

Outils diagnostiques d'imagerie dans l'endocardite, hors écho cœur : "PET-scan, IRM cérébrale, angio-cérébrale et scanner cardiaque pour tous ?"

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Evolution de l'épidémiologie

- **Incidence annuelle stable depuis 30 ans (30 cas par million d'habitants)**
- **Evolution du profil épidémiologique des patients atteints d'EI :**
 - ↗ âge moyen (58 ans en 1991, 62 ans en 2008)
 - ↗ des EI sans pathologies valvulaires connues
 - ↗ des EI sur valves prothétiques et des infections sur matériel (pacemaker, défibrillateurs)
 - ↗ des patients avec lourdes comorbidités (diabète, hémodialyse...)
 - ↗ des EI liées aux soins

Cohorte EURO-ENDO

Registre Européen
3116 patients, 156 hôpitaux
92% des patients pris en charge dans des centres spécialisés (> 20 EI/an)

Table 1 Patient demographics and clinical characteristics

	Total (n = 3116)	Prosthesis+Repair (n = 939)	Native (n = 1764)	PM/ICD (n = 308)	P-value
Demography					
Age (years)					
N	3116	939	1764	308	
Mean ± SD	59.25 ± 18.03	63.36 ± 16.81	55.61 ± 18.45	66.77 ± 14.11	<0.0001
Median (IQR)	63.0 (46.0–73.0)	67.0 (54.0–75.0)	58.0 (41.0–70.0)	69.0 (60.0–76.0)	<0.0001
Age ≥ 65 years	1443/3116 (46.3%)	538/939 (57.3%)	662/1764 (37.5%)	194/308 (63.0%)	<0.0001
Age ≥ 80 years	375/3116 (12.0%)	141/939 (15.0%)	163/1764 (9.2%)	56/308 (18.2%)	<0.0001
Females (%)	969/3116 (31.1%)	292/939 (31.1%)	553/1764 (31.3%)	86/308 (27.9%)	0.4901

Table 2 In-hospital mortality

	Total (n = 3116)	Prosthesis+Repair (n = 939)	Native (n = 1764)	PM/ICD (n = 308)	P-value
Death	532/3116 (17.1%)	187/939 (19.9%)	286/1764 (16.2%)	47/308 (15.3%)	0.038

Nouvelles recommandations européennes



European Society
of Cardiology

European Heart Journal (2023) 00, 1–95
<https://doi.org/10.1093/eurheartj/ehad193>

ESC GUIDELINES



2023 ESC Guidelines for the management of endocarditis



**Developed by the task force on the management of endocarditis
of the European Society of Cardiology (ESC)**

***Endorsed by the European Association for Cardio-Thoracic Surgery
(EACTS) and the European Association of Nuclear Medicine (EANM)***



AHA Scientific Statement



Infective Endocarditis in Adults: Diagnosis, Antimicrobial Therapy, and Management of Complications **A Scientific Statement for Healthcare Professionals From the American Heart Association**

Endorsed by the Infectious Diseases Society of America

2015

Diagnostic : critères de Duke (re)modifiés ?

ESC 2015

Major criteria

1. Blood cultures positive for IE

- a. Typical microorganisms consistent with IE from 2 separate blood cultures:
 - *Viridans streptococci*, *Streptococcus gallolyticus* (*Streptococcus bovis*), *HACEK* group, *Staphylococcus aureus*; or
 - Community-acquired enterococci, in the absence of a primary focus; or
- b. Microorganisms consistent with IE from persistently positive blood cultures:
 - ≥ 2 positive blood cultures of blood samples drawn >12 h apart; or
 - All of 3 or a majority of ≥ 4 separate cultures of blood (with first and last samples drawn ≥ 1 h apart); or
- c. Single positive blood culture for *Coxiella burnetii* or phase I IgG antibody titre $>1:800$

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 ^{18}F -FDG PET/CT (only if the prosthesis was implanted for >3 months) or radiolabelled leukocytes SPECT/CT.
- c. Definite paravalvular lesions by cardiac CT.

Minor criteria

1. Predisposition such as predisposing heart condition, or injection drug use.
2. Fever defined as temperature $>38^\circ\text{C}$.
3. Vascular phenomena (including those detected by imaging only) major arterial emboli, septic pulmonary infarcts, infectious (mycotic) aneurysm, intracranial haemorrhage, conjunctival haemorrhages, and Janeway's lesions.
4. Immunological phenomena: glomerulonephritis, Osler's nodes, Roth's spots, and rheumatoid factor.
5. Microbiological evidence: positive blood culture but does not meet a major criterion as noted above or serological evidence of active infection with organism consistent with IE.

Certaines :

2 majeurs

1 majeur + 3 mineurs

5 mineurs

Possible :

1 majeur + 1 mineur

3 mineurs

Ne remplace pas le sens clinique

Diagnostic : critères de Duke (re)modifiés ?

ESC 2023

Major criteria

(i) Blood cultures positive for IE

- (a) Typical microorganisms consistent with IE from two separate blood cultures:
Oral streptococci, *Streptococcus gallolyticus* (formerly *S. bovis*), HACEK group, *S. aureus*, *E. faecalis*
- (b) Microorganisms consistent with IE from continuously positive blood cultures:
 - ≥ 2 positive blood cultures of blood samples drawn >12 h apart.
 - All of 3 or a majority of ≥ 4 separate cultures of blood (with first and last samples drawn ≥ 1 h apart).
- (c) Single positive blood culture for *C. burnetii* or phase I IgG antibody titre $>1:800$.

(ii) Imaging positive for IE:

Valvular, perivalvular/periprosthetic and foreign material anatomic and metabolic lesions characteristic of IE detected by any of the following imaging techniques:

- Echocardiography (TTE and TOE).
- Cardiac CT.
- [18F]-FDG-PET/CT(A).
- WBC SPECT/CT.

Nouveautés :

- TEP et scintigraphie en l'absence de prothèse ?
- Absence de délai par rapport à la pose de la prothèse ?

“Therefore, a consensus of experts has concluded that the need for a time interval prior to investigation is questionable but accurate imaging interpretation by proper interpretation criteria is mandatory”

Diagnostic : critères de Duke (re)modifiés ?

ESC 2023

Minor criteria

- (i) Predisposing conditions (i.e. predisposing heart condition at high or intermediate risk of IE or PWIDs)³
- (ii) Fever defined as temperature >38°C
- (iii) Embolic vascular dissemination (including those asymptomatic detected by imaging only):
 - Major systemic and pulmonary emboli/infarcts and abscesses.
 - Haematogenous osteoarticular septic complications (i.e. spondylodiscitis).
 - Mycotic aneurysms.
 - Intracranial ischaemic/haemorrhagic lesions.
 - Conjunctival haemorrhages.
 - Janeway's lesions.
- (IV) Immunological phenomena:
 - Glomerulonephritis.
 - Osler nodes and Roth spots.
 - Rheumatoid factor.
- (V) Microbiological evidence:
 - Positive blood culture but does not meet a major criterion as noted above.
 - Serological evidence of active infection with organism consistent with IE.

Diagnostic : critères de Duke (re)modifiés ?

DUKE-ISCVID

Clinical Infectious Diseases

VIEWPOINTS



OXFORD

The 2023 Duke-International Society for Cardiovascular Infectious Diseases Criteria for Infective Endocarditis: Updating the Modified Duke Criteria

I. MAJOR CRITERIA

B. Imaging Major Criteria

(2) Positron emission computed tomography with 18F-fluorodeoxyglucose ([18F]FDG PET/CT imaging)

Abnormal metabolic activity^k involving a native or prosthetic valve, ascending aortic graft (with concomitant evidence of valve involvement), intracardiac device leads or other prosthetic material^{l,m}

I. MINOR CRITERIA

F. Imaging Criteria

Abnormal metabolic activity as detected by [18F]FDG PET/CT within 3 mo of implantation of prosthetic valve, ascending aortic graft (with concomitant evidence of valve involvement), intracardiac device leads or other prosthetic material

Rôle de l'imagerie en dehors de l'échographie cardiaque

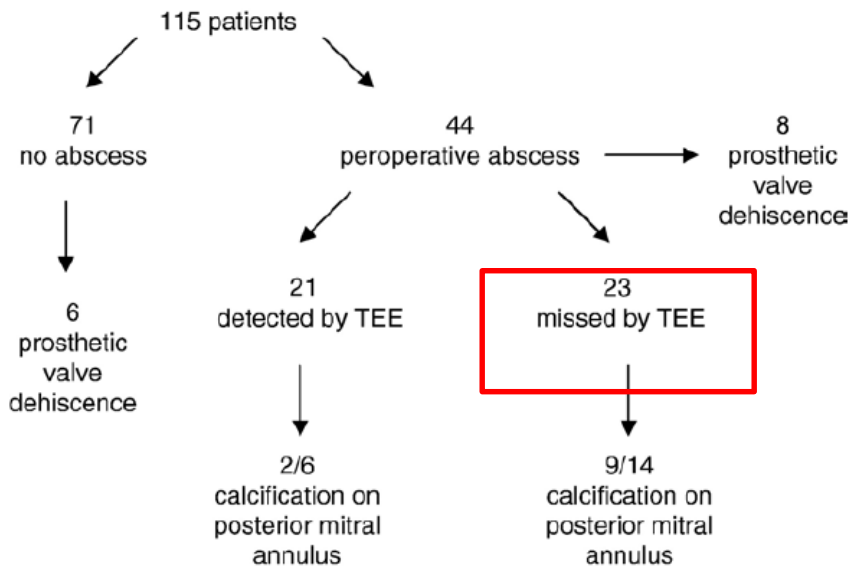


Diagnostic de l'atteinte cardiaque = critère majeur

Diagnostic des atteintes extra cardiaques = critère mineur

Echocardiographie : examen de référence, mais ?

