

# Les radiopharmaceutiques: exemple de l'oncologie

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# Principe de l'imagerie en Médecine nucléaire

## Détection de la distribution spatiale et temporelle d'un radiopharmaceutique à l'échelle du corps entier

Radiopharmaceutiques  $\approx$  traceur = Radionucléide +/- vecteur

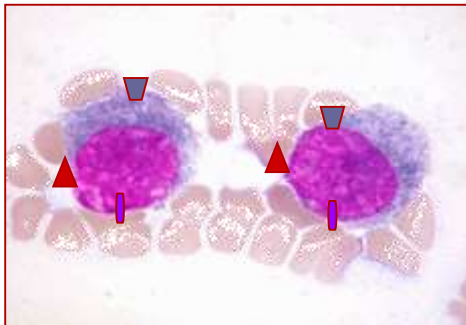
Affinité du vecteur marqué vis à vis d'un organe, d'une tumeur ou d'une fonction



Repérage spatial du radionucléide par une caméra

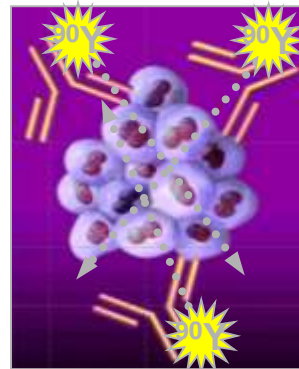
# Principe technique Imagerie en Médecine nucléaire

## Cible moléculaire

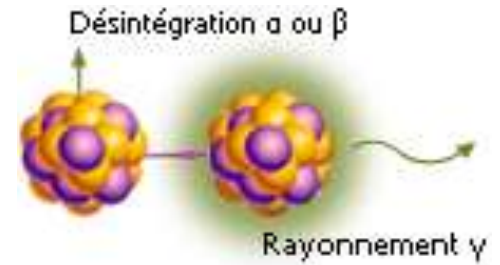


- Récepteur: SMS
- Antigène: ACE
- Transporteur: GLUT1
- ...

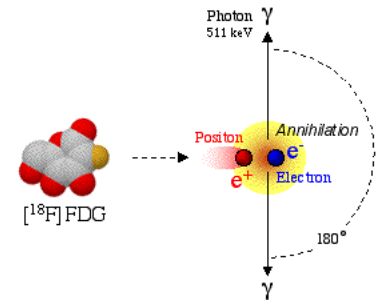
## Radiopharmaceutique



- Peptide
- Anticorps
- Glucose
- .....



## Scintigraphie



## TEP

Médecine nucléaire



Biomarqueurs

## **PET of Signal Transduction Pathways in Cancer**

Jason P. Holland<sup>1,2</sup>, Paul Cumming<sup>3</sup>, and Neil Vasdev<sup>1</sup>

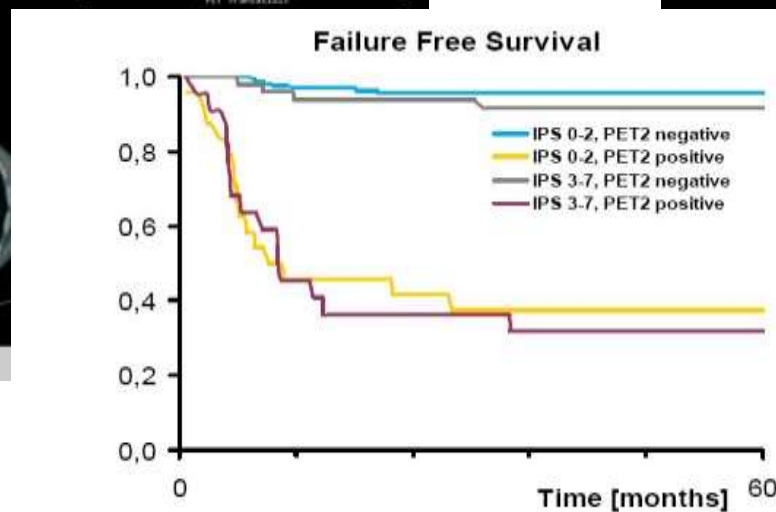
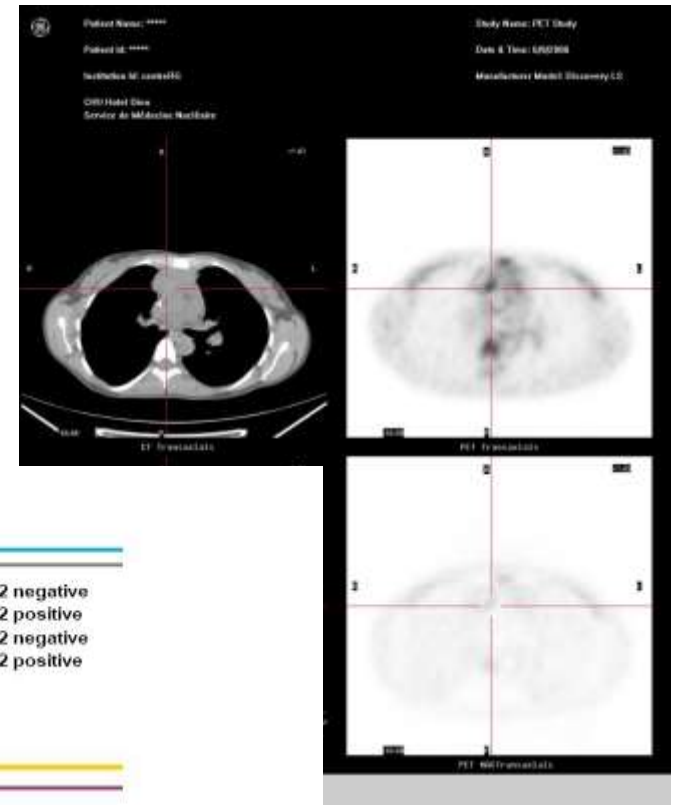
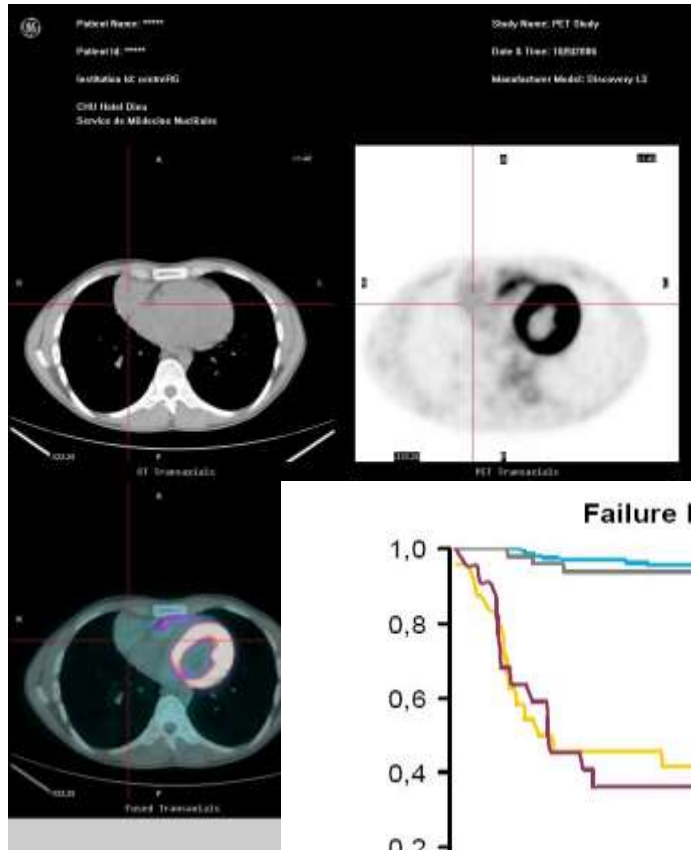
**J Nucl Med 2012; 53:1333–1336**

**DOI: 10.2967/jnumed.112.105387**

# Un leader : $^{18}\text{F}$ FDG, analogue du glucose

- Développement clinique majeur depuis 10 ans
- **Place majeure d'une imagerie moléculaire tri-dimensionnelle corps entier non invasive**
- Données métaboliques sur la masse tumorale
- Outil majeur en onco-hématologie : Staging, évaluation thérapeutique
- **Absence de spécificité tumorale du  $^{18}\text{F}$ -FDG**

