"Role of Imaging techniques in endocarditis and vascular infections”

Pr Xavier Duval
Bichat Claude Bernard university hospital
Paris, France

xavier.duval@aphp.fr
Infective Endocarditis

• IE incidence France: stable 25 /10^6 ind/year relatively uncommon : 1 300 cases/year

• Elderly 70 % > 50 years old
• Surgery 50 %
• Mortality 20 %

• Role of cardiac imaging clearly identified in surgical decision-making

Case History

• 62-year old man

• Bentall intervention in 2005 for severe AR on a bicuspid aortic valve + aortic aneurysm

• Hospitalized
  – persisting fever for 3 weeks
  – amoxicilline treatment for one week
  – normal clinical examination

• WBC 13500 leuco / ml, CRP 185 mg/l

• Negative blood cultures
TTE / TEE

- no evidence of abscess
- no regurgitation
- mobile mass 8 mm
- no prosthesis dysfunction
Cerebral MRI
Summary

• Major Duke criteria: vegetation
• Minor Duke criteria
  – Valve prosthesis
  – Fever
  – + 2 small asymptomatic strokes

• After cerebral MRI
  possible IE → definite IE
Radionuclide Labelled Leucocytes
Diagnosis of Endocarditis
Diagnosis of Endocarditis

Diagnostic features of infective endocarditis

- Persistent bacteremia
- Predisposing heart disease
- Vascular phenomena
- Active endocardial pathology
Diagnosis of Endocarditis

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Diagnostic features of infective endocarditis

- Persistent bacteremia
- Predisposing heart disease
- Vascular phenomena
- Active endocardial pathology
Cardiac echo
Cardiac echo

- Diagnostic of infectious anatomic lesions
- Consequences of these lesions on
  - Valve function
  - Cardiac chambers
  - Pulmonary artery pressures
Endocardial Involvement

• **Major Duke criteria:**
  • New regurgitation murmur

• **Echocardiography**
  – Vegetation (presence, size, mobility)
  – Abscess (frequency PVE>>NVE; Aortic position >> Mitral)
  – New dehiscence on a prosthetic valve

• **Improved sensitivity of TEE vs. TTE**
  – Native valve    70% → >90%
  – Prosthetic valve 50% → >90%

• The diagnostic value of TEE should be interpreted according to patient characteristics and the probability of endocarditis
An isolated periprosthetic regurgitation has a low positive predictive value for the diagnosis of IE

<table>
<thead>
<tr>
<th>Anatomic and echo definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgery / Necropsy</td>
</tr>
<tr>
<td>---------------------</td>
</tr>
<tr>
<td><strong>Vegetation</strong></td>
</tr>
<tr>
<td><strong>Abscess</strong></td>
</tr>
<tr>
<td><strong>Pseudoaneurysm</strong></td>
</tr>
<tr>
<td><strong>Perforation</strong></td>
</tr>
<tr>
<td><strong>Fistula</strong></td>
</tr>
<tr>
<td><strong>Valve aneurysm</strong></td>
</tr>
<tr>
<td><strong>Dehiscence of a prosthetic valve</strong></td>
</tr>
</tbody>
</table>

**Eur Heart J 2015**
An isolated periprosthetic regurgitation has a low positive predictive value for the diagnosis of IE
Echo and Cardiac chambers

• Even in case of severe regurgitation
  – Acute regurgitations in IE → limited or absent left ventricular enlargement
  – Severe acute regurgitations → rapid increase
    • In filling pressures
    • In systolic pulmonary artery pressures
      (Doppler analysis of tricuspid regurgitant flow)
Echo and embolic risk assessment

Three distinct predictors:

- *Microorganism*: *S. aureus*
- IE location: Mitral valve IE
- Vegetation length > 10 mm


### Chirurgie valvulaire _ Indications 2015

**Table 22** Indications and timing of surgery in left-sided valve infective endocarditis (native valve endocarditis and prosthetic valve endocarditis)

<table>
<thead>
<tr>
<th>Indications for surgery</th>
<th>Timing</th>
<th>Class</th>
<th>Level</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Heart failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic or mitral NVE or PVE with severe acute regurgitation, obstruction or fistula causing refractory pulmonary oedema or cardiogenic shock</td>
<td>Emergency</td>
<td>I</td>
<td>B</td>
<td>111,115, 213,216</td>
</tr>
<tr>
<td>Aortic or mitral NVE or PVE with severe regurgitation or obstruction causing symptoms of HF or echocardiographic signs of poor haemodynamic tolerance</td>
<td>Urgent</td>
<td>I</td>
<td>B</td>
<td>37,115, 209,216, 220,221</td>
</tr>
<tr>
<td>2. Uncontrolled infection (abscess, false aneurysm, fistula, enlarging vegetation)</td>
<td>Urgent</td>
<td>I</td>
<td>B</td>
<td>37,209, 216</td>
</tr>
<tr>
<td>Infection caused by fungi or multiresistant organisms</td>
<td>Urgent/elective</td>
<td>I</td>
<td>C</td>
<td>123</td>
</tr>
<tr>
<td>Persisting positive blood cultures despite appropriate antibiotic therapy and adequate control of septic metastatic foci</td>
<td>Urgent</td>
<td>IIa</td>
<td>B</td>
<td>9,58,72, 113,222</td>
</tr>
<tr>
<td>PVE caused by staphylococci or non-HACEK gram-negative bacteria</td>
<td>Urgent/elective</td>
<td>IIa</td>
<td>C</td>
<td>9</td>
</tr>
<tr>
<td>3. Prevention of embolism</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aortic or mitral NVE or PVE with persistent vegetations &gt; 10 mm after one or more embolic episode despite appropriate antibiotic therapy</td>
<td>Urgent</td>
<td>I</td>
<td>B</td>
<td>113,222</td>
</tr>
<tr>
<td>Aortic or mitral NVE with vegetations &gt; 10 mm, associated with severe valve stenosis or regurgitation, and low operative risk</td>
<td>Urgent</td>
<td>IIa</td>
<td>B</td>
<td>9</td>
</tr>
<tr>
<td>Aortic or mitral NVE or PVE with isolated very large vegetations (&gt; 30 mm)</td>
<td>Urgent</td>
<td>IIa</td>
<td>B</td>
<td>113</td>
</tr>
<tr>
<td>Aortic or mitral NVE or PVE with isolated large vegetations (&gt; 15 mm) and no other indication for surgery</td>
<td>Urgent</td>
<td>IIb</td>
<td>C</td>
<td>113</td>
</tr>
</tbody>
</table>
Discrepancies TTE / TEE

