CARDIAC PET
PERFUSION IMAGING
with RUBIDIUM-82

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et IRM

CHU Caen

Bordeaux
2006
Cardiac Perfusion-Metabolism Mismatch with PET

Cumulative Survival

- Revascularization
- Medical Therapy

Low Rank
\( \chi^2 = 4.60 \)
\( p = 0.03 \)
Objectives

• Background of cardiac PET
• Understand advantages of cardiac PET perfusion imaging
• Discuss cardiac PET and PET/CT imaging
• Quantification of coronary reserve: dream or reality?
## Diagnostic Accuracy of PET Myocardial Perfusion Imaging for CAD

<table>
<thead>
<tr>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>No. Patients</th>
<th>Agent</th>
<th>Author</th>
</tr>
</thead>
<tbody>
<tr>
<td>95</td>
<td>100</td>
<td>50</td>
<td>NH$_3$, $^{82}$Rb</td>
<td>Gould et al</td>
</tr>
<tr>
<td>94</td>
<td>95</td>
<td>193</td>
<td>$^{82}$Rb</td>
<td>Demer et al</td>
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<tr>
<td>93</td>
<td>78</td>
<td>202</td>
<td>$^{82}$Rb</td>
<td>Go et al</td>
</tr>
<tr>
<td>97</td>
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<td>45</td>
<td>NH$_3$</td>
<td>Schelbert et al</td>
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<td>49</td>
<td>NH$_3$</td>
<td>Yonekura et al</td>
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<td>93</td>
<td>146</td>
<td>$^{82}$Rb</td>
<td>Williams et al</td>
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<td>84</td>
<td>88</td>
<td>81</td>
<td>$^{82}$Rb</td>
<td>Stewart et al</td>
</tr>
<tr>
<td>95</td>
<td>95</td>
<td>25</td>
<td>NH$_3$</td>
<td>Tamaki et al</td>
</tr>
<tr>
<td><strong>93</strong></td>
<td><strong>92</strong></td>
<td><strong>791</strong></td>
<td></td>
<td><strong>Average</strong></td>
</tr>
</tbody>
</table>
Advantages of Cardiac PET Perfusion Imaging

• Improved efficiency
• Lower radiation exposure
• Fewer attenuation artifacts
• Improved resolution

Commercially Available Cardiac PET Agents in US

- Perfusion Imaging
  - Rubidium Rb 82
  - N-13 Ammonia

- Viability Imaging
  - F-18 Fluorodeoxyglucose (FDG)
<table>
<thead>
<tr>
<th>Author</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gould</td>
<td>95%</td>
<td>100%</td>
<td>50</td>
</tr>
<tr>
<td>Demer</td>
<td>94%</td>
<td>95%</td>
<td>193</td>
</tr>
<tr>
<td>Go</td>
<td>93%</td>
<td>78%</td>
<td>202</td>
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<tr>
<td>Schelbert</td>
<td>97%</td>
<td>100%</td>
<td>45</td>
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<td>Yonekura</td>
<td>93%</td>
<td>100%</td>
<td>49</td>
</tr>
<tr>
<td>Williams</td>
<td>98%</td>
<td>93%</td>
<td>146</td>
</tr>
<tr>
<td>Stewart</td>
<td>84%</td>
<td>88%</td>
<td>319</td>
</tr>
<tr>
<td><strong>Weighted Avg.</strong></td>
<td><strong>93% +/- 8</strong></td>
<td><strong>92% +/- 5</strong></td>
<td><strong>766</strong></td>
</tr>
</tbody>
</table>

## Cardiac PET Tracers

<table>
<thead>
<tr>
<th>Agent</th>
<th>Physical Half-life</th>
<th>Mean Positron range (mm)</th>
<th>Production</th>
<th>Extraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{13}$N NH$_3$</td>
<td>10.0 min</td>
<td>0.7</td>
<td>Cyclotron</td>
<td>80 %</td>
</tr>
<tr>
<td>$^{82}$Rb</td>
<td>78 s</td>
<td>2.6</td>
<td>Generator</td>
<td>50-60 %</td>
</tr>
<tr>
<td>$^{15}$O H$_2$O</td>
<td>2.0 min</td>
<td>1.1</td>
<td>Cyclotron</td>
<td>Diffusible</td>
</tr>
<tr>
<td>$^{18}$F FDG</td>
<td>110 min</td>
<td>0.2</td>
<td>Cyclotron</td>
<td>1-3 %</td>
</tr>
</tbody>
</table>
CardioGen-82®
(Rubidium Rb 82 Generator)

• Indication in US:

Useful in distinguishing normal from abnormal myocardium in patients with suspected myocardial infarction.
CardioGen-82®
(Rubidium Rb 82 Generator)

• Rubidium-82 (Rb-82) is produced by decay of Strontium-82 (Sr-82)
• 75 second T½
• Kinetics:
  – Potassium analog
  – High extraction fraction at high flow rates
• Defects visualized 2-7 minutes after injection
• Same sized dose at stress & rest due to short T¹⁄₂
• New generator every 28 days
• Dose available 24 hours per day, 7 days per week
• Pharmacologic stress studies ONLY
Cardiac Pet Tracer Dosimetry