# FDG : étude de la viabilité tumorale et Détermination du pronostic



Gallamini, Menton, 2011

# Les radiopharmaceutiques en oncologie ne se limitent pas au FDG.

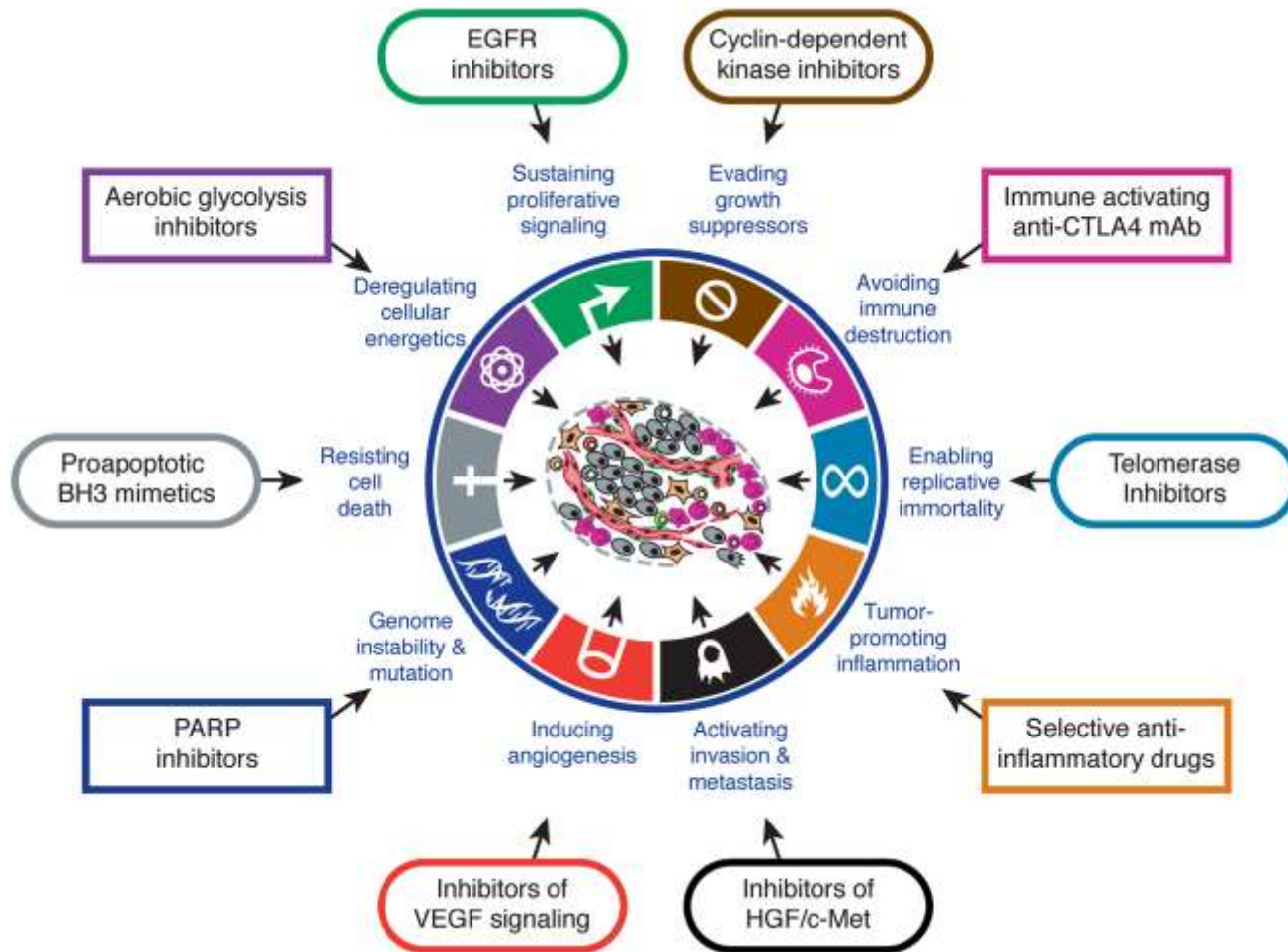
# Quels vecteurs biologiques?

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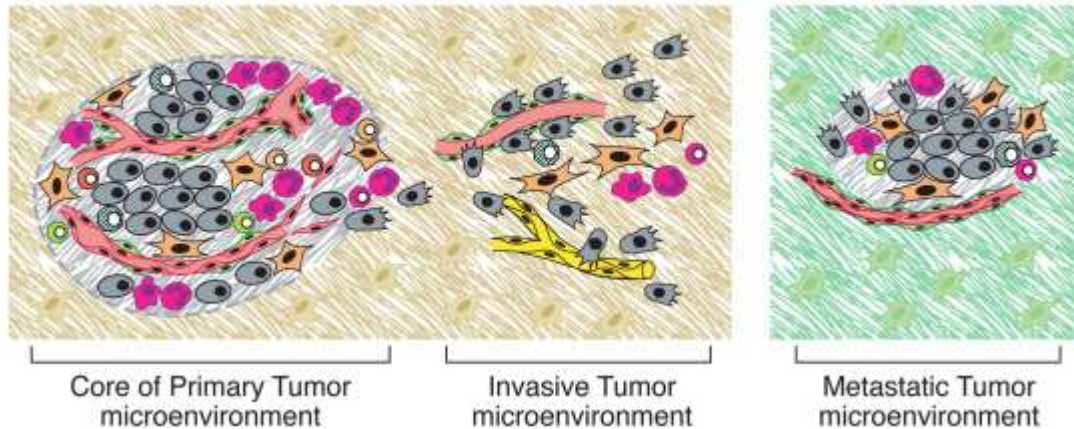
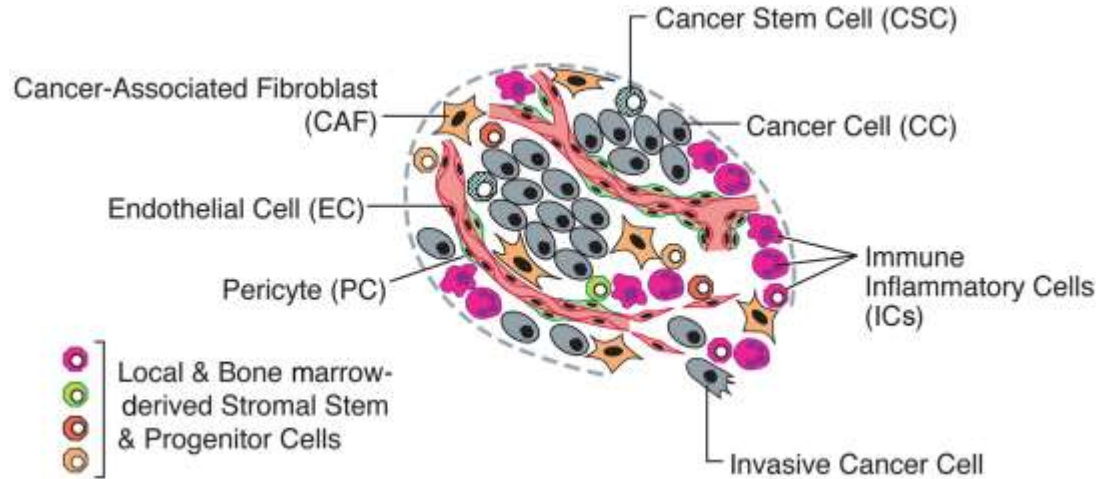




# Caractéristiques tumorales (2010)



# Caractéristiques tumorales (2010)

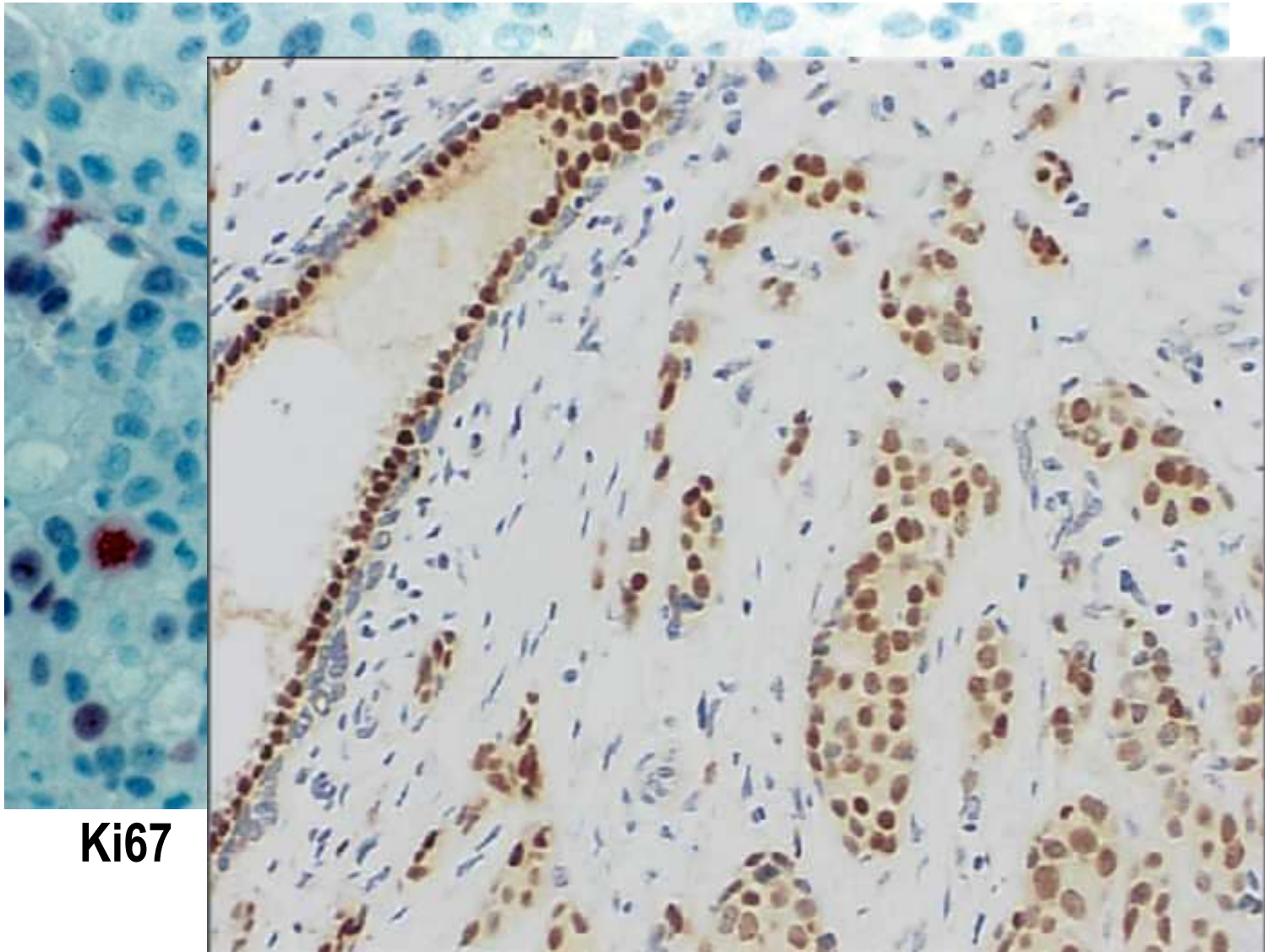


# Cibles moléculaires

- **Métabolisme**
  - Métabolisme énergétique
  - Hypoxie...
- **Processus biochimiques**
- **Antigènes**
- **Récepteurs**
- **Acides nucléiques**
- **Apoptose**

- **Stroma tumoral**
  - Angiogenèse
  - ...
- **(Bio) Médicaments**
  - Fludarabine
  - ...