• 10 patients / 105 with suspected endocarditis
  – Intermediate probability with TTE
  – 7 reclassified at high probability after TEE

• False positives with TTE
  – 8 patients
  – non-specific valvular thickening

• Increased diagnostic value with TEE if:
  – Intermediate probability after TTE
  – Sub-optimal imaging with TTE
  – Heart valve prosthesis

→ no contribution of TEE if low probability
Prosthetic Endocarditis

Limitations of Echocardiography

• Shadowing: attenuation of ultrasound by prosthetic material → false -

• Image artifacts → false -, false +

• Aortic prostheses
  – Posterior part poorly visualised in TTE
  – Anterior part poorly visualised in TEE

• Other artifacts (sutures ..)

➢ Importance of high resolution (TEE)
Indications for echocardiography

Clinical suspicion of IE

Transthoracic echocardiography

- Prosthetic valve or Intracardiac device
- Poor quality TTE
- Positive
- Negative

If initial TEE is negative but persistent suspicion of IE: repeat TEE within 7-10 days

Eur Heart J 2015
# Diagnosis

## Imaging techniques

### Echocardiography

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>Class</th>
<th>Level</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Diagnosis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• TTE is recommended as the first-line imaging modality in suspected IE.</td>
<td>I</td>
<td>B</td>
<td>64,65</td>
</tr>
<tr>
<td>• TOE is recommended in all patients with clinical suspicion of IE and a negative or non-diagnostic TTE.</td>
<td>I</td>
<td>B</td>
<td>64,68-71</td>
</tr>
<tr>
<td>• TOE is recommended in patients with clinical suspicion of IE, when a prosthetic heart valve or an intracardiac device is present.</td>
<td>I</td>
<td>B</td>
<td>64,71</td>
</tr>
<tr>
<td>• Repeat TTE and/or TOE within 5–7 days is recommended in case of initially negative examination when clinical suspicion of IE remains high.</td>
<td>I</td>
<td>C</td>
<td></td>
</tr>
<tr>
<td>• Echocardiography should be considered in Staphylococcus aureus bacteraemia.</td>
<td>IIa</td>
<td>B</td>
<td>66,67</td>
</tr>
</tbody>
</table>

## B. Follow-up under medical therapy

- Repeat TTE and/or TOE are recommended as soon as a new complication of IE is suspected (new murmur, embolism, persisting fever, HF, abscess, atrioventricular block)...

## C. Intraoperative echocardiography

- Intraoperative echocardiography is recommended in all cases of IE requiring surgery...

## D. Following completion of therapy

- TTE is recommended at completion of antibiotic therapy for evaluation of cardiac and valve morphology and function...
Cardiac multislice computed tomography (MSCT)
MSCT

- Mainly used to analyze perivalvular lesions
  - abscesses, fistulae and pseudoaneurysms
- May complete TEE to assess
  - the topography and extension of abscesses, fistulae and pseudoaneurysms.
- Sensitivity and specificity of MSCT:
  > 95% as compared with surgical findings
MSCT

• **Aortic prosthetic tubes:**
  – Superior to TTE and TEE to diagnose abscesses and/or pseudoaneurysms around.

• **Coronary MSCT**
  – To assess coronary anatomy
  – Mainly considered in pts at low risk of coronary artery disease, due to its high negative predictive value.
Multislice Computed Tomography in Infective Endocarditis

Comparison With Transesophageal Echocardiography and Intraoperative Findings

Gudrun M. Feuchtner, MD, PD,§ Paul Stolzmann, MD,§ Wolfgang Dichtl, MD, PhD, PD,† Thomas Scherl, MD,§ Johannes Bonatti, MD, FECTS,‡ Hans Schell, MD,§ Silvana Mueller, MD, André Plass, MD, Ludwig Mueller, MD, Thomas Bartel, MD, PD,† Florian Wolf, MD,¶ Hatem Alkadhi, MD, PD§

Innsbruck and Vienna, Austria; and Zurich, Switzerland

37 patients consécutifs suspects cliniquement d’EI
TEE et 64 coupes TDM
29 pts avec EI certaines

Comparaison ETO:
Sensibilité: 97%, spécificité: 88%, VPP: 97%, VPN 88%
Concordance interobservateur: 0.84
37 patients consécutifs suspects cliniquement d’EI
TEE et 64 coupes TDM
29 pts avec EI certaines

Comparaison ETO:
Sensibilité: 97%, spécificité: 88%, VPP: 97%, VPN 88%
Concordance interobservateurs: 0.84

Comparaison chirurgie:
Végétation: Sensibilité: 96%, spécificité: 97%, VPP: 97%, VPN 97%
Abcès: Sensibilité: 100%, spécificité: 100%, VPP: 100%, VPN 100%

Mobilité végétation correctement évaluée
Ne diagnostique pas les perforations
Meilleur évaluation de l’étendue des abcès perivalvulaires
Végétation mobile

Abcès

ETO: Abcès

Moins bonne visualisation de l’abcès à l’ETO
Multislice Computed Tomography in Infective Endocarditis

Comparison With Transesophageal Echocardiography and Intraoperative Findings
Nuclear Imaging

[18F]FDG PET/CT
Nuclear Imaging
[18F]FDG PET/CT

• **18F-FDG PET/CT:**
  – Reveal glucose consuming cells: tumoral, inflammation..
  – widely used in oncology for staging and evaluation of treatment response
• Introduced more recently for imaging of infection
• Gram positive bacteremia: cost-effective method for detection of metastatic infection
• High physiological cardiac and cerebral 18F-FDG uptake: unsuitable for detecting cardiac and cerebral infectious lesions?
Nuclear Imaging
[18F]FDG PET/CT