Figure 1



Detection of preoperative versus perioperative abscesses.

- 115 patients avec EI (valve native n=89; valve prothétique n= 26) opérés et ayant eu une ETO pré opératoire

- Comparaison avec les constatations per opératoires

=> **Seulement 48% des abcès détectés en pré opératoire**

=> Difficultés

- Abscès mitral postérieur
- Calcifications mitrales

Apport du TEP TDM : valves prothétiques

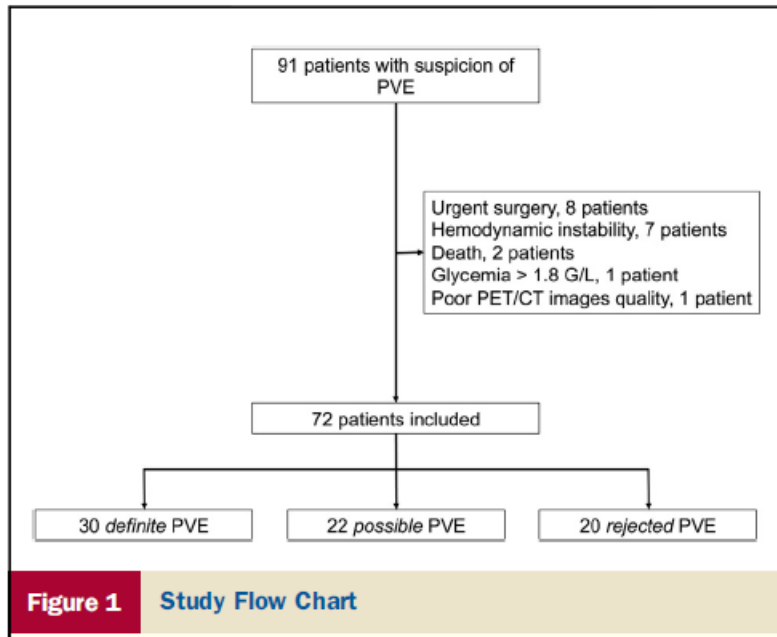


Table 5 Diagnostic Value of the Modified Duke Criteria at Admission With (Duke-PET/CT) and Without the Implementation of the PET/CT Results

	Final Diagnosis		
	Definite PVE	Possible PVE	Rejected PVE
Duke			
Definite PVE	21 (70)	0 (0)	0 (0)
Possible PVE	8 (27)	22 (100)	10 (50)
Rejected PVE	1 (3)	0 (0)	10 (50)
Duke-PET/CT			
Definite PVE	29 (97)	10 (45)	2 (10)
Possible PVE	1 (3)	12 (55)	10 (50)
Rejected PVE	0	0	8 (40)

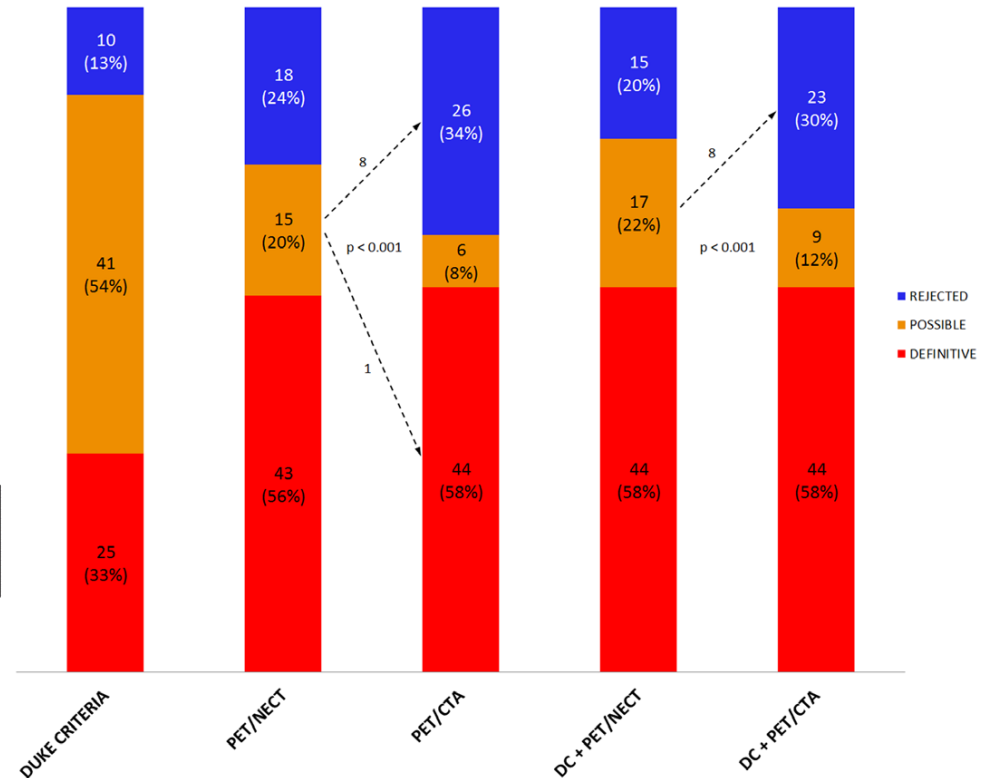
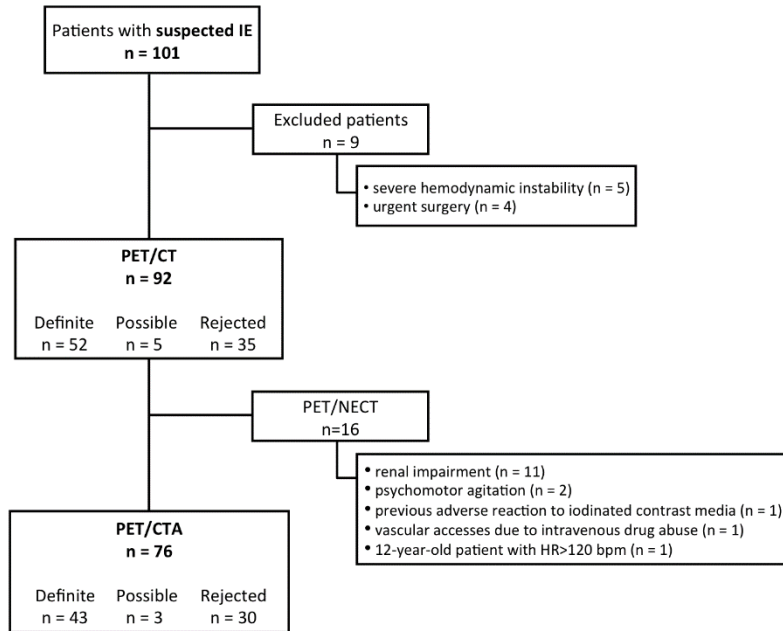
Values are n (% of each final diagnosis).
Abbreviations as in Tables 1 and 2.