# « Immunohistochimie in vivo »



**Ki67**

SAB October 16, 2006

**Récepteurs aux oestrogène**

# Quels radioéléments?

Nouvelles cibles



Nouveaux vecteurs



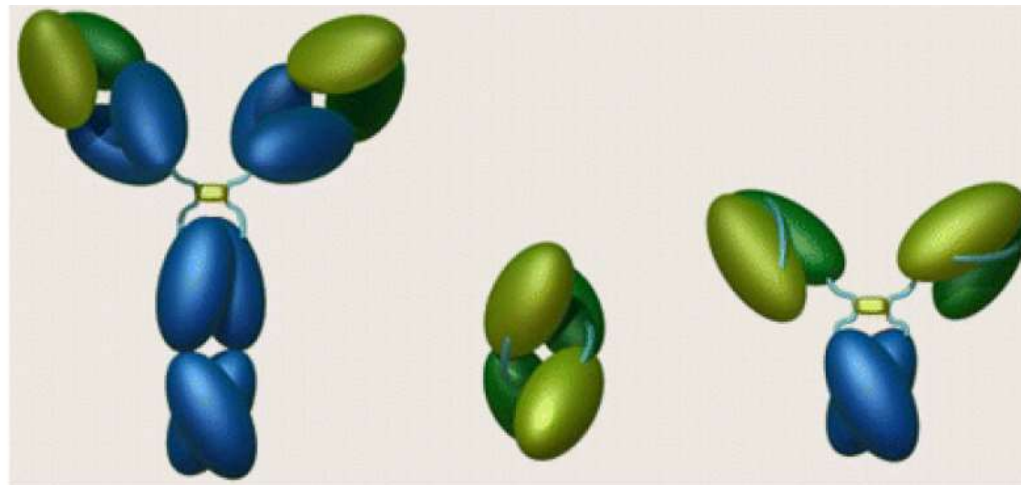
Nouveaux radioéléments

Matcher les périodes biologique et physique



## Principaux radioéléments d'intérêt en médecine Imagerie médicale

Radionucléide	Demi-vie	Emission
Emission gamma	Emission gamma	Emission gamma
<sup>99m</sup> Tc	6h	140 keV
<sup>111</sup> In	2,8 j	171 et 245 keV
<sup>67</sup> Ga	3,26 j	93, 184, 300 keV
<sup>123</sup> I	13,2 h	159 keV
Emission Beta +	Emission Beta +	Emission Beta +
<sup>124</sup> I	4,2 j	g : 602, 511 keV ; β <sup>+</sup> 1532, 2135 keV)
<sup>18</sup> F	1,83 h	g : 511 keV ; β <sup>+</sup> 633 keV)
<sup>68</sup> Ga	1,1 h	g : 511 keV ; β <sup>+</sup> 1094 ; 920 keV)
<sup>44m</sup> Sc <sup>44</sup> Sc	2,4 j 4h	g 240 keV g 1160 ; 511 ; β <sup>+</sup> 1460 keV)
<sup>64</sup> Cu	12,7 h	g : 511, 1345 keV ; β <sup>+</sup> 653 keV)
<sup>89</sup> Zr	78,4 h	



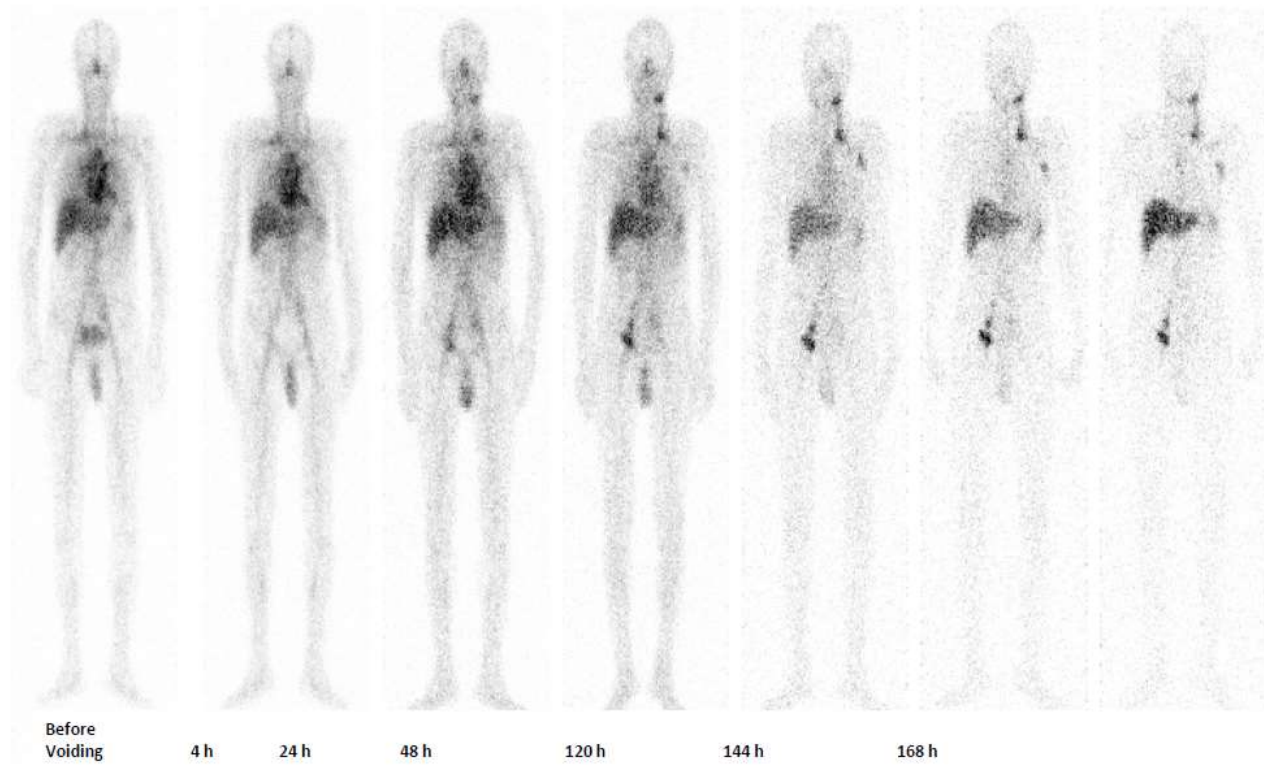
Ig intacte

Dimers of scFv  
Diabodies

Minibodies

*Wu et al., J Nucl Med. 2009;50(1):2-5*

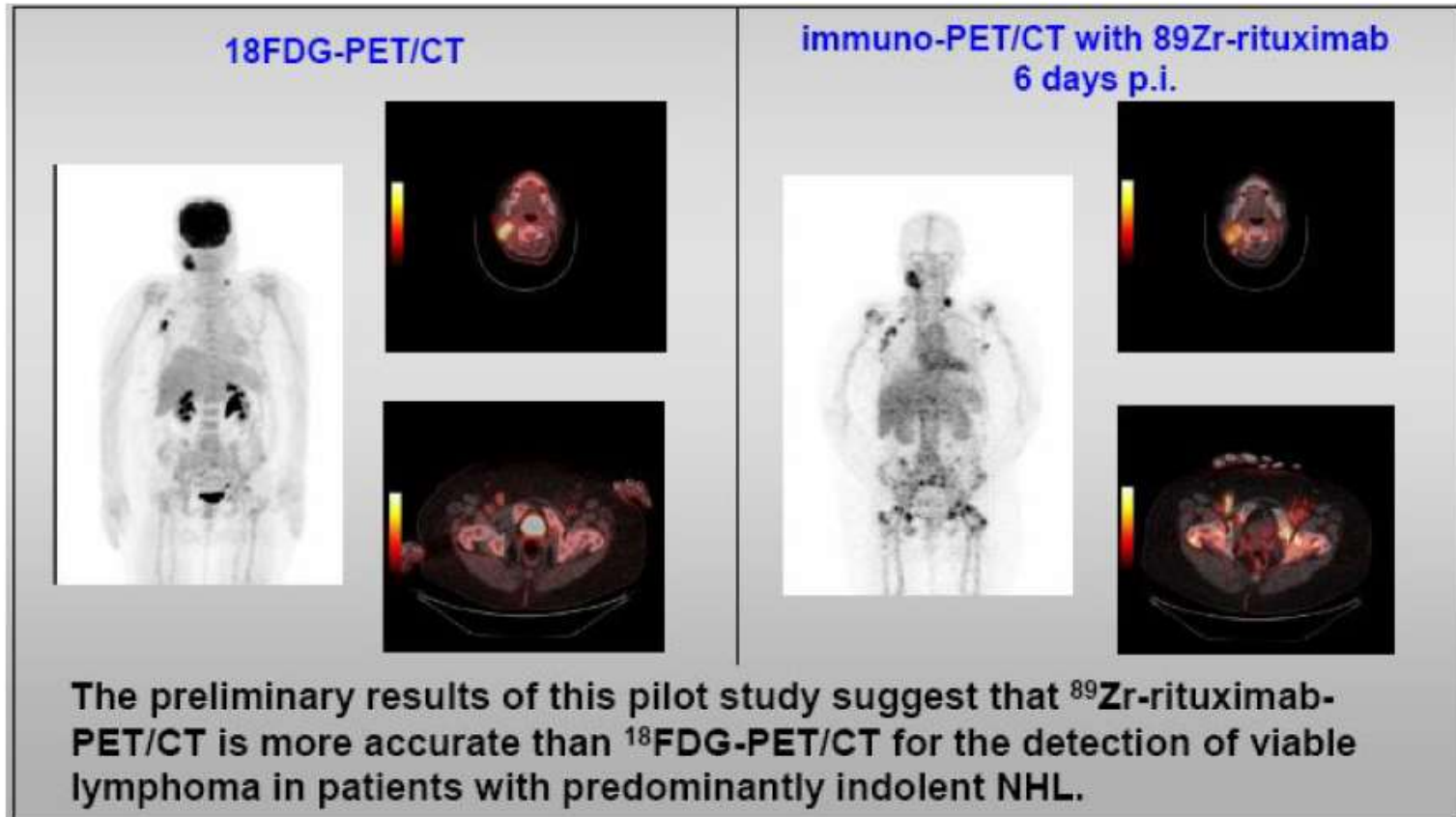
# Lymphome: Anti-CD22 hLL2-<sup>111</sup>In



