ECG (-) at >10 METS
  - low yield of SPECT abnormalities and very low 5-year mortality
Appropriate myocardial SPECT use and prognosis


Appropriate SPECT demonstrates high prognostic value
Inappropriate use lacks effectiveness for risk stratification
High-speed SPECT (CZT cameras)


- 40% reduction in radiation exposure in staff members
- 35% reduction in administered activity
High-speed SPECT (CZT cameras)

Myocardial Perfusion Reserve (CZT cameras)


Angiography: LAD prox occlusion, RCA severe atherosclerosis
PET in myocardial blood flow assessment


Coronary angiography:
totally occluded RCA & LCx
severe stenosis in mid LAD

<table>
<thead>
<tr>
<th>Coronary territory</th>
<th>Rest MBF (mL/min/g)</th>
<th>Stress MBF (mL/min/g)</th>
<th>CFR (stress/rest)</th>
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<tr>
<td>LAD</td>
<td>0.86</td>
<td>0.89</td>
<td>1.07</td>
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<tr>
<td>LCX</td>
<td>0.64</td>
<td>0.66</td>
<td>1.03</td>
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<tr>
<td>RCA</td>
<td>0.86</td>
<td>1.00</td>
<td>1.16</td>
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Diagnostic performance of PET vs SPECT

P = 0.035

n = 11,872
113 SPECT studies
9 PET studies

Sensitivity
SPECT: 88%
PET: 93%

Specificity
SPECT: 76%
PET: 81%
82Rb-PET myocardial imaging in risk stratification


Cardiac death (n=6,037)

Reclassification in 12% over clinical data

All-cause death (n=7,061)

Reclassification in 8% over clinical and LVEF data
Prognostic performance of PET vs SPECT


Annual event rate (%)

SPECT 69,665 pts
PET 4,392 pts

- **normal-mild**
- **moderate-severe**

SPECT:
- 0.85%
- 5.9%

PET:
- 0.4%
- 11.5%
Rb coronary flow reserve & cardiac mortality


Rb CFR provides powerful incremental prediction of cardiac death in patients with suspected or known CAD, over clinical and imaging data.
Hybrid myocardial imaging

In symptomatic patients with normal SPECT, global CFR but not CAC provides significant incremental risk stratification over clinical risk.
MFR is associated moderately
(a) with CTA stenosis severity
(b) the extent of atherosclerosis
(c) but not other CTA descriptors
of atherosclerosis (plaque length, composition, remodeling)
Flurpiridaz F-18 PET vs SPECT


21 sites, 125 pts, phase II trial

PET flurpiridaz F 18 was safe and superior to SPECT MPI for image quality, interpretative certainty and overall CAD diagnosis
Prosthetic valve endocarditis
Sensitivity 73%
Specificity 80%
Increased the sensitivity of the modified Duke criteria (70% → 97%)
Myocardial SPECT vs CMR (MR-IMPACT II)


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<tr>
<th></th>
<th>CMR Stress</th>
<th>SPECT Stress</th>
<th>Rest</th>
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<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
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|                  | F          | G            | D             | E             |

|                  |            |              | QCA LAD       | QCA RCA       |

<table>
<thead>
<tr>
<th>33 centers, 465 pts</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Non-evaluable</th>
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<tbody>
<tr>
<td>SPECT</td>
<td>59%</td>
<td>72%</td>
<td>3.7%</td>
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<tr>
<td>CMR</td>
<td>67%</td>
<td>61%</td>
<td>5.6%</td>
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Non-standardized SPECT performance
Excluded if: arrhythmia, contraindications to adenosine or contract media, MI & stenting vs MI & stenting with <75% residual stenosis
1.5 T CMR & lymphocyte DNA integrity


CMR should be used with caution with similar restrictions as for X-rays and nuclear imaging in order to avoid potential carcinogenic effect.
Economic outcomes in suspected CAD (SPARC)

Hlatky MA, et al. JACC 2014;63:1002-1008

2-year downstream costs

<table>
<thead>
<tr>
<th></th>
<th>PET</th>
<th>CCTA</th>
<th>SPECT</th>
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<tr>
<td>mortality</td>
<td>5.5%</td>
<td>0.7%</td>
<td>1.6%</td>
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<tr>
<td>cost</td>
<td>$6,647</td>
<td>$4,909</td>
<td>$3,965</td>
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SPECT had the lowest cost and better cost-effectiveness ratio
### Multimodality Appropriate Use Criteria


#### Symptomatic

<table>
<thead>
<tr>
<th>Low pretest probability of CAD</th>
<th>Exercise ECG</th>
<th>SPECT MPI</th>
<th>Stress echo</th>
<th>Stress CMR</th>
<th>Calcium scoring</th>
<th>CCTA</th>
<th>Invasive Angiogr</th>
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<td>ECG interpretable AND able to exercise</td>
<td>A</td>
<td>R</td>
<td>M</td>
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<td>ECG uninterpretable OR unable to exercise</td>
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<td>Intermediate pretest probability of CAD</td>
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Nuclear Cardiology at crossroads

Thank you for your attention