• Suppression of Cardiac $^{18}$F-FDG uptake
  – Carbohydrate-restricted diet
  – Patient fasts for at least 12 hours
• Improvement of images using correction for attenuation
• Semi-quantitative analysis of the intensity of FDG uptake
  – maximal standardized uptake value ($SUV_{max}$)
  – valve-to-background ratio: valve $SUV_{max}$ / atrial blood $SUV_{max}$
18FDG PET/CT

1. High sensitivity
2. Absolute quantification

Nguyen et al., Am J Physiol 1990
“True” whole-body acquisition

Oncology-derived field of acquisition:
skull base to upper thighs
Brain imaging

Trans Arterial Valve Implantation
Mycotic aneurysms
Portal of entry

- Recurrent chills, fever, and positive blood cultures (*E. faecalis*)
- Suspicion of aortic prosthetic valve infection
Diagnostic of valvular involvement
### Patients with **definite IE**

<table>
<thead>
<tr>
<th>Clinical situations</th>
<th>Total Nb pts Prosthetic V/PM/native V</th>
<th>Definite EI / total</th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV False +</th>
<th>NPV False -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Riet 2010 *</td>
<td>Definite IE 25 pts 10/0/15</td>
<td>all</td>
<td>12% (3/25)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Kestler M 2014</td>
<td>Definite IE 47pts 15/11/24</td>
<td>all</td>
<td>9.5% (4/47)</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

0/24 (0%) native valve

* NO carbohydrate-restricted diet
## Diagnostic of valvular involvement

### Patients with suspected IE

<table>
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<tr>
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<th>specificity</th>
<th>PPV False +</th>
<th>NPV False -</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Kouijzer 2013</strong></td>
<td>Gram + bacteremia</td>
<td>72 pts 6/5 61</td>
<td>18/72</td>
<td>39% (7/18)</td>
<td>93%</td>
<td>64% 36%</td>
</tr>
<tr>
<td></td>
<td>Prosthetic valve AND Fever or crp &gt; 10 mg, or bacteremia or + serology or echo pos</td>
<td>72pts 72 0/0</td>
<td>30/72</td>
<td>73% (22/30)</td>
<td>80%</td>
<td>85% 15%</td>
</tr>
</tbody>
</table>

* NO carbohydrate-restricted diet
SUV$_{\text{max}}$ value to improve PET diagnosis performance

Results of the Prosthetic Valve SUV$_{\text{max}}$ and Prosthetic Valve-to-Background SUV$_{\text{max}}$ Ratio According to the Final Diagnosis

The SUV$_{\text{max}}$ was significantly higher in patients with definite PVE in comparison with the 2 other groups (A), whereas the prosthetic valve-to-background SUV$_{\text{max}}$ ratio was not significantly higher (B). *p < 0.05. Abbreviations as in Figures 1 and 2.

L. Saby JACC 2013
False positive results in patients with valvular prosthesis

Subject of concern?
18F-FDG uptake pattern in non-infected prosthetic heart valves

• Bichat Hospital PET/CT database (Jan-Dec 2013)

• Inclusion criteria:
  Prosthetic heart valve
  – biological and/or mechanical
  – aortic and/or mitral positions

• Exclusion criteria:
  – Infection (bacteremia)
  – Antibiotic regimen: 2 weeks before / 6 weeks after PET/CT
Absence of uptake on the PV

Myocardial uptake / Absence of uptake on the PV

Non infected prosthesis

Intense / Homogeneous uptake on the PV
Results: patients & valves

- **Patients**
  - 51 patients with **54 prosthetic valves**
  - Sex: male 29 (57%)
  - Age: mean 66±15 years [range: 25 – 85]

- **Cardiac valve type**
  - biological (n=32) – mechanical (n=22) prosthesis

- **Indication**
  - Oncology (n=26); Inflammatory syndrome (n=15); Vasculitis (n=10)

- **Time interval between valve implantation and PET/CT**
  - Median: 2.7 years [9 days – 25 years]
  - <2 months: 12 patients
Perivalvular uptake in No-IE patients

• Visual analysis of perivalvular uptake
  - Uptake:
    - AC: n=50 / 54 (93%), Homogeneous in all

• Quantitative analysis (SUV-V)
  - Mechanical: 4.4±1.5
  - Biological: 3.4±0.9 (p=0.01)

SUV: standardized uptake value
Perivalvular uptake

Uptake according to the indications

- **Visual analysis of perivalvular uptake**
  - Uptake:
    - AC: \( n=50 /54(93\%) \), Homogeneous in all

- **Quantitative analysis (SUV-V)**
  - Mechanical: \( 4.4 \pm 1.5 \)
  - Biological: \( 3.4 \pm 0.9 \) \((p=0.01)\)

SUV: standardized uptake value
Perivalvular uptake in pts with valvular prosthesis IE versus NON-IE

L. Saby JACC 2013
Perivalvular uptake in NON-IE patients

According to time from implantation

All patients (n=51)

R = -0.07 ; p = 0.60

Uptake is not different
Absence of uptake on the PV

Myocardial uptake / Absence of uptake on the PV

Intense / Homogeneous uptake on the PV

Non infected prosthesis
Absence of uptake on the PV

Myocardial uptake / Absence of uptake on the PV

Intense / Homogeneous uptake on the PV

Intense / Heterogeneous uptake on the PV in IE pts

Non infected prosthesis

Heterogeneity rather than intensity of the uptake to distinguish infected from non-infected prosthesis

Infected prosthesis
Incremental value of iodure CT scan
Improving the Diagnosis of Infective Endocarditis in Prosthetic Valves and Intracardiac Devices With $^{18}$F-Fluordeoxyglucose Positron Emission Tomography/Computed Tomography Angiography
Initial Results at an Infective Endocarditis Referral Center

María N. Pizzi, MD; Albert Roque, MD; Nuria Fernández-Hidalgo, MD, PhD;