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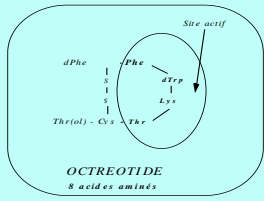
# TEP-FDG vs anti-CD20-89Zr



*Muyllé, Menton, 2011*

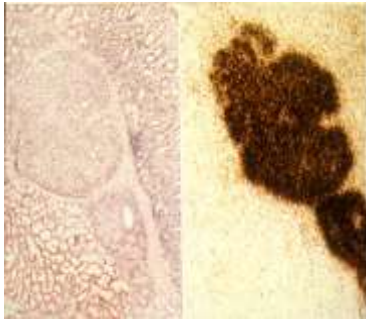
SAB October 16, 2006

# Analogues de la SMS



**1984**

**Autoradiographie**



**1987**

**Octreoscan  
111In**



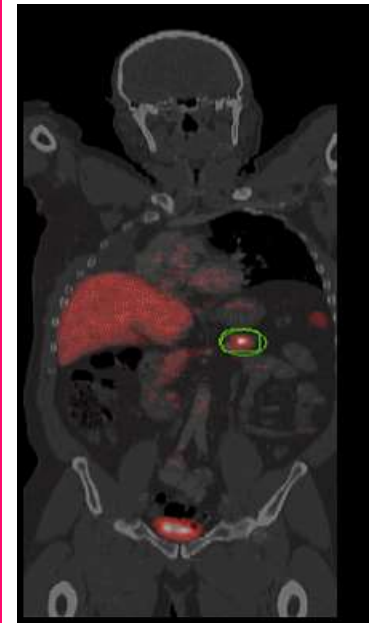
**1992**

**thérapie 177Lu**



**2006**

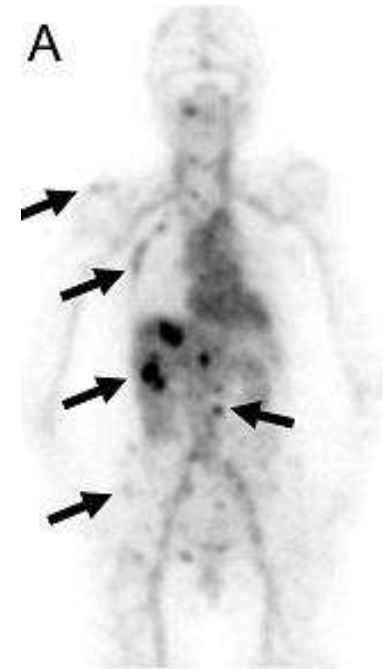
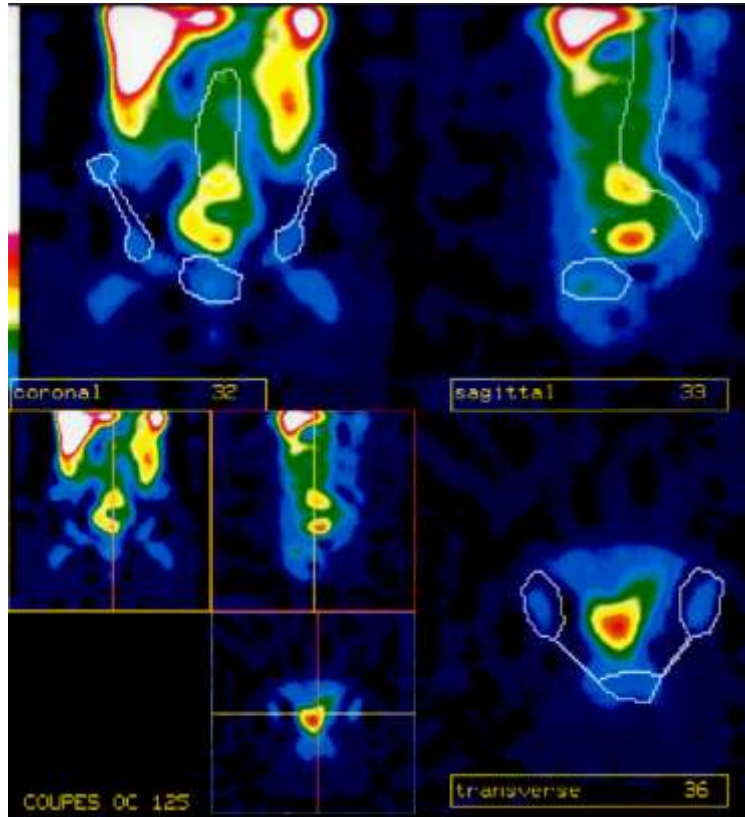
**68Ga-TEP**