72 patients suspicion d'endocardite sur prothèse

Diagnostic définitif après 3 mois de suivi

Duke avec TEP : sensibilité 70% => 97%

Apport du TEP TDM : valves prothétiques

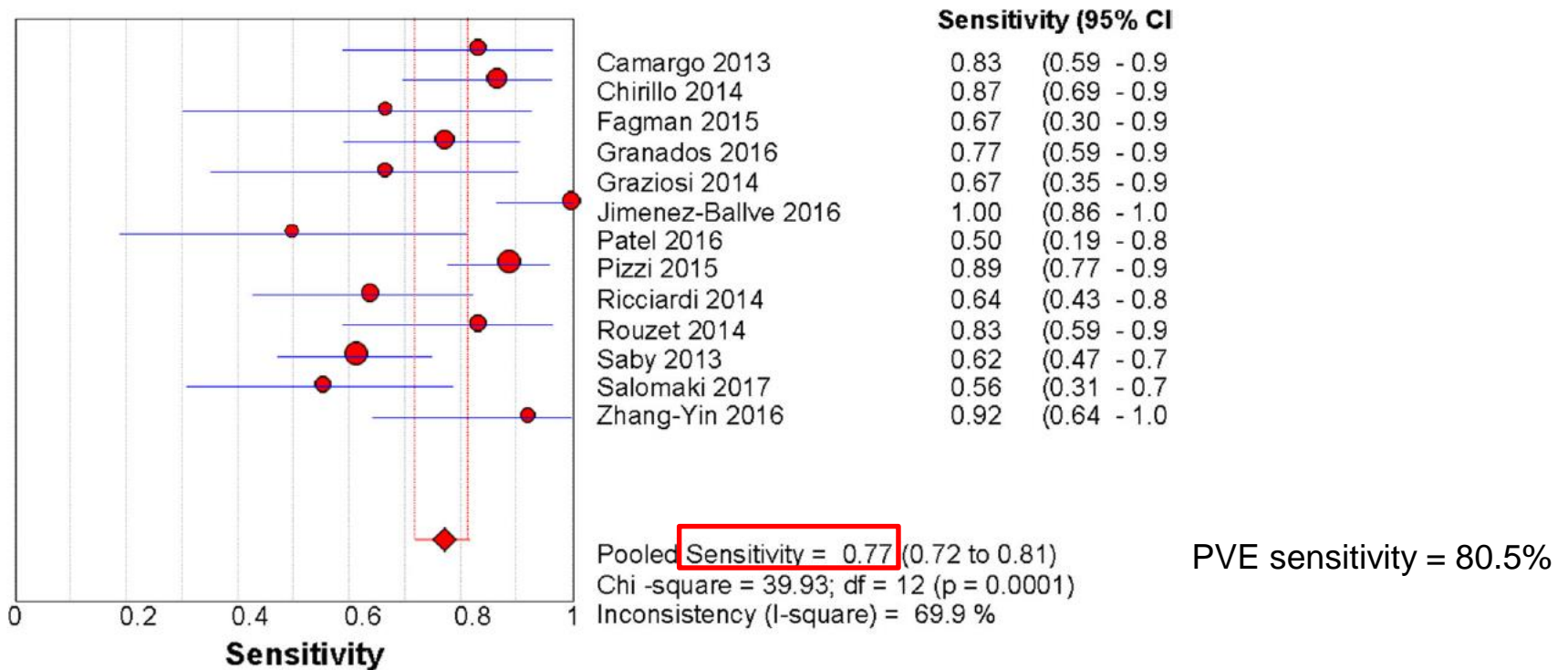


⇒ Use of this technique led to an increase in the sensitivity of the modified DC from 52% to 90.7% and resulted in a conclusive diagnosis in 95% of cases.

⇒ Produit de contraste augmente la spécificité

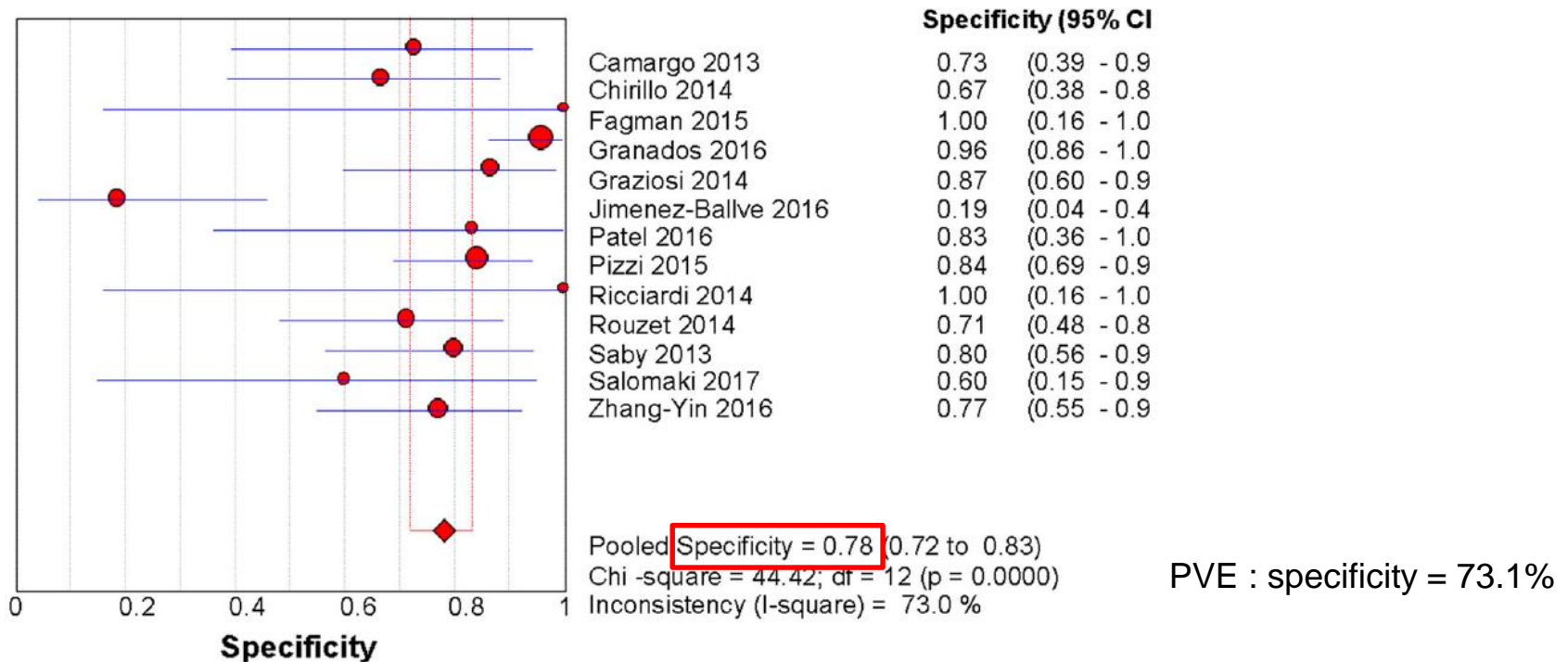
Apport du TEP TDM

Meta-analysis of 18F-FDG PET/CT in the diagnosis of infective endocarditis



Apport du TEP TDM

Meta-analysis of ¹⁸F-FDG PET/CT in the diagnosis of infective endocarditis



Apport du TEP TDM : valves natives ?

Impact of Systematic Whole-body ^{18}F -Fluorodeoxyglucose PET/CT on the Management of Patients Suspected of Infective Endocarditis: The Prospective Multicenter TEPvENDO Study

Clinical Infectious Diseases

MAJOR ARTICLE

140 patients avec suspicion d'EI

70 valves natives (VN), 70 valves prothétiques (VP)

Diagnostic définitif après 6 mois de suivi

Impact du TEP sur le diagnostic : modification de la classification ESC

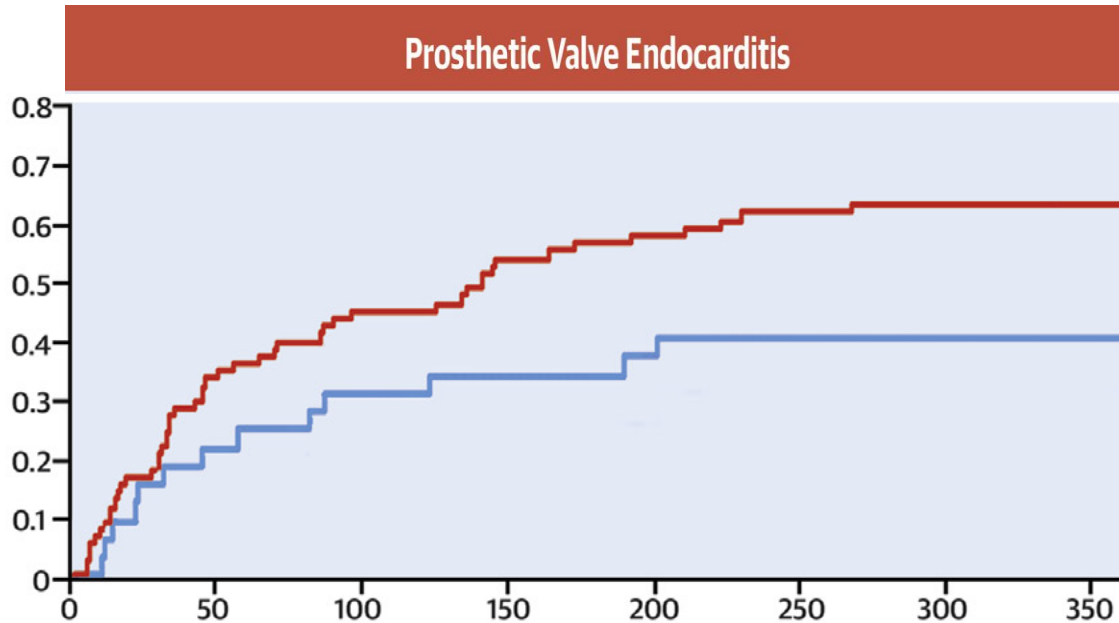
- VN 5,7%
- VP 24,3%

Modification de la prise en charge (ATB ou chir)

- VN 31,4%
- VP 21,4%

=> Détection et caractérisation des **localisations infectieuses extracardiaques**

Apport du TEP TDM : valeur pronostique ?