Figure 1. Flowchart of patient progress through the study. CT indicates computed tomography; CTA, computed tomography angiography; HR, heart rate; IE, infective endocarditis; NECT, nonenhanced computed tomography; and PET, $^{18}$F-fluordeoxyglucose positron emission tomography.
Diagnosis of peripheral complications
## Diagnosis of peripheral complications

### Patients with **definite IE**

<table>
<thead>
<tr>
<th>Clinical situations</th>
<th>Total Nb pts</th>
<th>Prosthetic/PM/native V</th>
<th>Definite IE / total</th>
<th>Peripheral localisations</th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Van Riet 2010 **</td>
<td>25 pts</td>
<td>10/0/15</td>
<td>25/25</td>
<td>11/25 (44%)</td>
<td>100%</td>
<td>91%</td>
<td>91%</td>
<td>9%</td>
</tr>
<tr>
<td>Kestler M 2014</td>
<td>47pts</td>
<td>15/11/24</td>
<td>47/47</td>
<td>31/47 (66%)</td>
<td>100%</td>
<td>80%</td>
<td>90%</td>
<td>10%</td>
</tr>
</tbody>
</table>

Cf Article Asmar 2014  
Pizi Circulation 2015 detection of 14 cases (15%) of peripheral emboli, 10 of which asymptomatic

Kestler M: Cases/controls study; peripheral localisations detected in **57.4%** of cases (TEP) vs **18%** in control (without TEP) p=0.0001
## Diagnosis of peripheral complications

### Patients with suspected IE

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<th>NPV False -</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vos 2010 **</td>
<td>Gram pos bacteremia *</td>
<td>115 pts</td>
<td>21/115</td>
<td>11/21 (50%) 50% silent</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Saby 2013</td>
<td>Prosthetic valve AND Fever or crp &gt; 10 mg, or bacteremia or positive serology or echo pos</td>
<td>72 pts 72/0/0</td>
<td>30/72</td>
<td>8/30 (25%)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>?</td>
</tr>
<tr>
<td>Bonfiglioli 2013</td>
<td>Clinical suspicion</td>
<td>71 pts 38/0/33</td>
<td>29/71</td>
<td>17/29 (?) 74%</td>
<td>94%</td>
<td>94%</td>
<td>94%</td>
<td>94%</td>
</tr>
</tbody>
</table>

*Pts with at least one risk factor for complicated bacteremia (community acquisition, signs of infection more than 48 h before initiation of appropriate treatment, fever more than 72 h after initiation of appropriate treatment, and positive blood cultures more than 48 h after initiation of appropriate treatment*
Impact on Duke classification
Positron Emission Tomography/Computed Tomography for Diagnosis of Prosthetic Valve Endocarditis

Increased Valvular $^{18}$F-Fluorodeoxyglucose Uptake as a Novel Major Criterion

Ludivine Saby, MD,* Olivia Laas, MD,† Gilbert Habib, MD,* Serge Cammilleri, MD, PhD,† Julien Mancini, MD, PhD,‡ Laetitia Tessonnier, MD,† Jean-Paul Casalta, MD,§ Frederique Gouriet, MD, PhD,§ Alberto Riberi, MD,|| Jean-Francois Avierinos, MD,* Frederic Collart, MD,|| Olivier Mundler, MD, PhD,† Didier Raoult, MD, PhD,§ Franck Thuny, MD, PhD*§¶

Figure 1 Study Flow Chart

Of the 91 patients with suspicion of prosthetic valve endocarditis (PVE), 72 were included and classified according to the final diagnosis determined using the modified Duke criteria established after a 3-month follow-up. PET/CT = positron emission tomography/computed tomography.

Table 5 Diagnostic Value of the Modified Duke Criteria at Admission With (Duke-PET/CT) and Without the Implementation of the PET/CT Results

<table>
<thead>
<tr>
<th></th>
<th>Definite PVE</th>
<th>Possible PVE</th>
<th>Rejected PVE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duke</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definite PVE</td>
<td>21 (70)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Possible PVE</td>
<td>8 (27)</td>
<td>22 (100)</td>
<td>10 (50)</td>
</tr>
<tr>
<td>Rejected PVE</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>10 (50)</td>
</tr>
</tbody>
</table>

30 definite IE

Values are n (% of each final diagnosis).
Abbreviations as in Tables 1 and 2.
Duke classification upgraded due to
- cardiac uptake in  7/8
- peripheric uptake in  1/8

30 definite IE
Interobserver variability

Subject of concern ?
Interobserver variability

- Harmonization strategy conducted before a multicenter protocol on PET
- 17 clinical cases of IE suspected pts (PET images)
- Read by 8 nuclear medicine specialists originating in 8 different hospitals
- Interpretation: IE probable; doubtful, excluded
Interobserver variability

- Harmonization strategy conducted before a multicenter protocol on PET
- 17 clinical cases of IE suspected pts (PET images)
- Read by 8 nuclear medicine specialists originating in 8 different hospitals
- Interpretation: IE probable; doubtful, excluded
- **Agreement among the 8 readers:**
  - 3/17 clinical cases: total agreement
  - 14/17 clinical cases: disagreement
    - Minor (excluded versus doubtful or doubtful versus definite) n=4
    - Major (at least 2 readers with extreme disagreement (excluded versus definite)) n=10

Training session
CIED infection diagnosis

CIED: cardiovascular intra cardiac electronic device
CIED infection diagnosis

• 42 pts suspected of CIED infection

CIED: cardiovascular intra cardiac electronic device
CIED infection diagnosis

• 42 pts suspected of CIED infection

<table>
<thead>
<tr>
<th></th>
<th>Confirmed infection</th>
<th>18F-FDG PET/CT uptake</th>
<th>SUVmax</th>
<th>ETOVegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A Suspected CIED infection N=42</td>
<td>35 (83%)</td>
<td>32/42 1 false pos 3 false neg</td>
<td>4.4 ± 1.6</td>
<td>12/42</td>
</tr>
</tbody>
</table>