# Intérêt par rapport à l'imagerie radiologique?

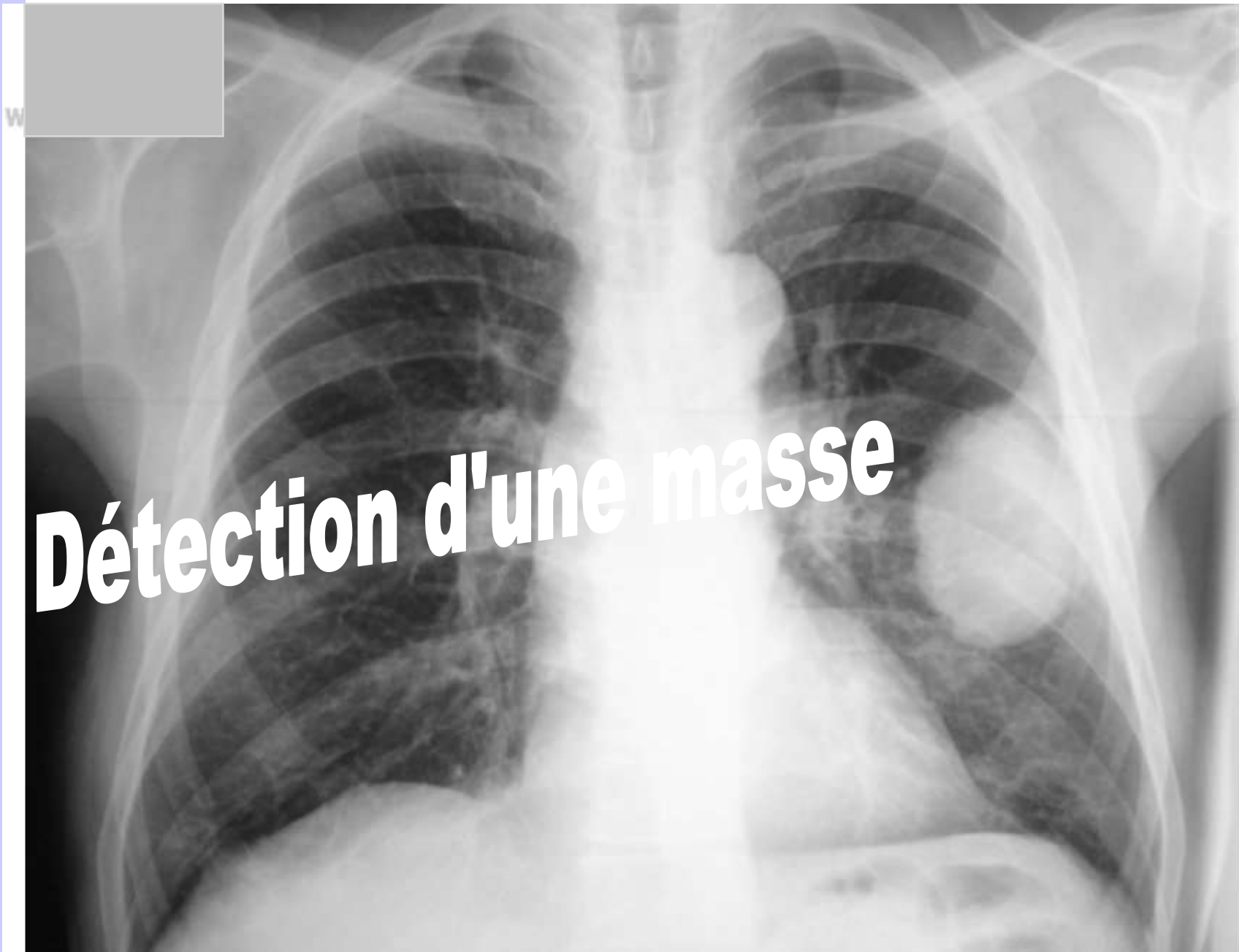
SAB October 16, 2006

# Cartographie corps entier d'une fonction biologique ou d'un biomarqueur



**Scintigraphie**  
 **$^{111}\text{In-OC125}$**  SAB October 16, 2006

**TEP**  
 **$^{89}\text{Zr-trastuzumab}$**   
**Dijkers *et al* JNM 2009**

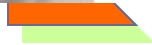


**Détection d'une masse**



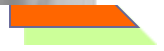
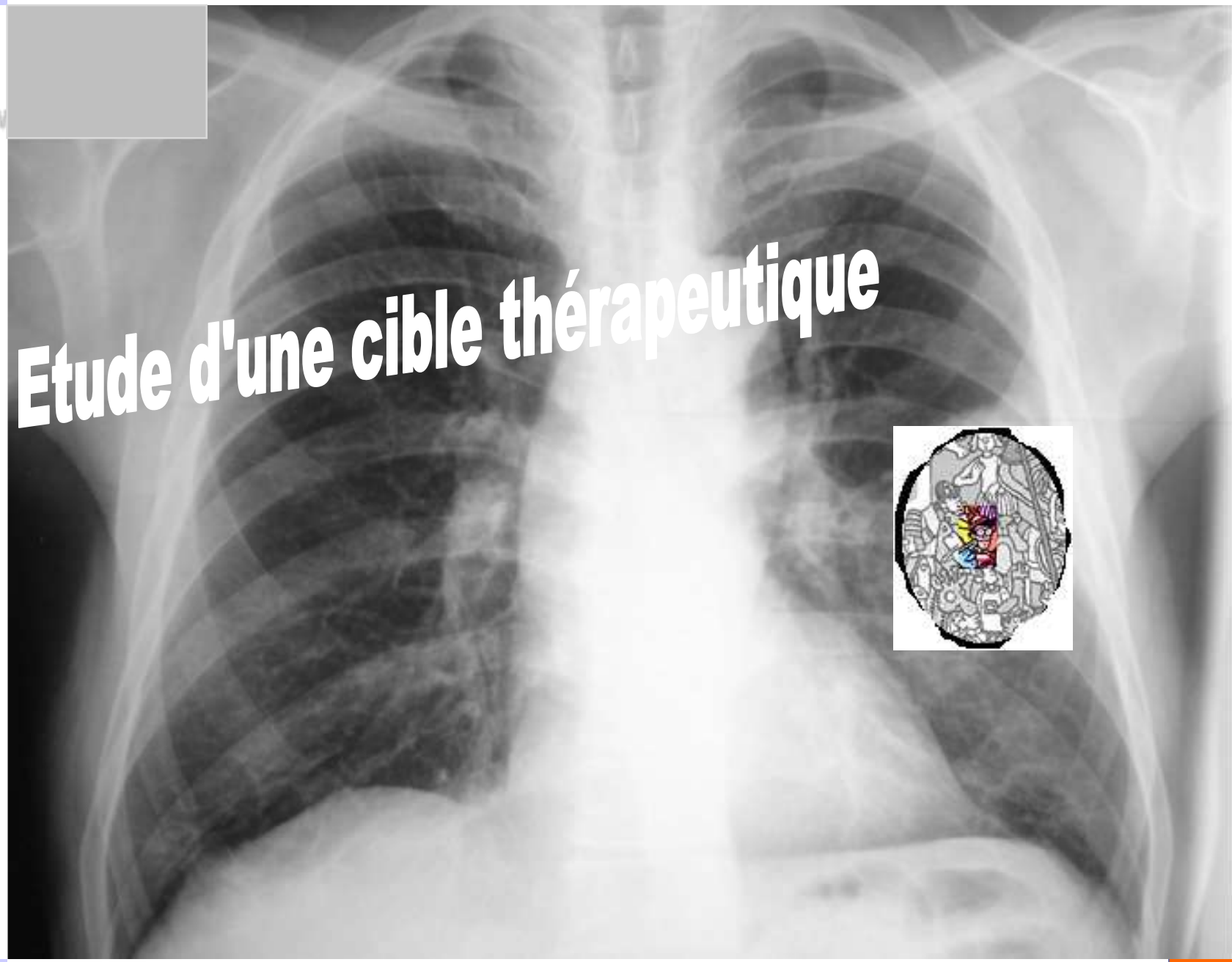
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# Etude de son métabolisme



w

# Etude d'une cible thérapeutique





**TABLE 1. Molecular Imaging Probes Used at MSKCC**

Radiotracer	Function
$^{18}\text{F}$ -FDG (48)	Glycolysis
$^{18}\text{F}$ -FLT	Proliferation
$^{11}\text{C}$ -methionine (49–51), anti-1-amino-3-[ $^{18}\text{F}$ ]fluorocyclobutyl-carboxylic acid (52)	Amino acid transport
$^{18}\text{F}$ -FES (53)	Estrogen receptor
$^{18}\text{F}$ -FDHT (54–56)	Androgen receptor
Na $^{124}\text{I}$	NIS
$^{11}\text{C}$ -acetate	Krebs cycle, FA syn
$^{18}\text{F}$ -FMISO (57)	Hypoxia
$^{68}\text{Ga}$ -Fab'2 trastuzumab	HER 2
$^{124}\text{I}$ -cG250	Carbonic anhydrase IX
$^{124}\text{I}$ -A33	A33 antigen
$^{124}\text{I}$ -3F8	GD2
$^{64}\text{Cu}$ -trastuzumab	HER 2
$^{124}\text{I}$ -Fluoroiodoarabinosyluridine* (58)	Thymidine kinase (herpes virus)
$^{18}\text{F}$ -Fluoroethanilarabinosyluridine* (59)	Thymidine kinase (herpes virus)
*Gene expression imaging.	

SAB October 16, 2006

Zhao, et al. *J Nucl Med.* 2009;50:239–249.



# Médecine nucléaire en 2015: outils de la médecine personnalisée

## Prognostic imaging: $^{18}\text{F}$ FDG

Staging, restaging, aggressiveness

## Predictive imaging:

FES, peptides (SSR), antibodies (HER2), new biomarkers,

New radionuclides:  $^{68}\text{Ga}$ ,  $^{64}\text{Cu}$ ,  $^{124}\text{I}$ ,  $^{89}\text{Zr}$

## Targeted therapies

Multimodality strategies

Minimal residual disease

Interim imaging:  $^{18}\text{F}$ FDG,  $^{18}\text{F}$ FLT  
prognosis

Patient outcome

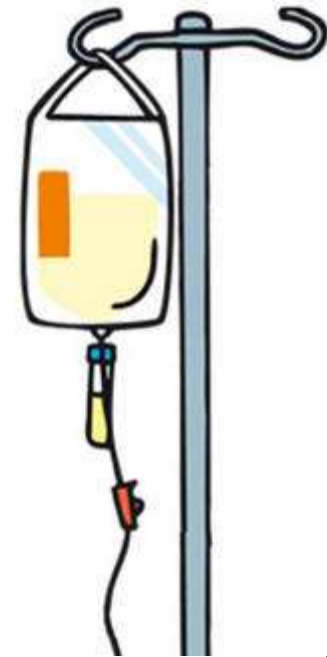
# Prédire l'efficacité d'une thérapie ciblée

## Médecine personnalisée

< 10% de la population



# Théranostique et compagnon diagnostic



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**Biomarqueur** : « caractéristique qui est objectivement mesurée et évaluée comme un indicateur de processus biologiques normaux ou pathologiques, ou de réponses pharmacologiques à une intervention thérapeutique » (définition du *National Institute of Health, US*). cf. terme « marqueur ».

**Facteur (marqueur) de risque** : facteur (marqueur) associé à une augmentation de fréquence (couramment appelée risque) du critère de jugement considéré (exemples : décès, survenue d'une complication) chez les sujets qui en sont porteurs par rapport aux autres.

**Facteur (marqueur) prédictif** : facteur (marqueur) influençant l'effet du traitement et dont l'aptitude à modifier le devenir clinique des patients est démontrée. La démonstration de la valeur prédictive d'un marqueur est équivalente à celle de l'utilité clinique du test diagnostique associé.

**HAS**

HAUTE AUTORITÉ DE SANTÉ

GUIDE METHODOLOGIQUE

## Test compagnon associé à une thérapie ciblée : Annexe scientifique

Février 2014

**Médecine « personnalisée »** : terme consistant en un abus de langage à proscrire et à remplacer par le terme médecine « stratifiée » compte tenu du fait que la validation du couple marqueur/traitement est fondée sur une approche populationnelle classique de validation de thérapeutique. La particularité de cette approche est limitée au fait que la population des patients est stratifiée en sous-populations en fonction du marqueur pressenti comme prédictif. cf. terme (médecine) « stratifiée ».

**Médecine « stratifiée » (*stratified medicine*)** : correspond à une approche thérapeutique où l'objectif est de sélectionner les patients auxquels administrer un traitement en fonction d'un marqueur prédictif, afin de ne traiter que la sous-population susceptible de recevoir un bénéfice du traitement.

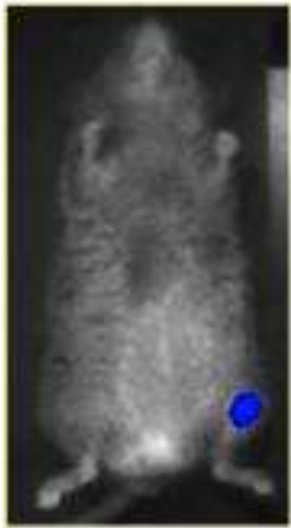
**Test compagnon** : test diagnostique permettant de sélectionner, en fonction de leur statut pour un marqueur prédictif identifié par ce test, uniquement les patients chez lesquels le traitement est susceptible d'apporter un bénéfice parmi ceux diagnostiqués pour une maladie donnée. Le test est considéré comme « compagnon » d'utilisation du traitement.

**Théranostic (ou théragnostic)** : néologisme qui dérive de la contraction des termes « thérapeutique » et « diagnostic » ; c'est l'utilisation d'un test diagnostique, identifiant un marqueur, pour orienter la thérapeutique du patient en fonction de son statut pour le marqueur (statut positif ou négatif pour un marqueur binaire).

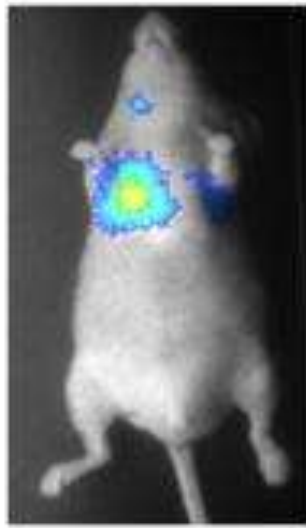
L'objectif de ce document est d'exposer les fondements théoriques et méthodologiques de l'évaluation d'un test diagnostique, nommé **test compagnon**, permettant de sélectionner par l'identification d'un **marqueur prédictif** les patients seuls susceptibles de recevoir un bénéfice d'une **thérapie dite ciblée**.