173 endocardites certaines. VP = 109, VN = 64

Impact pronostique de la fixation au TEP retrouvée uniquement dans le groupe VP

Delay from Hospitalization to Primary Endpoint, Days

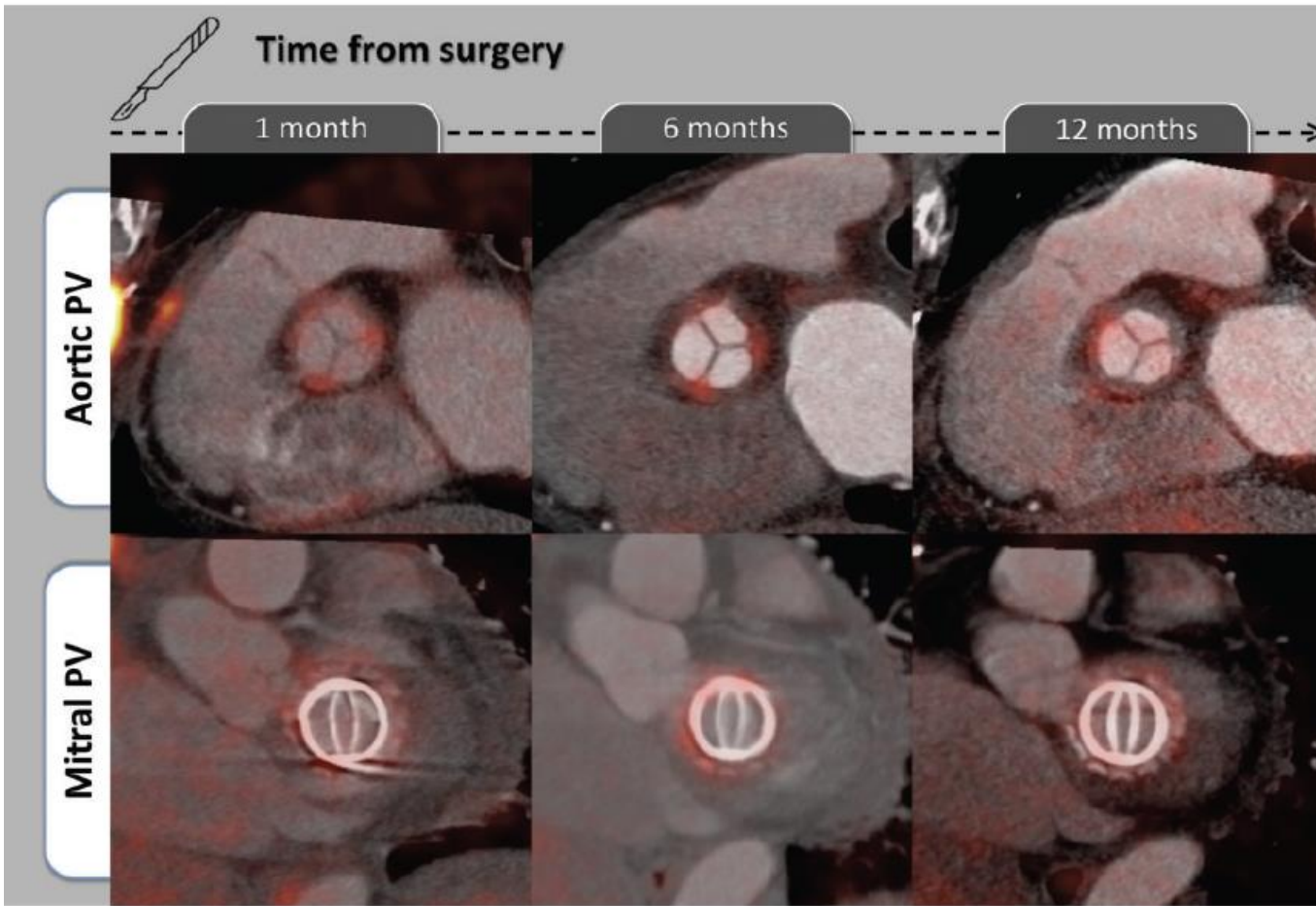
- Negative or Low ¹⁸F-Fluorodeoxyglucose Uptake
- Moderate-to-Intense ¹⁸F-Fluorodeoxyglucose Uptake

Primary Endpoint

- In-hospital death
- Acute cardiac insufficiency
- 1-year death
- Recurrence
- Re-hospitalization
- New embolic event

TEP TDM et délais de la chirurgie

Recommandations ESC 2015 : difficultés d'interprétation dans les 3 mois suivant la chirurgie

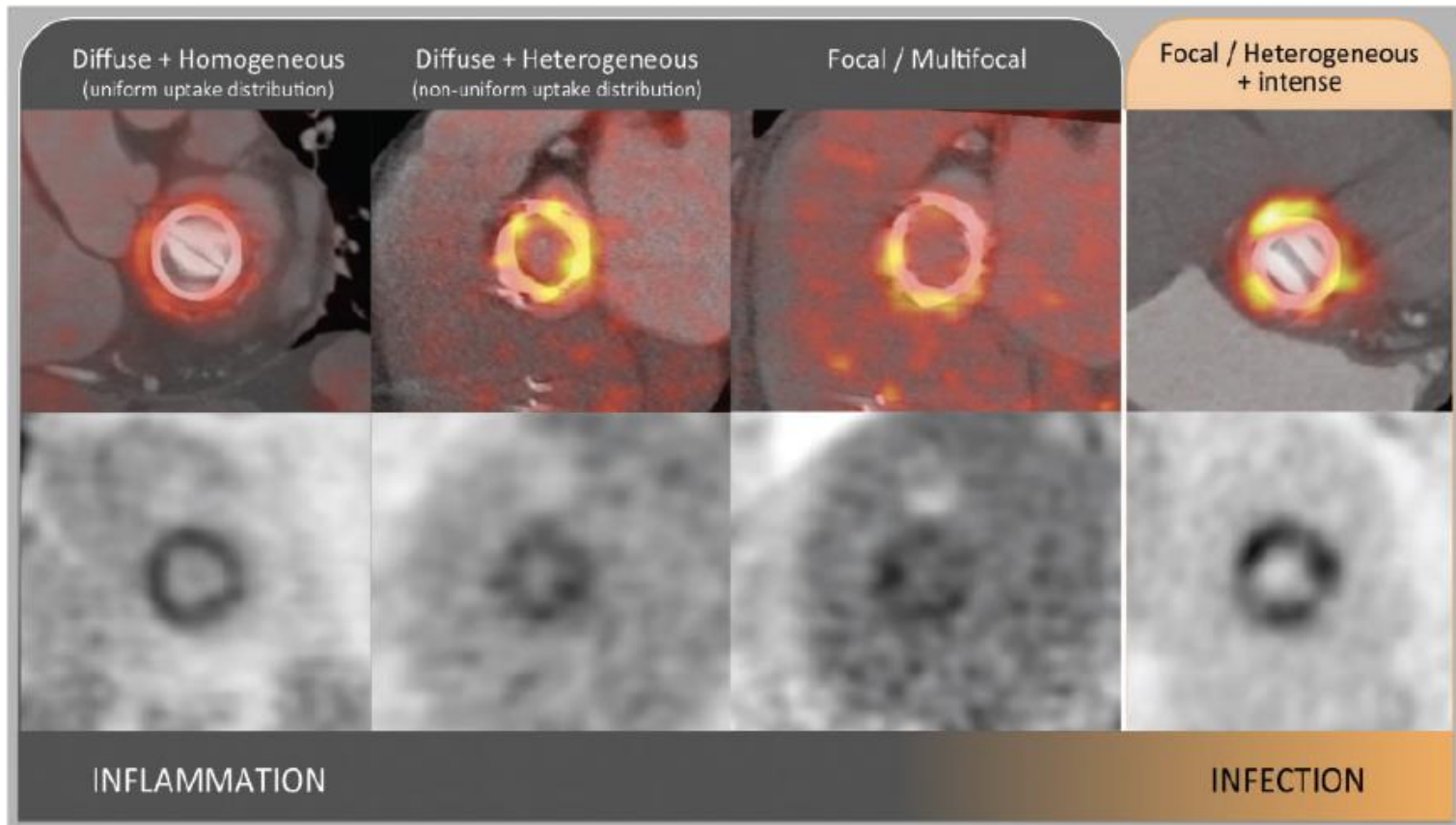


37 patients

TEP scan à M1, M6
et M12 post
implantation

**=> Fixation post
opératoire stable
dans l'année qui suit
la pose de la
prothèse**

TEP TDM et délais de la chirurgie

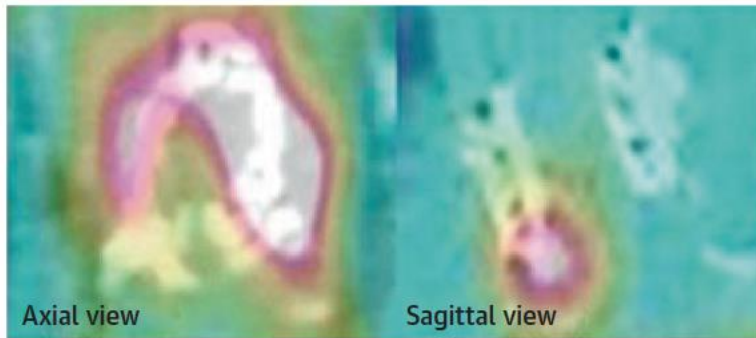


=> L'aspect de la fixation est associée au diagnostic d'EI

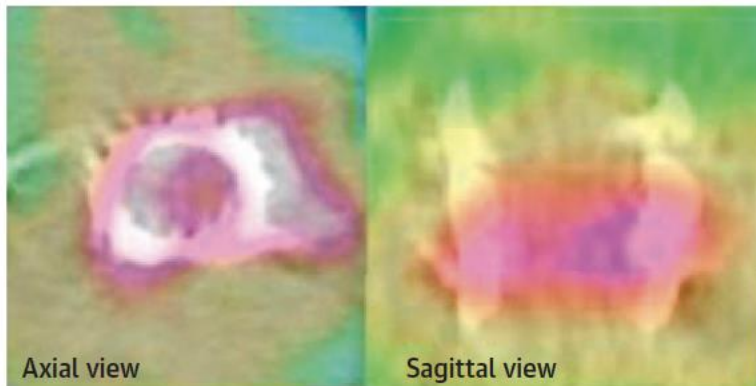
TEP TDM et délais de la chirurgie : TAVI ?