CIED: cardiovascular intra cardiac electronic device

Sarrazin JF et al. JACC 2012
CIED infection diagnosis

- 42 pts suspected of CIED infection

<table>
<thead>
<tr>
<th>Group A</th>
<th>Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspected CIED infection</td>
<td>Controls</td>
</tr>
<tr>
<td>N=42</td>
<td>6 W post implantation</td>
</tr>
<tr>
<td></td>
<td>N=12</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Confirmed infection</th>
<th>35 (83%)</th>
<th>0</th>
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<table>
<thead>
<tr>
<th>18F-FDG PET/CT uptake</th>
<th>32/42</th>
<th>No or mild uptake</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 false pos</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 false neg</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SUVmax</th>
<th>4.4 ± 1.6</th>
<th>1.2 ± 1.4</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>ETOvegation</th>
<th>12/42</th>
<th>0</th>
</tr>
</thead>
</table>

CIED: cardiovascular intra cardiac electronic device

Sarrazin JF et al. JACC 2012

<table>
<thead>
<tr>
<th>sensitivity</th>
<th>specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.886</td>
<td>0.857</td>
</tr>
</tbody>
</table>
CIED infection diagnosis

- 42 pts suspected of CIED infection

<table>
<thead>
<tr>
<th>Group A Suspected CIED infection N=42</th>
<th>Group B Controls 6 W post implantation N=12</th>
<th>Group C Controls &gt; 6 Mths post implantation N=12</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0</td>
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<table>
<thead>
<tr>
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<th>specificity</th>
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<tbody>
<tr>
<td>88 %</td>
<td>86 %</td>
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CIED: cardiovascular intra cardiac electronic device

Sarrazin JF et al. JACC 2012
CIED infection diagnosis

• 27 pts suspected of CIED infection

CIED: cardiovascular intra cardiac electronic device
CIED infection diagnosis

- 27 pts suspected of CIED infection

<table>
<thead>
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<th></th>
<th>Group A</th>
<th></th>
<th>Group B</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CIED infection</td>
<td>N=11</td>
<td>No CIED infection</td>
<td>N=16</td>
</tr>
<tr>
<td>18F-FDG PET/CT uptake</td>
<td>7/11</td>
<td>4 false neg</td>
<td>3/16</td>
<td>2 false pos</td>
</tr>
<tr>
<td>ETO vegetation</td>
<td>?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>sensitivity</th>
<th>specificity</th>
<th>PPV</th>
<th>NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>18F-FDG PET/CT uptake</td>
<td>63%</td>
<td>86%</td>
<td>77%</td>
<td>76%</td>
</tr>
</tbody>
</table>

CIED: cardiovascular intra cardiac electronic device

Nuclear Imaging
Labelled leukocytes
Radiolabelled leukocytes: methods

Blood sample 40-50 ml

Plasma Platelets Leukocytes

RBC

99mTc-HMPAO

PMNs + plasma

Gradient centrifugation
Added Value of $^{99m}$Tc-HMPAO–Labeled Leukocyte SPECT/CT in the Characterization and Management of Patients with Infectious Endocarditis

- 51 pts with suspected IE (prosthetic IE)
- Final Diagnosis of EI
- 51/131 (39%) patients
- Sensitivity: 90%
- Specificity: 100%

Results of $^{99m}$Tc-HMPAO-WBC Scintigraphy in the 51 Patients with Final Diagnosis of IE, Stratified According to Duke Criteria

<table>
<thead>
<tr>
<th>Duke criterion</th>
<th>Positive results</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cardiac only</td>
<td>Cardiac and extracardiac</td>
<td>Extracardiac only</td>
<td>Negative results</td>
<td></td>
</tr>
<tr>
<td>Definite IE (n = 24)</td>
<td>9</td>
<td>11*</td>
<td>0</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Possible IE (n = 25)</td>
<td>13</td>
<td>11†</td>
<td>1*</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Rejected IE (n = 2)</td>
<td>1</td>
<td>1*</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

*Septic embolism consequent to IE.
†Eight patients with septic embolism, 1 with vasculitis, and 2 false-positive scans due to vertebral crush and metastasis from prostate cancer.
Labelled leukocytes and infective endocarditis

- 42 pts with suspected prosthetic IE (valve prosthesis / aortic tube / patch)
- Non-conclusive TTE/TEE in all cases
- 14 (33%) positive uptake (intense in 9, mild in 5)

(Hyafil et al. Eur Heart J Cardiovasc Imaging 2013;34:1597-606)
Nuclear Imaging
[18F]FDG PET/CT versus Labelled leukocytes
FDG PET vs. WBC SPECT

- Single-centre prospective study (Bichat Hospital, Paris)
- **39 patients** (males: 22), aged 62±17 years
- Suspected of **prosthetic valve endocarditis** (PVE)
- Delay between FDG PET and WBC SPECT: 7±7 days
- Diagnosis after ≥3-months follow-up (Duke-Li):
  - Definite, n=14 (36%)
  - Possible, n=3
  - Rejected, n=21

## FDG PET vs. WBC SPECT

<table>
<thead>
<tr>
<th></th>
<th>Final diagnosis after ≥3 mo follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Definite (n=14)</td>
</tr>
<tr>
<td>FDG PET +</td>
<td>13 (93)</td>
</tr>
<tr>
<td>FDG PET -</td>
<td>1</td>
</tr>
<tr>
<td>WBC SPECT +</td>
<td>9 (64)</td>
</tr>
<tr>
<td>WBC SPECT -</td>
<td>5</td>
</tr>
</tbody>
</table>

- FDG PET false positive <2 months after valve implantation (n=6)
- WBC SPECT false negative (n=5): Coxiella (n=2), Candida (n=1), no abscess (n=2)

FDG PET: Higher sensitivity  
WBC SPECT: Higher specificity
Perspectives: FDG PET

Remains to be determined
- Cost-effectiveness
- Diagnostic value, impact on patients’ management and outcomes in multicentre trials

• NCT01916005 - F. Thuny, Marseille, France
Diagnostic Value of 18F-fluorodeoxyglucose Positron Emission Tomography/Computed Tomography in Prosthetic Valve Endocarditis.

