Nuclear Cardiology
How to detect cardio-vascular prosthetic valves and devices infections by 18F-FDG-PET? part I

Prof Denis AGOSTINI, MD PhD
Cardiologist and Nuclear Physician
Instructor at the ESNM
University Hospital Caen-Normandy
France

Vienna IAEA 2016
2015 ESC Guidelines for the management of infective endocarditis

Clinical suspicion of IE

Modified Duke criteria (Li)

Definite IE
Possible/rejected IE but high suspicion
Rejected IE Low suspicion

Native valve
Prosthetic valve

1. Repeat echo (TTE + TOE)/microbiology
2. Imaging for embolic events
3. Cardiac CT

1. Repeat echo (TTE + TOE)/microbiology
2. 18F-FDG PET/CT or Leucocytes labeled SPECT/CT
3. Cardiac CT
4. Imaging for embolic events

ESC 2015 modified diagnostic criteria

Definite IE
Possible IE
Rejected IE
No myocardial FDG uptake needs very HIGH-FAT, low-carbohydrate, protein-permitted diet the night before PET imaging.
True whole-body acquisition FDG-PET the D-Day

Fed condition 6-8 h before

2.5-5 MBq/kg FDG IV

Acquisition + 90 min

Whole-body + cardiac acquisitions
Analysis of myocardial FDG uptake non attenuation-corrected images for PVE
Brain imaging
Mycotic aneurysms
Portal of entry
FDG uptake pattern in non-infected PV

Absence of uptake on the PV

Intense / Homogeneous uptake on the PV
Study patients

201 patients with Gram-positive bacteraemia

148 patients with ≥1 risk factor

126 patients asked for consent

115 patients included

2 patients died before $^{18}$F-FDG PET was performed
2 patients refused consent

$^{18}$F-FDG-PET performed in 111 patients

Control patients

456 patients assessed for eligibility

366 patients with ≥1 risk factor

296 eligible patients

230 matched patients 2:1 matching

90 patients without risk factor

70 patients ≥14 days in ICU
FDG-PET and detection of metastatic foci: 50% are asymptomatic

### TABLE 2. Localization of Metastatic Foci and Number of Foci First Detected by $^{18}$F-FDG PET/CT

<table>
<thead>
<tr>
<th>Metastatic foci</th>
<th>Study patients ($n = 115$)</th>
<th>Controls ($n = 230$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total number</td>
<td>%</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>--------------</td>
<td>---</td>
</tr>
<tr>
<td>Patients with foci identified</td>
<td>78</td>
<td>67.8</td>
</tr>
<tr>
<td>Total number of foci</td>
<td>124</td>
<td></td>
</tr>
<tr>
<td>Endocarditis</td>
<td>21</td>
<td>18.3</td>
</tr>
<tr>
<td>Endovascular</td>
<td>20</td>
<td>17.4</td>
</tr>
<tr>
<td>Lung</td>
<td>12</td>
<td>10.4</td>
</tr>
<tr>
<td>Liver</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Spleen</td>
<td>1</td>
<td>0.9</td>
</tr>
<tr>
<td>Arthritis</td>
<td>10</td>
<td>8.7</td>
</tr>
<tr>
<td>Spondylodiskitis</td>
<td>11</td>
<td>9.6</td>
</tr>
<tr>
<td>Osteomyelitis</td>
<td>6</td>
<td>5.2</td>
</tr>
<tr>
<td>Psoas abscess</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>Soft tissue</td>
<td>11</td>
<td>9.6</td>
</tr>
<tr>
<td>Central nervous system</td>
<td>11</td>
<td>9.6</td>
</tr>
<tr>
<td>Eye</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td>Joint prosthesis</td>
<td>9</td>
<td>7.8</td>
</tr>
<tr>
<td>Intraabdominal</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td>Kidney</td>
<td>1</td>
<td>0.9</td>
</tr>
</tbody>
</table>

*Epidural extension of $^{18}$F-FDG uptake in 3 patients with spondylodiskitis, confirmed by MRI. In 30 study patients and 22 controls, more than 1 metastatic localization was identified.
Prosthetic valve endocarditis (PVE)

- Delay >1 month after valve implantation (IQR: 526 to 3,396 days)
- Median delay: 9 days (IQR: 5 to 19 days) after the beginning of antibiotherapy (n=55)
- Positive PET/CT (n=36) in patients with biological and mechanical prosthetic valve: 52% vs. 46% (p=0.63)

Saby et al JACC 2013
Diagnostic value

Pizzi et al Circulation 2015
Multimodal imaging

A ECHO
B CT
C PET-CT
D PET-CTA

Tanis et al JACC 2013
FDG PET + Contrast-enhanced CT
FDG-PET and Bacteriema at enterococcus faecalis

PVE on aortic bioprothesis
Metastatic foci: nodes + spleen
FDG PET and cardiac defibrillator

Infection on right ventricular lead + DFI
FDG PET and Infective Endocarditis with streptocoque type A

Infection of leads and Right Atrium
Metastatic foci on lungs
Perspectives: new PET tracers

- Leukocytes labelled with positron emitters (PET)
  - Requires a long half-life isotope ($^{64}\text{Cu}$pper = 12.7 hours) Bhargava et al. NMB 2009