FDG UPTAKE IN CONTROL GROUP

Hemi-circumferential uptake (from 25% to 75%)

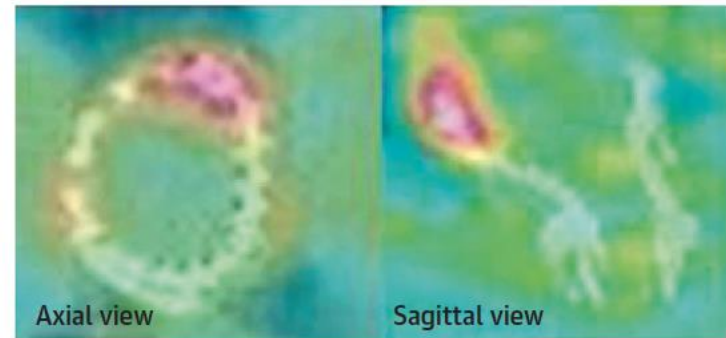


Circumferential uptake (>75%)



FDG UPTAKE IN DEFINITE IE-TAVI GROUP

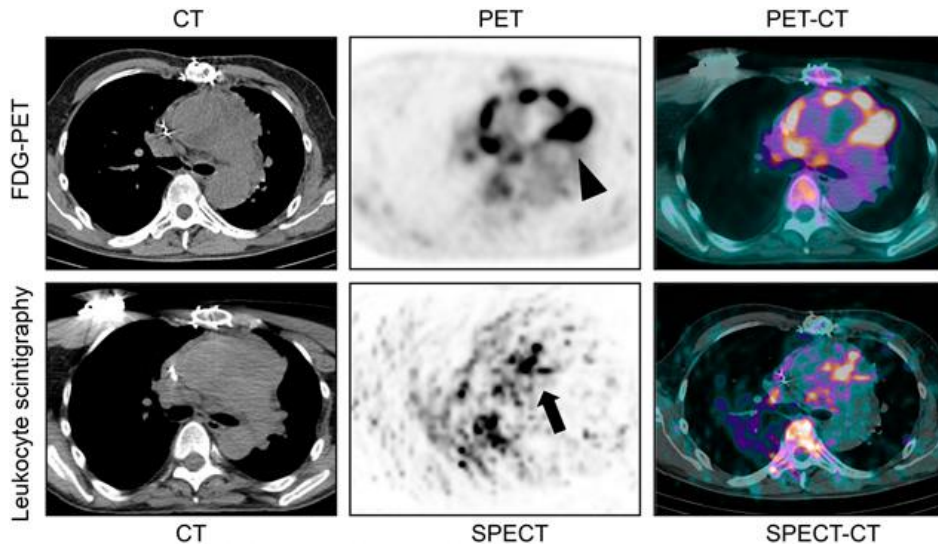
Focal uptake (<25%)



Multifocal uptake



Scintigraphie aux leucocytes marqués

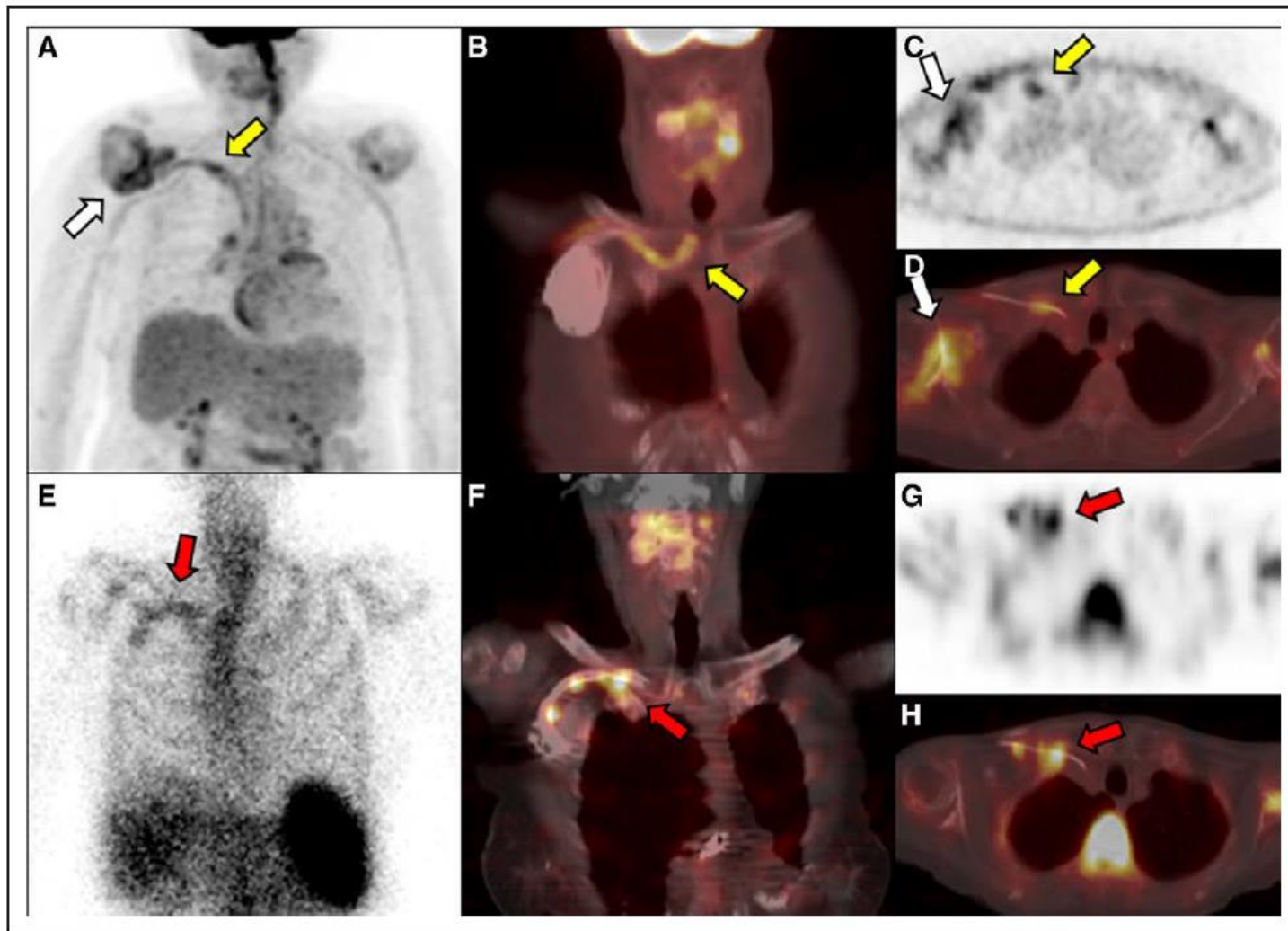


- 39 patients consécutifs Bichat
- Prothèses valvulaires
- Suspicion d'endocardite
- 14 jours à 24 ans après la chirurgie
- 15 jours d'antibiothérapie en moyenne
- **TEP + scinti aux leucos marqués**
- Suivi de 3 mois pour diagnostic définitif

=> 18 diagnostics « redressés »