• TEPvENDO - X. Duval, Bichat, Paris, France
Diagnostic and therapeutic impact of FDG PET at the acute phase of infective endocarditis (8 centres).
Perspectives: new imaging agents

Leukocytes labelled with positron emitters (PET)

- Requires a long half-life isotope ($^{64}$Cu $\approx$ 12.7 hours)
- *Bhargava et al. NMB 2009*

$^{99m}$Tc-Annexin A5

- Target: vegetations (phosphatidylserine expressed by activated platelets)
- No physiological uptake in heart and brain

AnnIE
Sponsor: Inserm
Proof-of-concept study
Patients suspected of IE
Kick off: 2015

*Rouzet et al., Circulation 2008*
*Benali et al., Mol Imaging 2014*
SPECT/CT à la $^{99m}$Tc-Annexine (Etude AnnIE)
Endocardite streptococcique sur bioprothèse aortique
Cerebral complications of IE
Cerebral complications of IE

Symptomatic neurological complications
• 9 to 40 % according to series
• associated with poor prognosis

Detection of asymptomatic cerebral lesions
• Help to establish IE diagnosis
• Better assessment of
  – Embolic risk
  – Surgery indications
  – IE prognosis (short and long term prognosis)
• Initiation of specific treatment of cerebral complications
• Improvement of IE prognosis ?
Cerebral complications of IE

Which cerebral complications could be detected?

**Vascular**
- Ischemic events
  - Stroke
  - Transient ischemic attack (TIA)
  - Silent embolism
- Hemorrhagic events
  - H. stroke
  - Microbleeds
  - Sub arachnoidal H
- Aneurysms

**Infectious**
- Meningitis
- Abscess
Cerebral complications of IE

Which imaging to detect cerebral complications?

Cerebral
- CT scan
- CT scan with angiography
- MRI
- MRI with angiography
- Conventional 4 vessel angiography
Findings of systematic cerebral imaging studies
Findings of systematic cerebral imaging studies

– CT scanner
Neurological complications incidence
Systematic cerebral CT

453 consecutive definite IE patients; 2 French referral centers;
January 1990 to March 2005

Systematic Cerebral CT

Cerebrovascular Complications
n=109 24%

Silent Cerebral Embolism
n=17 4%

Ischemic Stroke
n=50 11%

TIAs
n=30 7%

Primary Intracerebral Hemorrhage
n=12 2.6%

Findings of systematic cerebral imaging studies

– CT scanner
– CT scanner with angiography
Systematic cerebral CT with angiography

81 consecutive definite IE patients;
Systematic Cerebral CT with angiography

Cerebrovascular Complications
n=51 63%

Symptomatic Stroke
n=34

Silent emboli
n=17 (21%)
Systematic cerebral CT with angiography

81 consecutive definite IE patients;

Systematic Cerebral CT with angiography

Cerebrovascular Complications

n=51 63%

Symptomatic Stroke n=34

ICMA n=11

Silent emboli n=17

(21%)

ICMA n=15

21% out of 81
36% of 47 asymptomatic pts

ICMA: intracerebral mycotic aneurysm

N= 26 32%
Findings of systematic cerebral imaging studies

- CT scanner
- CT scanner with angiography
- MRI with angiography
130 patients admitted to Bichat Claude Bernard Hospital, Paris
(June 2005-Sept 2008)
with systematic cerebral MRI with MRangiography

Neurological Complications
n=106
82%

Large Ischemic lesions
n=33
(24 silent)
25%

Small Ischemic lesions
n=60
(45 silent)
46%

Large Intracerebral Hemorrhage
n=10
(8 silent)
8%

Microbleed
n=74
(66 silent)
58%

Sub. Arachnoidal Hemorrhage
n=11
(11 silent)
8%

Aneurysms
n=10
(10 silent)
8%

Abscess
n=8
(7 silent)
6%

Symptomatic lesions
12%

Effects of Early Cerebral Magnetic Resonance Imaging on Clinical Decisions in Infective Endocarditis, the IMAGE study

Xavier Duval, Bernard Iung, Isabelle Klein, Eric Brochet, Gabriel Thabut, Florence Arnoult, Laurent Lepage, Jean Pierre Laissy, Michel Wolff and Catherine Leport and the IMAGE study group.
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Symptomatic lesions 12%

25% 46% 8% 58% 8% 8% 6%
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n=11 (11 silent)

Aneurysms
n=10 (10 silent)

Abscess
n=8 (7 silent)

Symptomatic lesions 12%
Findings of systematic cerebral imaging studies

- CT scanner
- CT scanner with angiography
- MRI with angiography
- Conventional 4 vessel angiography
Conventional cerebral angiography

- No prospective studies with systematic angiography

- Retrospective study of 168 pts who underwent cerebral angiography:
  - 15/168 pts (8.9%) had mycotic aneurysms;
    - 93.3% (14/15) of those had CNS hemorrhage
    - 66.7% (10/15) had acute ischemic findings

- Retrospective study of 151 pts who underwent cerebral angiography before surgery:
  - 7/151 (4.6%) had mycotic aneurysm
  - absence of intracranial bleed on MRI: (NPV) of 0.98

Symptomatic and Asymptomatic Neurologic Events
Prospective Series with Systematic Imaging

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>Imaging</th>
<th>Symptomatic Events (%)</th>
<th>Asymptomatic Embolism (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thuny et al.</td>
<td>453</td>
<td>CT</td>
<td>22</td>
<td>4</td>
</tr>
<tr>
<td>Meshaal et al</td>
<td>81</td>
<td>CT + angio</td>
<td>43</td>
<td>21</td>
</tr>
<tr>
<td>Snygg-Martin et al.</td>
<td>49</td>
<td>MRI</td>
<td>35</td>
<td>30</td>
</tr>
<tr>
<td>Cooper et al.</td>
<td>40</td>
<td>MRI</td>
<td>32</td>
<td>48</td>
</tr>
<tr>
<td>Duval et al.</td>
<td>130</td>
<td>MRI</td>
<td>12</td>
<td>47</td>
</tr>
</tbody>
</table>

Meshaal et al Plos one 2015
Diagnostic impact of detected lesions
**Exta cardiac manifestations of IE count as a minor modified-Duke criteria**