# Imagerie : outil prometteur pour l'industrie pharmaceutique pour sélectionner les médicaments candidats

Tumeur primitive



Métastases pulmonaires



Développement Pré-clinique



Développement Clinique



Phase I

Détermination Dose recommandée  
Données de PK/PD  
Nb de sujet: 20 à 40



Phase II

Détermination de l'Efficacité  
Données de PK/PD: +/-  
Nb de sujet: 60 à 100



Phase III

Détermination Gain en Survie/toxicité  
Nb de sujet: Important



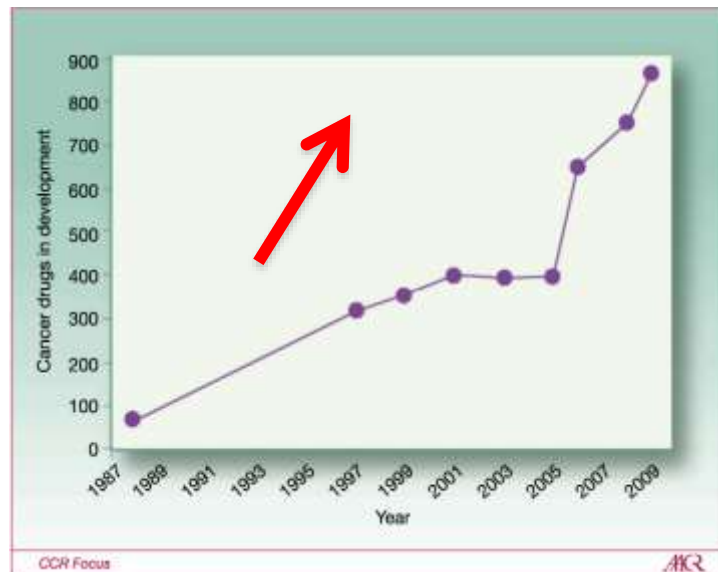
Enregistrement

≈ 15 ans

1 molécule sur 20

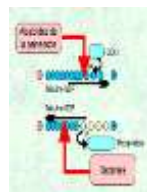
SAB October 16, 2006

# En oncologie



Clin Cancer Res; 16(6) March 15, 2010

En 10 ans croissance de 140 %  
Et augmentation de 55 % du coût



CT

HT

Ac





# Médecine nucléaire en 2015: outils de la médecine personnalisée

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biomarkers,  
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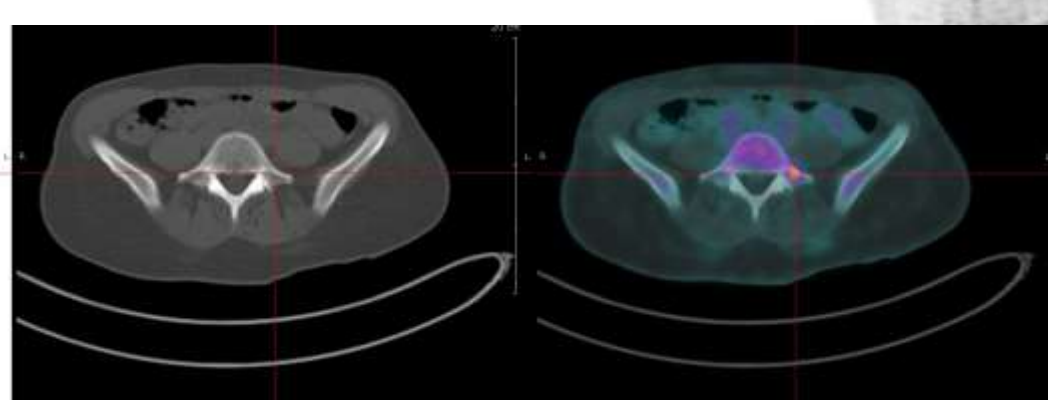
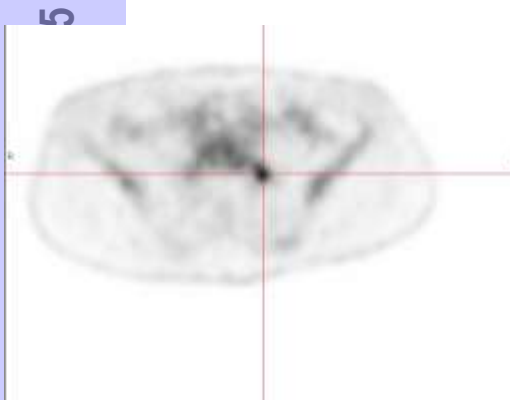
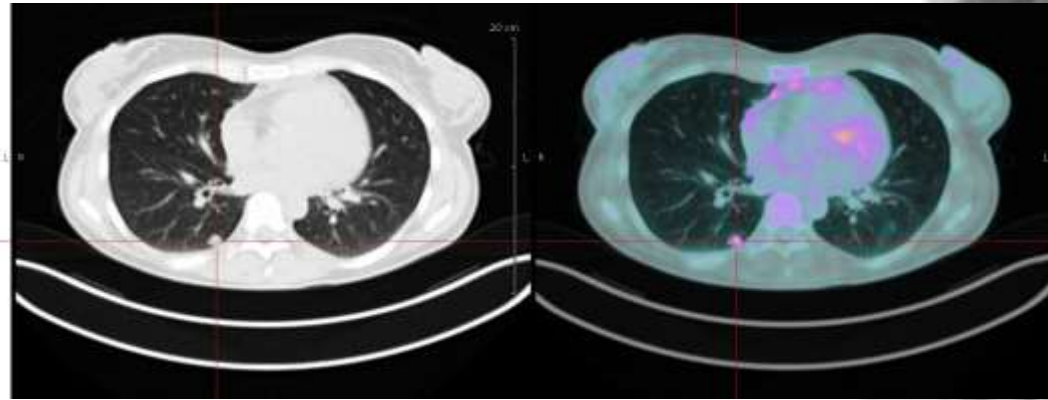
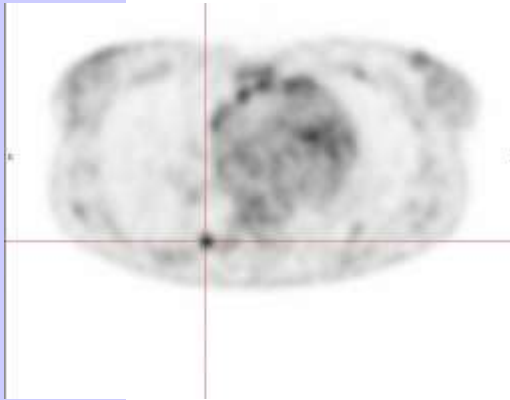
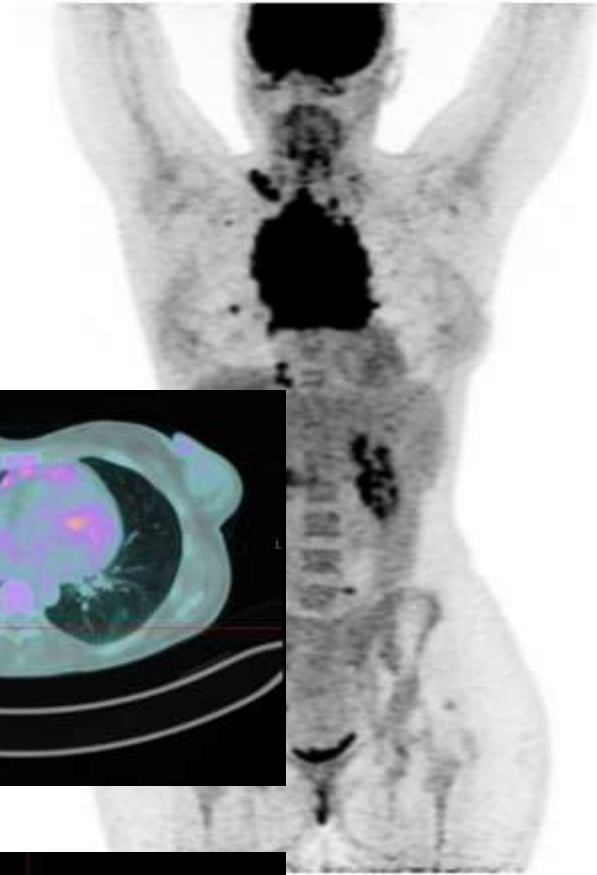
**Targeted therapies**