<table>
<thead>
<tr>
<th>Agent</th>
<th>Activity (mCi)</th>
<th>Critical Organ</th>
<th>Organe Dose (rem)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{13}$N NH$_3$</td>
<td>20</td>
<td>Bladder</td>
<td>0.52</td>
</tr>
<tr>
<td>$^{82}$Rb</td>
<td>60</td>
<td>Kidneys</td>
<td>1.98</td>
</tr>
<tr>
<td>$^{15}$O H$_2$O</td>
<td>60</td>
<td>Heart</td>
<td>0.49</td>
</tr>
<tr>
<td>$^{18}$F FDG</td>
<td>10</td>
<td>Bladder</td>
<td>7.00</td>
</tr>
</tbody>
</table>

Less irradiation with Rb82 than technetium agents for technicians (MYOVIEW) (J Nucl Cardiol 2006)
Comparison of PET and SPECT Myocardial Perfusion Imaging for Detection of CAD in the Same Patients

<table>
<thead>
<tr>
<th>Author</th>
<th>Tracer</th>
<th>Accuracy (%)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Go et al (n = 132)</td>
<td>Rb-82</td>
<td>92</td>
<td>95</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Tl-201</td>
<td>78</td>
<td>79</td>
<td>76</td>
</tr>
<tr>
<td>Stewart et al (n = 81)</td>
<td>Rb-82</td>
<td>85</td>
<td>87</td>
<td>82</td>
</tr>
<tr>
<td></td>
<td>Tl-201</td>
<td>78</td>
<td>87</td>
<td>52</td>
</tr>
<tr>
<td>Tamaki et al (n = 51)</td>
<td>NH3</td>
<td>98</td>
<td>98</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Tl-201</td>
<td>98</td>
<td>96</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>PET</td>
<td>91</td>
<td>93</td>
<td>82</td>
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<tr>
<td>SPECT</td>
<td>81</td>
<td>85</td>
<td>67</td>
<td></td>
</tr>
</tbody>
</table>
Sample Dedicated PET Protocol (35 min)

- Rest Tx Scan
- Emission Scan 2D
  - 10 phases
  - 30 seconds
  - Approx 4 min
  - Approx 5 min
- 3D Gated Scan
  - Approx 3 min
- Stress Tx Scan
- Emission Scan 2D
  - 10 phases
  - 30 seconds
  - Approx 4 min
  - Approx 5 min
- 3D Gated Scan
  - Approx 3 min

Dipy 0.56 mg/kg

Protocol courtesy of Timothy Bateman, MD
Approximately 35 minutes
PET/CT Protocol (30 min)

Approximately 30 minutes

Rb-82
50-60 mCi

Dipy
0.56 mg/kg

scout CT-trans

Rb-82
50-60 mCi

gated rest

pt out

scoutCT-trans

gated stress

70-90 sec
90-120 sec

Approx 1 min

Approx 7 min

Approx 6 min

Approx 1 min

Approx 7 min

Protocol courtesy of Marcelo DiCarli, MD
Approximately 30 minutes
CASE 1

STRESS
Normal Database Comparison: PET vs. SPECT/ Rb-82 vs ammonia

<table>
<thead>
<tr>
<th></th>
<th>Stress Uncorrected</th>
<th>Stress corrected</th>
<th>PET Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender-matched</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender-combined</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SPECT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-day rest/stress sestamibi protocol</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Rb-82</td>
<td></td>
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<td></td>
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</tbody>
</table>
The PET/CT design

Gantry dimensions:
170 cm x 168 cm x 110 cm

Rotation: 30 rpm

QC Issues: Table sag, patient motion, organ motion (ave. vs. instant)
* Avoid Misalignment between Emission & Transmission Sequential Scans

Rest  

Stress

Cardiac motion artifact:

Heart moved during pharmacological stress

John Votaw, Ph.D., 2003
PET/CT

1. CT used for attenuation correction (obese patients)
   - CT vs. Radioactive sources

2. CT used for fusion of coronary anatomy and calcium deposits with perfusion distribution (risk stratification for CAD patients).
Calcium Deposit (Calcium scoring using CT)

Soft Plaque
(CT Coronary Angiography)

Perfusion deficit
(Perfusion stress and rest)

LV Function

PET/CT One-Stop Shop:
Four Tests in One Sitting
Clinical Applications of Coronary Flow Reserve Quantification

1 - Verification of efficacy of pharmacological vasodilation
2 - Detection of global/diffuse disease
3 - Evaluation of extent of multivessel disease
4 - Evaluation of significance of individual vessel lesions
5 - Detection of coronary steal syndrome-collaterals
6 - Evaluation of endothelial function
7 - Monitoring therapy
Conclusions

- Rb-82 is currently the best PET myocardial perfusion tracer available for clinical work.
- Rb-82 provides the most homogeneous normal distribution of myocardial perfusion.
- PET AC works better than SPECT and can be performed using either CT,
- Emission and transmission misregistrations due to patient motion or breathing can cause artifacts. QC should be routinely performed.
- Image fusion of CT angiography and PET perfusion is a promising clinical tool.
Prospective in France

- 1st site in Europe (UK 2006) from US
- Cyclotron (Arronax) in Nantes 2009 to produce Rb82 generators in France and Europe
- The best “parc” of PET-CT in the world (today: 55 and 100 in the next 5 years)
- Compromise between oncology and cardiology in the nuclear department
- Selection of patients:
  - obesity
  - women
  - triple vessels disease
(thanks to Bertrand Merino for your invitation in the Wine’s Country)
REUNIONS DE LA SOCIETE FRANCAISE DE CARDIOLOGIE
MARS-OCTOBRE-DECEMBRE

Prochaine réunion SFC:
le 15 DECEMBRE
18h – 20h
MERIDIEN ETOILE
– PARIS –