**Duke minor**

**Vascular phenomena**

<table>
<thead>
<tr>
<th>MINOR CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Predisposition:</strong> predisposing heart condition, injection drug use</td>
</tr>
<tr>
<td><strong>Fever:</strong> temperature &gt; 38°C</td>
</tr>
<tr>
<td><strong>Vascular phenomena:</strong> major arterial emboli, septic pulmonary infarcts, mycotic aneurysm, intracranial haemorrhage, conjunctival haemorrhages, Janeway lesions</td>
</tr>
<tr>
<td><strong>Immunologic phenomena:</strong> glomerulonephritis, Osler’s nodes, Roth’s spots, rheumatoid factor</td>
</tr>
<tr>
<td><strong>Microbiological evidence:</strong> positive blood culture but does not meet a major criterion or serological evidence of active infection with organism consistent with IE</td>
</tr>
</tbody>
</table>

**Diagnosis of IE is definite in the presence of**
- 2 major criteria, or
- 1 major and 3 minor criteria, or
- 5 minor criteria

**Diagnosis of IE is possible in the presence of**
- 1 major and 1 minor criteria, or
- 3 minor criteria
Diagnostic impact of detected lesions

– May account for a minor criteria
  arterial emboli, mycotic aneurysm, intracranial haemorrhage

– Only assessed for MRI in the IMAGE study
• Impact of cerebral lesion detection on IE diagnosis
  – Modified-Duke classification upgraded in 32%
Prognostic impact of asymptomatic cerebral lesions
Cerebral ischemic spot risk factors

- Risk factors for Symptomatic cerebral emboli
  - Vegetation length > 10 mm
  - Staphylococcus aureus IE
  - History of emboli …,
Cerebral ischemic spot risk factors

- Risk factors for Symptomatic cerebral emboli
  - Vegetation length > 10 mm
  - Staphylococcus aureus IE
  - History of emboli …,

- Risk factors for Asymptomatic cerebral emboli detected by MRI

<table>
<thead>
<tr>
<th>Lesion Characteristic</th>
<th>All Patients (n = 130), n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischemic lesion</td>
<td>68 (52)</td>
</tr>
<tr>
<td>Large systematized ischemic lesion*</td>
<td>33 (25)</td>
</tr>
<tr>
<td>Small ischemic lesion</td>
<td>60 (46)</td>
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Determinants of asymptomatic ischemic lesions

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>IC 95%</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Vegetation length</td>
<td>1.1 per mm</td>
<td>1.03-1.16</td>
<td>p=0.003</td>
</tr>
<tr>
<td>- Staph aureus IE</td>
<td>2.65</td>
<td>1.01-6.96</td>
<td>p=0.05</td>
</tr>
</tbody>
</table>

Cerebral ischemic spot risk factors

- Risk factors for Symptomatic cerebral emboli
  - Vegetation length > 10 mm
  - Staphylococcus aureus IE
  - History of emboli …,

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<td></td>
<td></td>
</tr>
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Determinants of asymptomatic ischemic lesions

- Vegetation length
  - 1.1 per mm
  - IC 95%

- Staph aureus IE
  - 2.65
  - IC 95%

Cerebral ischemic spot risk factors

- Risk factors for Symptomatic cerebral emboli
  - Vegetation length > 10 mm

Same risk factors for symptomatic and asymptomatic emboli

Ischemic spot may be a risk factor for symptomatic emboli?
Currently no arguments presented in the literature

• Impact of ischemic spot on short-term prognosis?

Difficult to assess as their discovery may have induced a modification of IE treatment
Cerebral ischemic spot and IE Long-term prognosis?
Cerebral ischemic spot and IE
Long-term prognosis

• Outside the IE context
  – Cerebral ischemic spots associated with lower cognition and higher odds of dementia

Microinfarct Pathology, Dementia, and Cognitive Systems

Zoe Arvanitakis, MD, MS; Sue E. Leurgans, PhD; Lisa L. Barnes, PhD; David A. Bennett, MD; Julie A. Schneider, MD, MS

Methods—Four hundred twenty-five subjects enrolled in the Religious Orders Study underwent annual clinical evaluations, including 19 neuropsychological tests and assessment for dementia, and brain autopsy (39% men; mean age at death, 87; Mini-Mental State Examination score, 21). Neuropathologic examination documented the presence, number, and location of chronic microinfarcts on 6-μm hematoxylin–eosin-stained sections from cortical and subcortical regions. Multiple regression analyses adjusted for age at death, sex, education, macroscopic infarcts, Alzheimer disease pathology, and Lewy bodies.

Conclusions—Microinfarcts are common, and persons with multiple cortical microinfarcts have higher odds of dementia. Microinfarcts are also associated with lower cognition, specifically perceptual speed and semantic and episodic memory. (Stroke. 2011;42:722-727.)
Cerebral ischemic spot and IE
Long-term prognosis

• Outside the IE context
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*Conclusions*—Microinfarcts are common, and persons with multiple cortical microinfarcts have higher odds of dementia. Microinfarcts are also associated with lower cognition, specifically perceptual speed and semantic and episodic memory. *(Stroke. 2011;42:722-727.)*

• Impact unknown in IE patients
Microbleeds and IE?
Cerebral microbleeds
Case-control study

OR increase with the increase in the number of microbleeds suggesting a causal relationship

Klein I Stroke 2009
Cerebral microbleed risk factors

• Risk factors for microbleeds
  – not reported in the literature
  – in the IMAGE study

<table>
<thead>
<tr>
<th>Lesion Characteristic</th>
<th>All Patients (n = 130), n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hemorrhagic lesion</td>
<td>79 (61)</td>
</tr>
<tr>
<td>Intraparenchymal hemorrhagic lesion</td>
<td>10 (8)</td>
</tr>
<tr>
<td>Microhemorrhage</td>
<td>74 (58)</td>
</tr>
<tr>
<td>Subarachnoidal hemorrhage</td>
<td>11 (8)</td>
</tr>
</tbody>
</table>

Determinants of microhemorrhages

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>IC 95%</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prosthetic valve</td>
<td>8.01</td>
<td>2.58-24.90</td>
<td>P&lt;0.001</td>
</tr>
<tr>
<td>Anticoagulation therapy</td>
<td></td>
<td></td>
<td>p=0.67</td>
</tr>
</tbody>
</table>