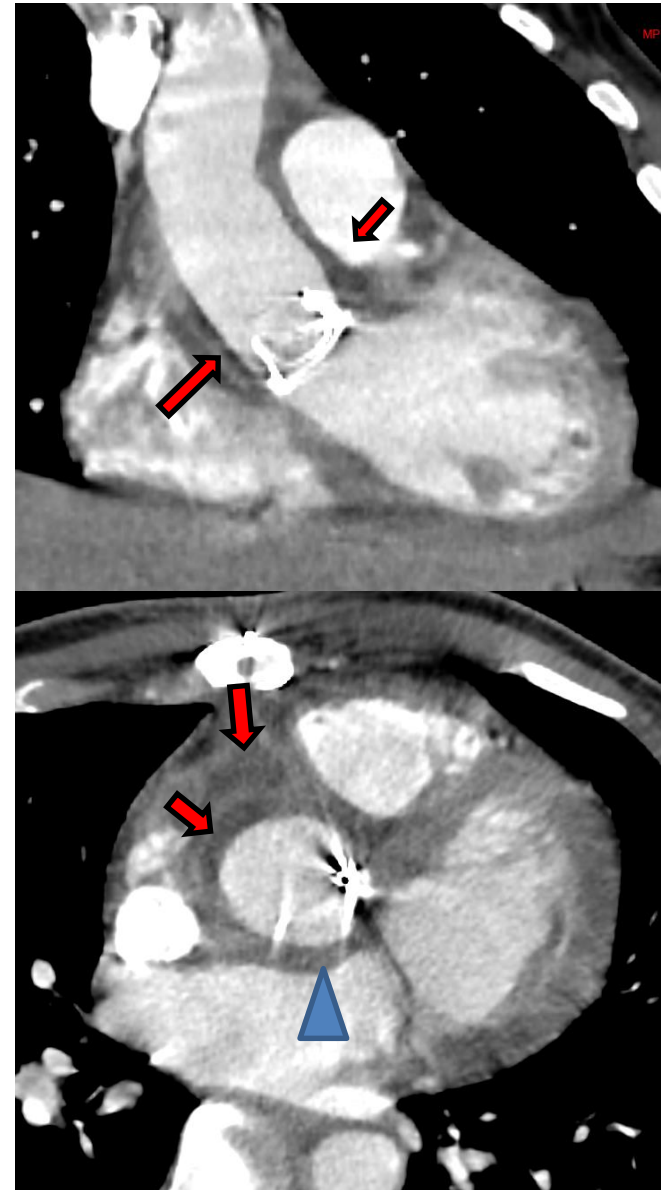
	PET-CT	SPECT-CT
Sensibilité	93%	64%
Spécificité	71%	100%
VPP	68%	100%
VPN	94%	81%

Scintigraphie aux leucocytes marqués: PM/DAI



Scanner cardiaque multicoupe

- Scanner volumique avec synchronisation ECG
- Atteintes péri valvulaires +++
- Complément de l'ETO en cas de prothèses (cônes d'ombres)
- Synchronisation ECG permet de réaliser un coroscanner



Scanner cardiaque multicoupe

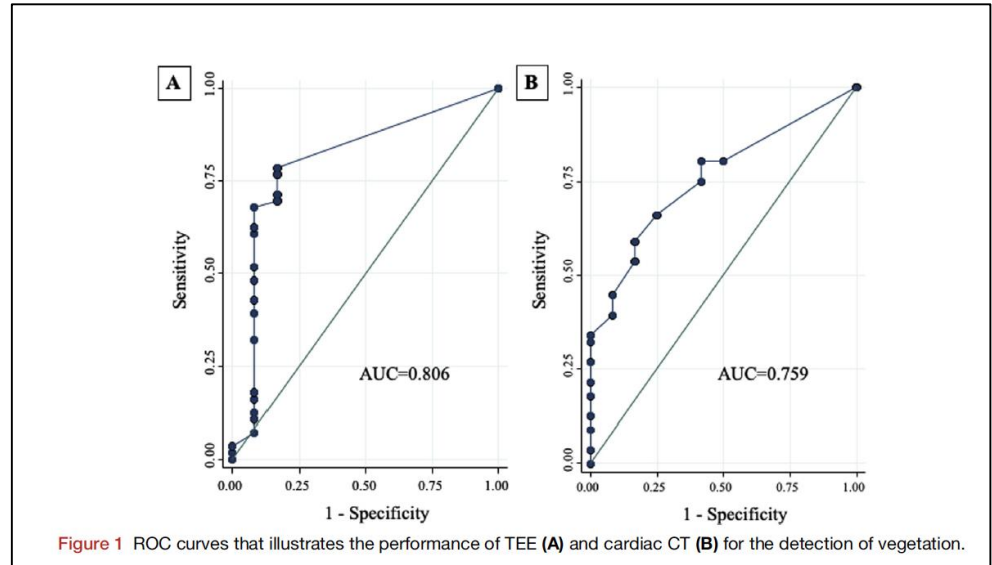
Table 3 Diagnostic Performance of CT

	Percent	95% CI
For the Detection of Vegetations, Paravalvular Abscesses, and Pseudoaneurysms (37 Patients, 73 Valves) in Patients With Possible and Definite IE: Comparison With TEE		
Per-patient-based analysis		
Sensitivity (28/29)	97	82%–100%
Specificity (7/8)	88	47%–100%
Positive predictive value (28/29)	97	82%–100%
Negative predictive value (7/8)	88	47%–100%
Diagnostic accuracy (35/37)	95	82%–100%

Scanner cardiaque multicoupe

- 68 patients opérés du cœur gauche
- ETO avec reconstruction 3D et scanner cardiaque
- Comparaison aux constatations opératoires

=> impact sur la prise en charge ?



HIGHLIGHTS

- TEE performed better than CT for detection of valvular IE-related lesions.
- TEE and CT were ~~similar in the detection of paravalvular IE-related lesions~~. CT > TEE pour pseudo-anévrysmes
- CT may be useful when TEE is equivocal or not feasible in left-side IE.

Rôle de l'imagerie en dehors de l'échographie cardiaque



Diagnostic de l'atteinte cardiaque = critère majeur

Diagnostic des atteintes extra cardiaques = critère mineur

Place de l'IRM cérébrale

Figure 2. Infarcts and microhemorrhages.

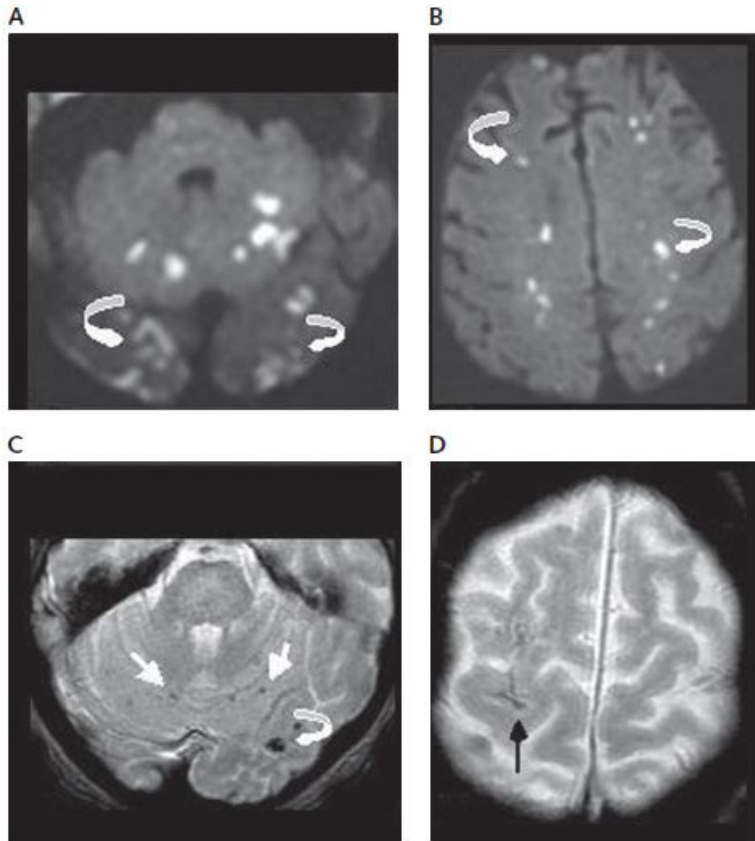


Table 3. Effect of Systematic MRI on Infective Endocarditis Diagnosis*

Diagnosis After MRI	Diagnosis Before MRI†		
	Definite (n = 77)	Possible (n = 50)	Excluded (n = 3)
Definite (n = 91 [101])	77	14 [24]	–
Possible (n = 39 [29])	–	36 [26]	3
Excluded (n = 0)	–	–	0

MRI = magnetic resonance imaging.

* Evaluated through the reclassification of Duke modified criteria in 130 patients. Numbers in square brackets include microhemorrhages as vascular phenomena in the Duke modified classification.

† According to Duke modified classification.