- $^{99}\text{mTc}$-Annexin A5
  - Target: vegetations (phosphatidylserine expressed by activated platelets)
  - No physiological uptake in heart and brain
Conclusion

• FDG PET in infective endocarditis
  • Allows early identification of
  • Septic emboli / metastatic infection
  • Portal of entry
  • Impacts on diagnosis of PVE
  • Impacts on patients’ management
• Guidelines: EANM/ESC/EACVI
Nuclear Cardiology
How to determine coronary flow reserve by dynamic CZT camera?
part II

Vienna IAEA 2016
**Waterday protocol (NCT 02278497)**

**INCLUSION CRITERIA: November 2014 – November 2016**
- Patients needed angiographic CAD because of positive ischemic test (treadmill, bicycle, echo, scinti, MRI)
- No immediate revascularization following angiography
- No occlusion or subocclusion on the main CA
- Non STEMI
- 18 to 80 years old

**PRIMARY OBJECTIVE:**
*Assessment of CFR using Tc99m-sestamibi and D-SPECT camera in comparison with PET H$_2$O$^{15}$ and FFR in 50 pts.*

Inclusion criteria:

- Angiography
- FFR on 3 main vessels (adenosine)
- Tc-Mibi Dynamic D-SPECT within 30 days (regadenoson)
- PET H$_2$O$^{15}$ within 30 days (regadenoson)
Dynamic application to determine global MBF in Caen Hospital

- **MPI protocol duration:** 60 min
- **Data:** RST-STR Perfusion, Gated & Dynamic
- **Radiation exposure:** < 9 mSv (2.6 mSv and 6 mSv)
- **96 screened pts – 33 included pts for CZT protocol so far**

*Perfusion imaging times may differ depending on patient BMI.*
Dynamic scan & reconstruction

Typical acquisition:
- Dynamic mode scan: continuous step & shoot
- Total of 6 min scan for stress and rest scans

Typical reconstruction:
- 20 set of SPECT frames x 3 sec
- 1 set of SPECT frame x 9 sec
- 1 set of SPECT frame x 15 sec
- 1 set of SPECT frame x 21 sec
- 1 set of SPECT frame x 27 sec
- 7 set of SPECT frames x 30 sec
Dynamic processing

Bolus & LA ROIs

Time activity curves (TAC)

Sestamibi kinetic model (Net retention) & extraction factor K1 calculation

Apply sestamibi extraction fraction correction (Leppo)

Calculate Relative flow & reserve

\[ K1 = Flow \ast (1 - A \ast e^{-\frac{B}{Flow}}) \]

ESNM European School of Nuclear Medicine

[Image of dynamic processing flowchart]
D-SPECT vs PET Myocardial Blood Flow

R=0.81
D-SPECT vs PET Coronary Flow Reserve

R=0.84
Coronary Flow Reserve vs Fractional Flow Reserve

D-SPECT Reserve vs FFR (same population as PET)

PET Reserve vs FFR
Coronary Flow Reserve vs FFR

Max accuracy | Reserve threshold | Sensitivity | Specificity | Accuracy
--- | --- | --- | --- | ---
PET | 1.85-1.86 | 90% | 84.5% | 85.2%
D-SPECT | 1.85-1.95 | 80% | 91.5% | 90.1%

Threshold = 2.0 | Reserve threshold | Sensitivity | Specificity | Accuracy
--- | --- | --- | --- | ---
PET | 2.0 | 90% | 80.3% | 81.5%
D-SPECT | 2.0 | 80% | 88.7% | 87.7%

Threshold = 2.5 | Reserve threshold | Sensitivity | Specificity | Accuracy
--- | --- | --- | --- | ---
PET | 2.5 | 90% | 53.5% | 58.0%
D-SPECT | 2.5 | 80% | 63.4% | 65.4%
Case: WD008 Angiography

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Stenosis</th>
<th>FFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAD</td>
<td>80%</td>
<td>0.47</td>
</tr>
<tr>
<td>LCX</td>
<td>60%</td>
<td>0.74</td>
</tr>
<tr>
<td>RCA</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>
Case: WD008 Perfusion scan

64yo, female
DM, Hypertension, DLP,
Family history
Angina
Case: WD008 Dynamic CZT scan

CFR is abnormal (< 2) in LAD-LCX-RCA regions
Case: WD008 PET scan

CFR is abnormal (< 2) in LAD- LCX-RCA regions
Case: WD013 Angiography

<table>
<thead>
<tr>
<th>Vessel</th>
<th>Stenosis</th>
<th>FFR</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAD</td>
<td>60%</td>
<td>0.82</td>
</tr>
<tr>
<td>LCX</td>
<td>0%</td>
<td>1.00</td>
</tr>
<tr>
<td>RCA</td>
<td>0%</td>
<td>0.95</td>
</tr>
</tbody>
</table>
Case: WD013 Perfusion scan

73yo, male
Smoking
Chemo (5 FU) follow-up
Angina

Stress
Rest
Case: WD013 Dynamic scan

CFR is abnormal (<2) in the 3 vessel regions
Conclusion

• **PET-FDG and infective endocarditis + CV devices infection** is well-recommended by the ESC and « expert-team » is also mandatory in each hospital

• **Dynamic CZT-SPECT** is feasible and reliable but needs a learning curve to be able to determine global and regional CFR