Microbleeds: 86.8% of pts with prosthetic IE vs 47.6% with native valve IE (P<0.001)

Microbleed and ischemic lesions: distinct mechanisms

Cerebral microbleeds and IE short-term prognosis

• In individuals without endocarditis
  – Associated with cerebral hemorrhagic risk

• In IE patients
  
  **Japanese study**
  – **26 patients** with cerebral MRI
  – Cerebral microbleeds: 54%
    – **Intracerebral hemorrhage** occurred in 8 patients within 3 months (31%)
    – Number of microbleeds associated with ICH

  **Determinants of impending ICH**
  
<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>IC 95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preceding ICH</td>
<td>40.0</td>
<td>2.5–2,870</td>
</tr>
<tr>
<td>CMB ≥ 1</td>
<td>34.0</td>
<td>1.3–17000</td>
</tr>
<tr>
<td>CMB ≥ 2</td>
<td>42.1</td>
<td></td>
</tr>
<tr>
<td>CMB ≥ 3</td>
<td>70.1</td>
<td></td>
</tr>
</tbody>
</table>

Shuhei Okazaki, Cerebrovasc Dis 2011;32:483–488
Cerebral microbleeds and IE Long-term prognosis

- **Outside the IE context, associated with**
  - Dementia
  - Cognitive decline
  - Chronic cerebrovascular diseases
  - Subarachnoidal hemorrhages

- **Long-term impact Unknown in IE patients**

Lei C; J Neurol Neurosurg Psychiatry. 2013
Cerebral asymptomatic lesions and long-term prognosis

Clinical and MRI follow-up of the IMAGE cohort is ongoing

- Evolution of cerebral lesions diagnosed during the acute phase
- Consequences on neurologic and cognitive status
Therapeutic impact of asymptomatic cerebral lesions
In 29/130 pts (22%): experts modified IE treatment plans based on MRI results

- Modification of anticoagulation level \( n = 6 \)
- Modification of antibiotics \( n = 5 \)
- Modification of surgery plan \( n = 18 \)
  - Surgery date postponed \( 6 \)
  - Surgery date advanced \( 6 \)
  - Type of valvular prosthesis \( 1 \)
  - Reasons for surgery \( 1 \)
  - Cancellation of surgery \( 2 \)
  - Indication for surgery \( 2 \)
- Embolisation of aneurysm \( n = 4 \)

However, it is not clear whether silent neurological complications are associated with a poor prognosis.
Modification of treatment in 21 pts with ICMA (25.6%) (more than one change in 11 pts)

- 15 pts: invasive treatment of ICMA (13 endovasc)
  - No procedure-related complication
- Anticoagulation stopped in 3 pts with prosthetic valve
- Modification of the cardiac surgery type in 17 pts
- Regression of ICMA in 3/11 not treated pts
2015 ESC Guidelines for the management of infective endocarditis

The Task Force for the Management of Infective Endocarditis of the European Society of Cardiology (ESC)

Imaging techniques in IE

Diagnosis
Diagnosis

Imaging techniques

Nuclear imaging
**Table 14**  Definitions of the terms used in the European Society of Cardiology 2015 modified criteria for the diagnosis of infective endocarditis

<table>
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<td>a. Typical microorganisms consistent with IE from 2 separate blood cultures:</td>
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<td>• <em>Viridans streptococci</em>, <em>Streptococcus galolyticus</em> (<em>Streptococcus bovis</em>), HACEK group, <em>Staphylococcus aureus</em>; or</td>
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<td>a. Echocardiogram positive for IE:</td>
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<td>• Abscess, pseudoaneurysm, intracardiac fistula;</td>
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<td>• Valvular perforation or aneurysm;</td>
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<td>• New partial dehiscence of prosthetic valve.</td>
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<td>b. Abnormal activity around the site of prosthetic valve implantation detected by ¹⁸F-FDG PET/CT (only if the prosthesis was implanted for &gt;3 months) or radiolabelled leukocytes SPECT/CT.</td>
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<tr>
<td>c. Definite paravalvular lesions by cardiac CT.</td>
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2. Imaging positive for IE
a. Echocardiogram positive for IE:
• Vegetation;
• Abscess, pseudoaneurysm, intracardiac fistula;
• Valvular perforation or aneurysm;
• New partial dehiscence of prosthetic valve.

b. Abnormal activity around the site of prosthetic valve implantation detected by 18F-FDG PET/CT (only if the prosthesis was implanted for >3 months) or radiolabelled leukocytes SPECT/CT.
c. Definite paravalvular lesions by cardiac CT.

More study is needed to define the utility of 18F-fluorodeoxyglucose positron emission tomography/CT in the diagnosis and management of IE.
Conclusions (I)

• The diagnosis of infective endocarditis relies on the conjunction of different criteria which all have limitations.

• Imaging plays a key role in the diagnosis of endocardial involvement and vascular phenomena.

• Indications and pitfalls of echocardiography are well addressed in guidelines.

• Radionuclide imaging (PET/CT, labelled leucocytes) has an incremental diagnostic value in difficult cases (prosthetic endocarditis).
Conclusions (II)

• Systematic imaging reveals a high incidence of asymptomatic embolic events during acute endocarditis.

• The detection of silent cerebral embolism using cerebral MRI has an impact on diagnosis and therapeutic management.

• Need for further analyses of:
  – Usefulness of systematic multimodality imaging
  – Prognostic assessment of asymptomatic embolism
  – Indications for radionuclide imaging
Acknowledgments

- Dr F. Rouzet, Nuclear imaging Bichat, Paris
- Pr B. Iung, Cardiology, Bichat, Paris
- Dr I. Klein, Radiology, Bichat, Paris
Neurological complications incidence
Systematic MRI

• Cooper Ha (Circulation 2009)
  – 40 definite IE pts with MRI:
  – 19 asymptomatic ischemic lesions: 48%

• Snygg-Martin U (CID 2008)
  – 60 definite IE patients with MRI
  – Asymptomatic lesions : 30%