Multimodality strategies  
Minimal residual disease

**Interim imaging:  $^{18}\text{F}$ FDG,  $^{18}\text{F}$ FLT**  
prognosis

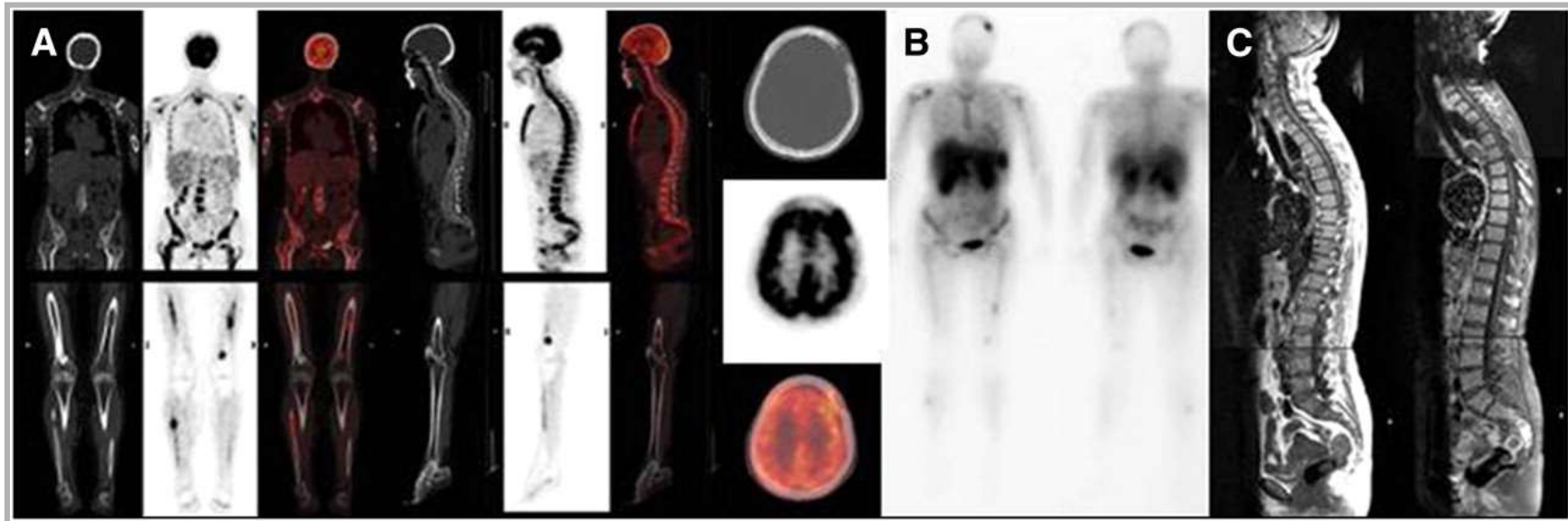
**Patient outcome**

# Staging par le FDG lymphome



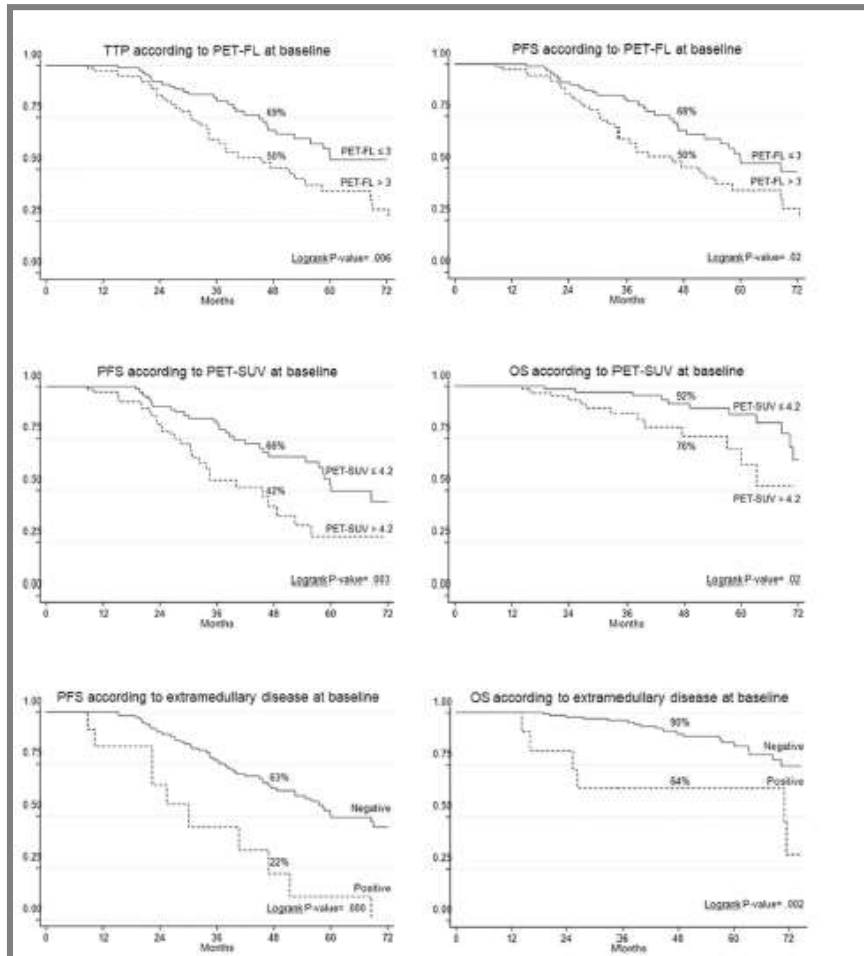


# Staging par le FDG myelome



## Prognostic relevance of 18-F FDG PET/CT in newly diagnosed multiple myeloma patients treated with up-front autologous transplantation

Elena Zamagni, Francesca Patriarca, Cristina Nanni, Beatrice Zannetti, Emanuela Englaro, Annalisa Pezzi, Paola Tacchetti, Silvia Buttignol, Giulia Perrone, Annamaria Brioli, Lucia Pantani, Carolina Terragna, Francesca Carobolante, Michele Baccarani, Renato Fanin, Stefano Fanti and Michele Cavo



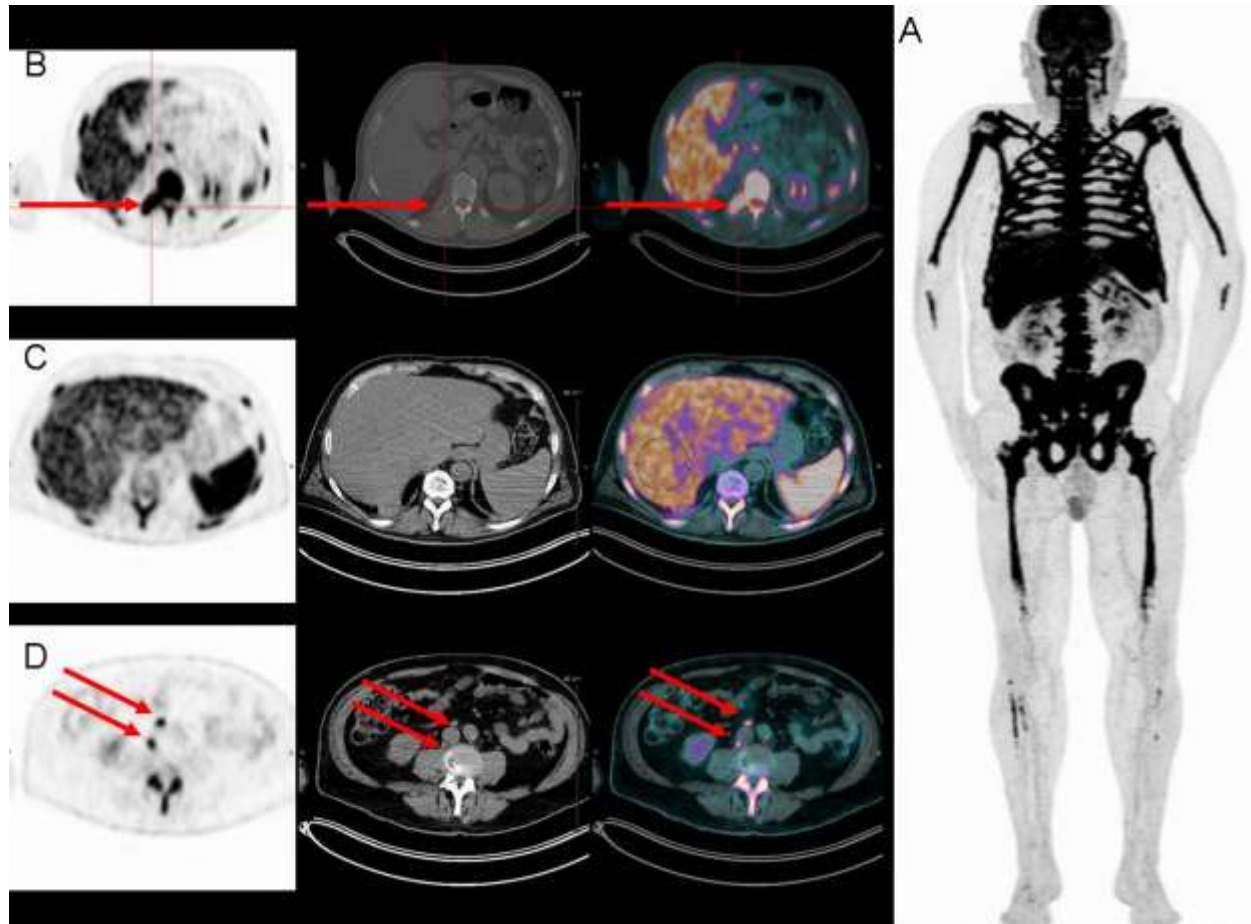
**Table 4. Multivariate Cox regression analysis of baseline variables adversely affecting PFS and OS**

Variables	HR (95% CI)	P
<b>PFS</b>		
EMD	5.28 (1.43-19.53)	.013
SUV > 4.2	2.13 (1.10-4.12)	.024
ISS stage II-III	2.12 (1.13-3.98)	.020
del(17p) ± t(4;14)	2.00 (1.03-3.88)	.040
<b>OS</b>		
EMD	9.75 (3.44-27.65)	.000
SUV > 4.2	3.23 (1.35-7.72)	.008

PFS indicates progression-free survival; OS, overall survival; HR, hazard ratio; CI, confidence interval; SUV, standardized uptake value; EMD, extramedullary disease; del, deletion; t, translocation; and ISS, international staging system.

# TEP FDG et bilan initial dans la myelome:

## Critères TEP de mauvais pronostiques



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**Targeted therapies**

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Minimal residual disease

**Interim imaging:  $^{18}\text{F}$ FDG,  $^{18}\text{F}$ FLT**  
prognosis

**Patient outcome**

# Caractériser et prédire

- Wagner H.N. Molecular Nuclear Medicine : from genotype to phenotype via chemotype.