- IRM systématique chez 130 patients suspects d'EI
- 72% valves natives
- 17 cas « reclassés » (sans les micro-saignements)
 - 14 possibles => certaines
 - 3 exclus => possibles

TEP TDM : localisations extra cardiaques

Impact of Systematic Whole-body ^{18}F -Fluorodeoxyglucose PET/CT on the Management of Patients Suspected of Infective Endocarditis: The Prospective Multicenter TEPvENDO Study

Clinical Infectious Diseases

MAJOR ARTICLE

140 patients avec suspicion d'EI

70 valves natives (VN), 70 valves prothétiques (VP)

Diagnostic définitif après 6 mois de suivi

Modification de la classification ESC : impact du TEP sur le diagnostic

- VN 5,7%
- VP 24,3%

Modification de la prise en charge (ATB ou chir)

- VN 31,4%
- VP 21,4%

=> Détection et caractérisation des localisations infectieuses extracardiaques

TEP TDM : anévrismes mycotiques

FIGURE 2 Patient #2

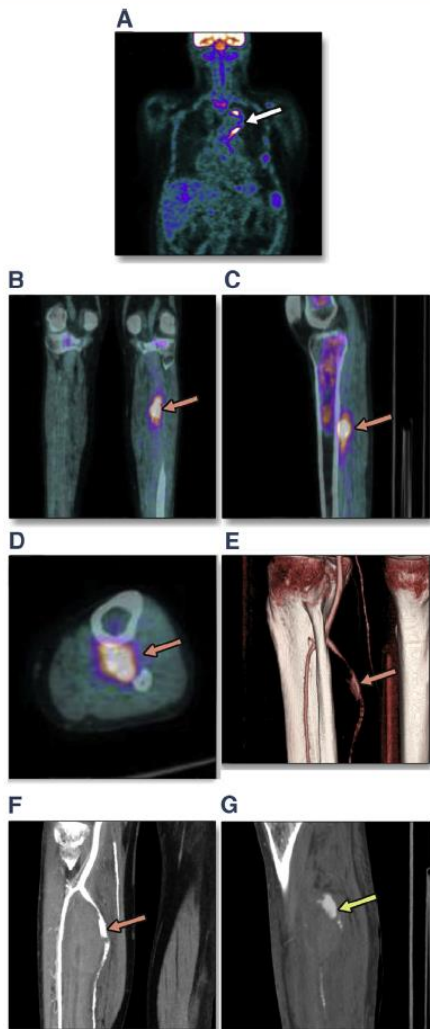


FIGURE 4 Patient #4

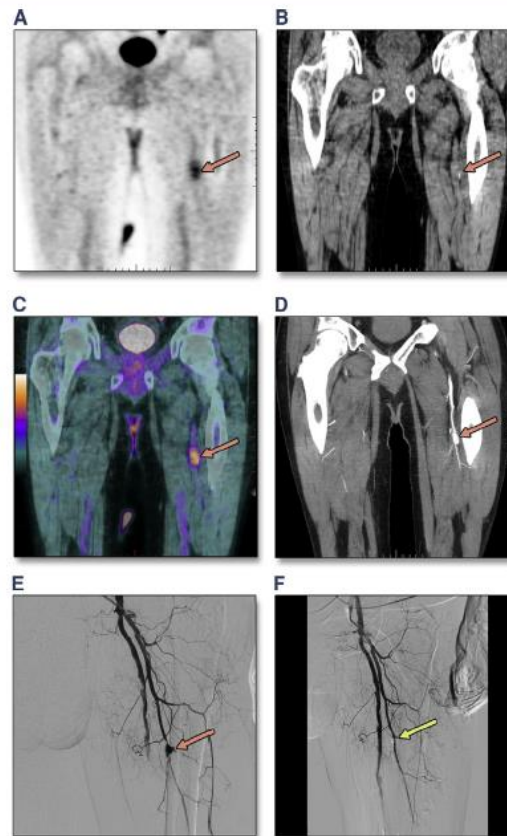
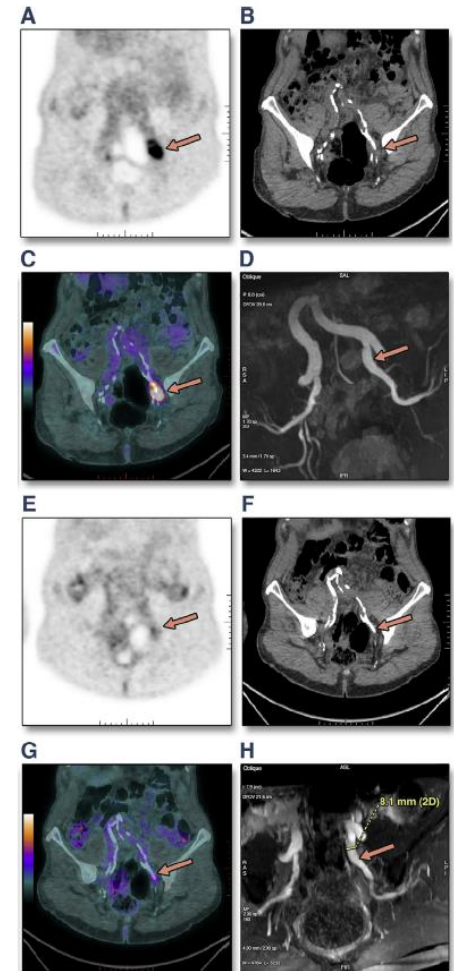


FIGURE 1 Patient #1

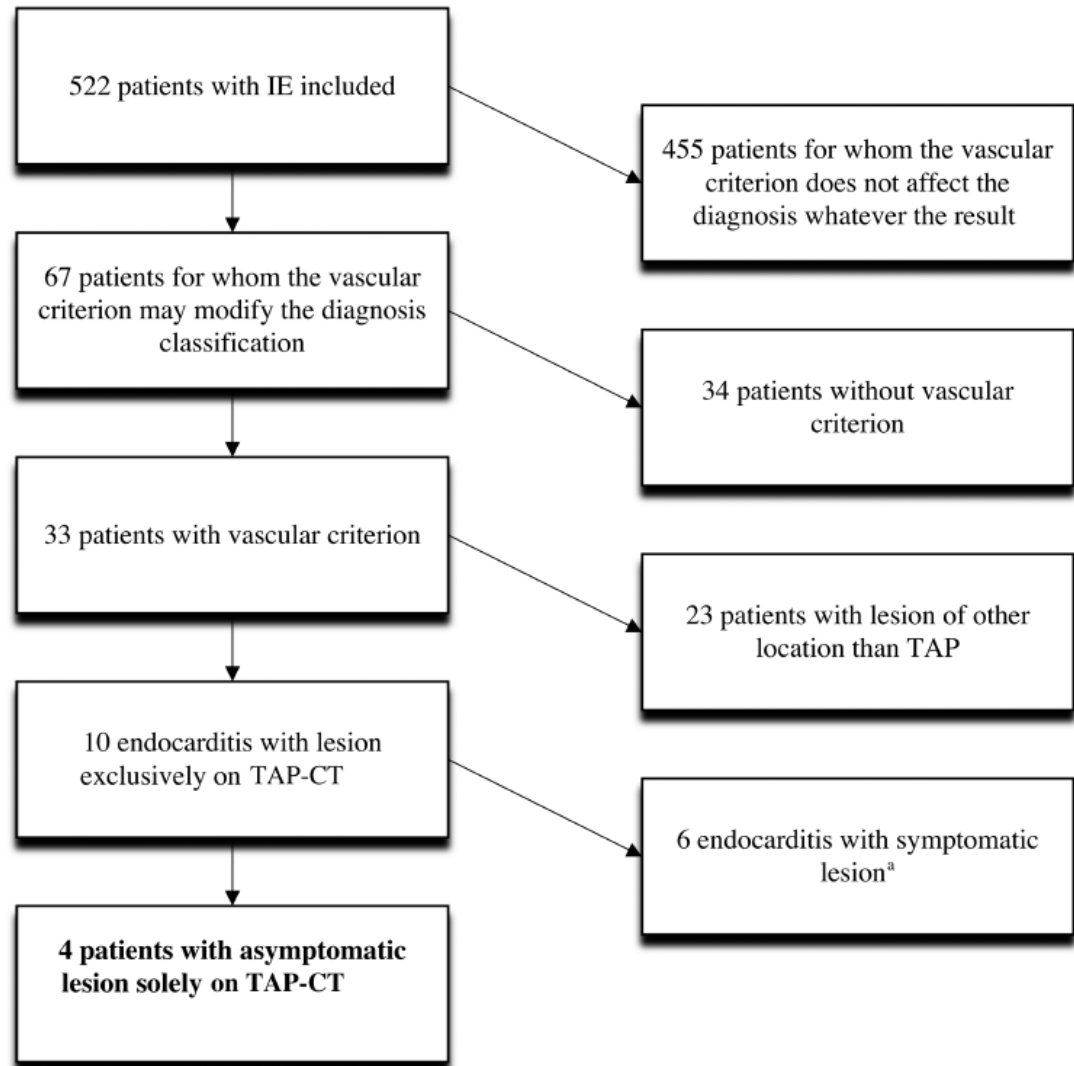


Scanner thoraco-abdomino-pelvien

Clinical Infectious Diseases

MAJOR ARTICLE

Modification du
diagnostic ?



Scanner thoraco-abdomino-pelvien

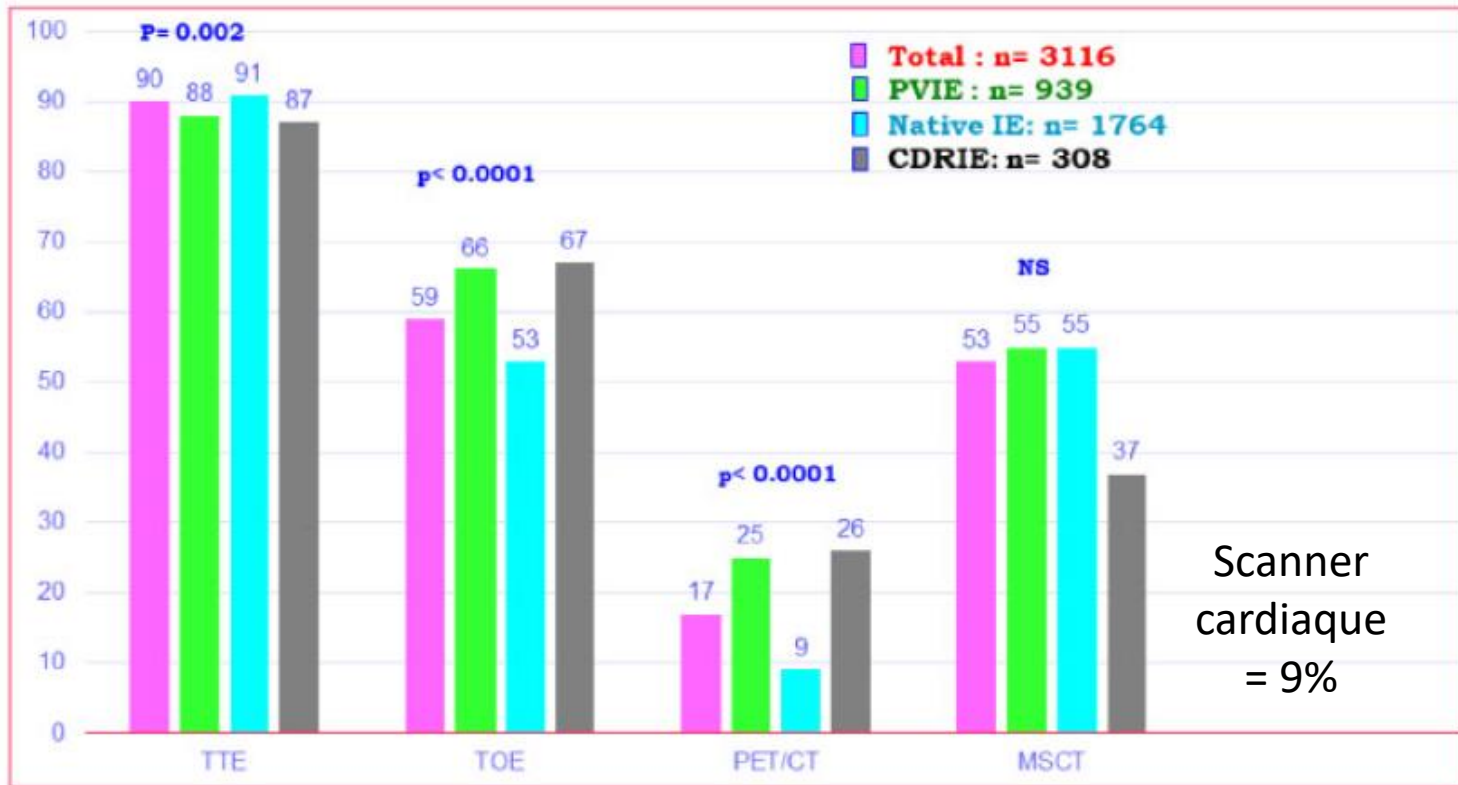
Modification de la prise en charge ?

Lesion	Lesion on TAP-CT	Lesion With Modification of Treatment	Asymptomatic Lesion With Modification of the Treatment
Spondylodiscitis	25	23	5
Abscess ^a	254	10	0
Vascular	11	3	2
Pulmonary	39	6	2
Total	325	42	9

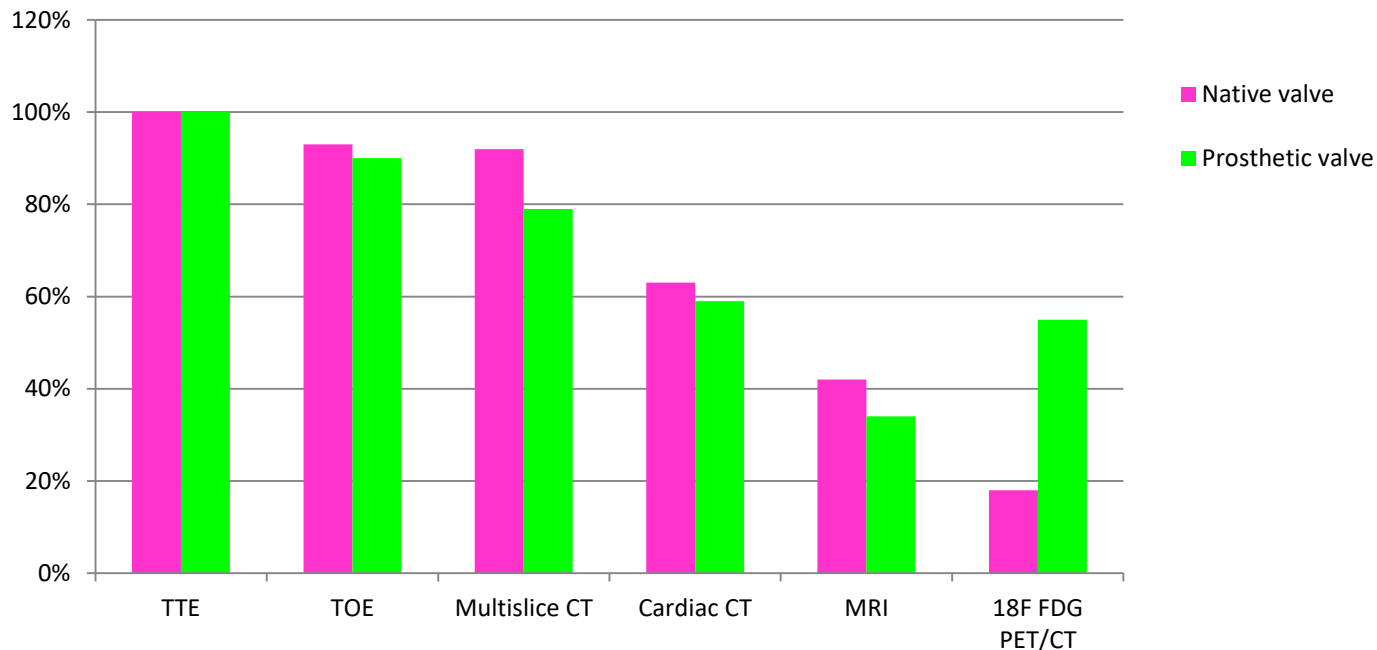
IRA chez 78 patients (17%) dans les 5 jours suivant le scanner

En pratique ? Cohorte EURO-ENDO

Place de l'imagerie ?



En pratique ? Cohorte Mondor



- PET CT was more frequently used in PVIE (55%) VS in NVE (18%),
- PET CT was positive in 37% with a better sensitivity in PVIE (60%)

« Endocarditis Team » : recommandations

- Fortement recommandée dans les recos ESC :

2015 ESC Guidelines for the management of infective endocarditis



The present Task Force on the management of IE of the ESC strongly supports the management of patients with IE in reference centres by a specialized team (the ‘Endocarditis Team’). The main characteristics of the Endocarditis Team and the referring indications are summarized in Tables 8 and 9.

Quels moyens ?

Characteristics of the reference centre

1. Immediate access to diagnostic procedures should be possible, including TTE, TOE, multislice CT, MRI, and nuclear imaging.
2. Immediate access to cardiac surgery should be possible during the early stage of the disease, particularly in case of complicated IE (HF, abscess, large vegetation, neurological, and embolic complications).
3. Several specialists should be present on site (the 'Endocarditis Team'), including at least cardiac surgeons, cardiologists, anaesthesiologists, ID specialists, microbiologists and, when available, specialists in valve diseases, CHD, pacemaker extraction, echocardiography and other cardiac imaging techniques, neurologists, and facilities for neurosurgery and interventional neuroradiology .

Conclusions

- **Echocardiographie** reste l'examen de référence mais plusieurs techniques d'imagerie alternatives à l'échocardiographie
- **TEP scanner**
 - Intérêt diagnostic largement validé sur **valves prothétiques**
 - Sur valves natives intérêt potentiel pour la recherche des **localisations secondaires**, intérêt sur la prise en charge ?
 - Profil de la fixation > délais de la chirurgie
- **Scanner cardiaque**
 - Complément de l'échocardiographie ou quand ETO impossible
 - Moins performant sur les végétations mais intérêt sur les **lésions péri-valvulaires**
 - Associé au scanner TAP systématiquement ?
- **IRM Cérébrale :**
 - **Intérêt diagnostic** validé pour la recherche de localisations cérébrales asymptomatiques
 - Intérêt dans la prise en charge thérapeutique à définir
- Situations souvent complexes
- Imagerie multi modale et équipe multidisciplinaire : « Endocarditis team »