*J Nucl Med 1995 ; 36(Suppl) : 2S-4S*



## INVITED PERSPECTIVE

## Imaging Tumor Phenotype: 1 Plus 1 Is More Than 2

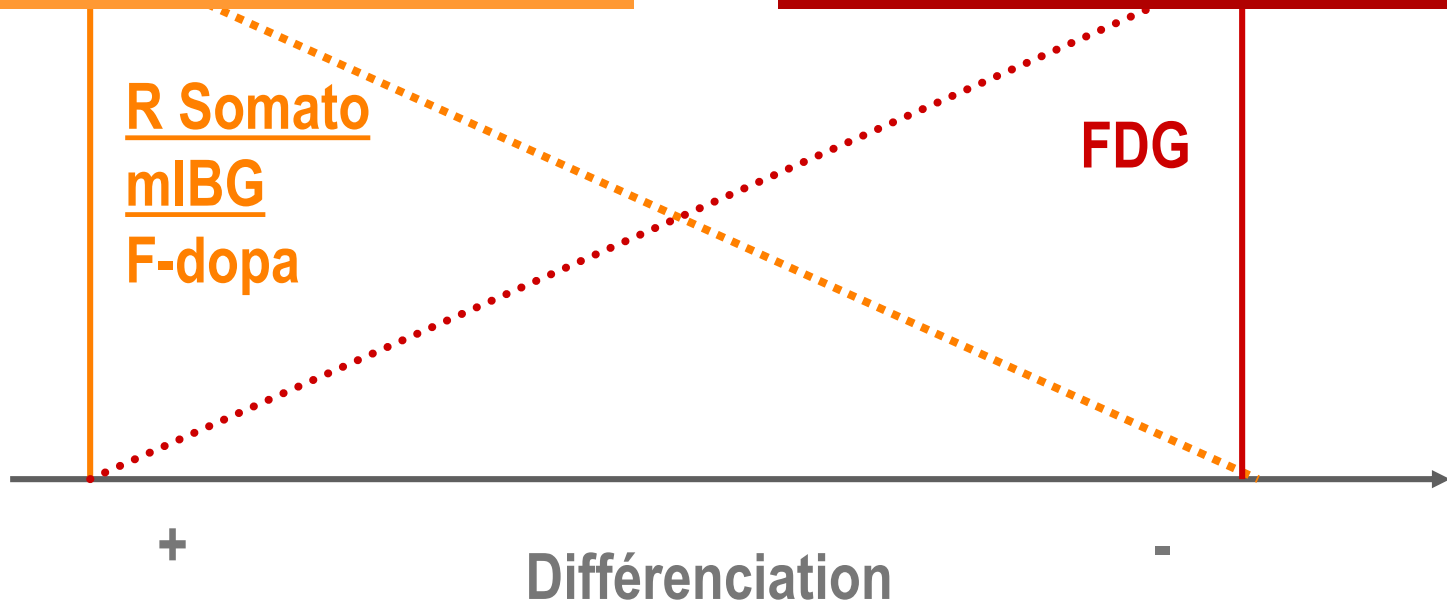
An increasing trend in cancer treatment is personalized therapy, individualized for each patient based on patient characteristics and the biology of the patient's tumor (1). A key component of personalized cancer therapy is the ability to measure tumor phenotypic features to predict clinical behavior, for example, the propensity for progression and metastasis, and to select therapy with a high likelihood of success (2). An early example is seen in the endocrine treatment of breast cancer, in which assay of tumor biopsy material for estrogen receptor (ER) expression predicts both the prognosis—that is, the aggressiveness

October 16, 2006

# Comparer 2 traceurs: Caractérisation des tumeurs endocrines

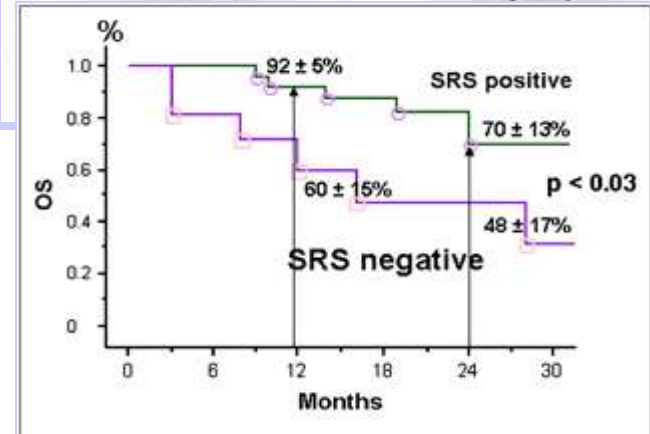
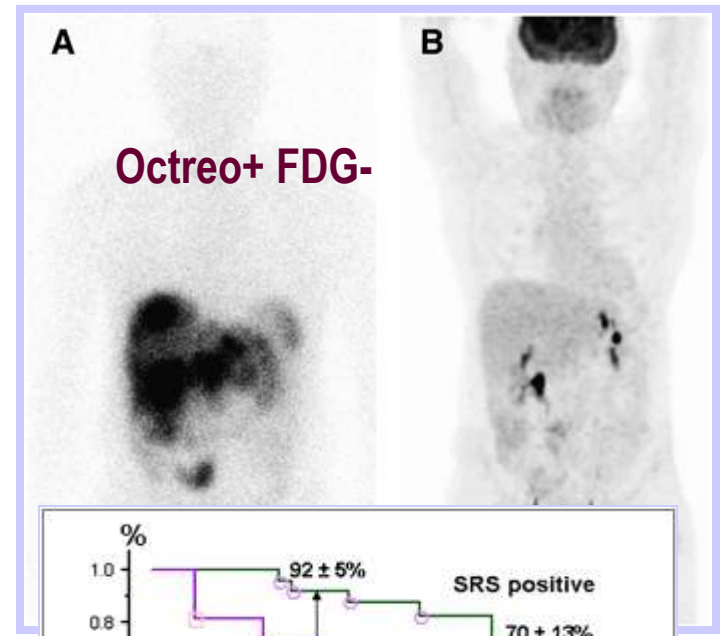
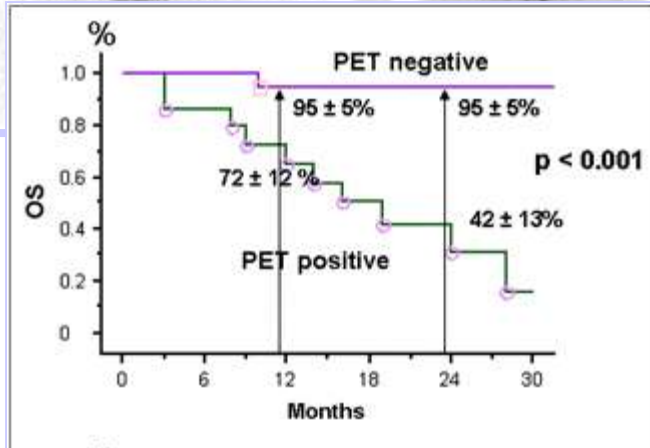
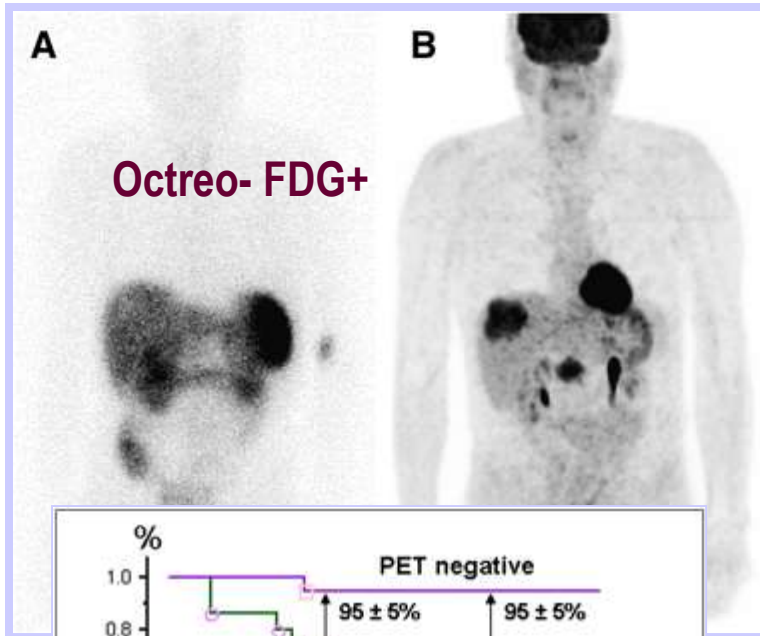
Phénotype endocrine  
Indolence  
Réponse à l'hormonoTTT

Perte des fonctions endocrines  
Agressivité  
Réfractaire à l'hormonoTTT



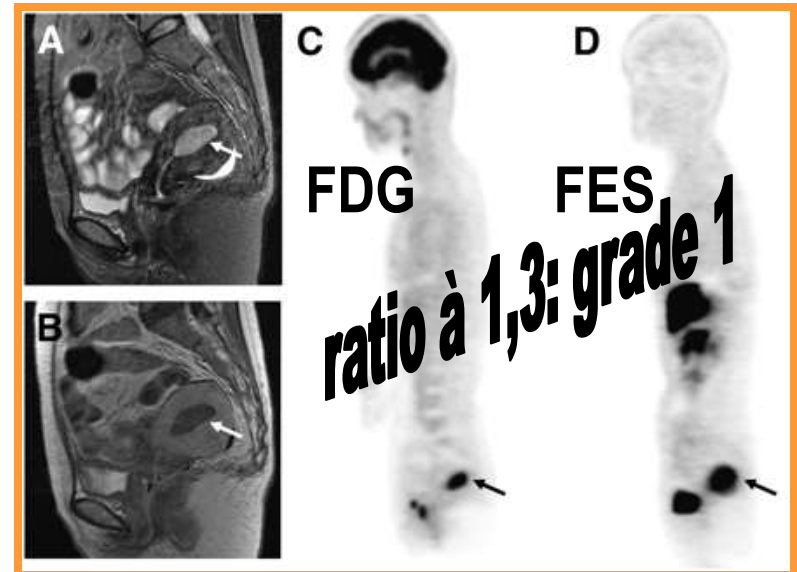
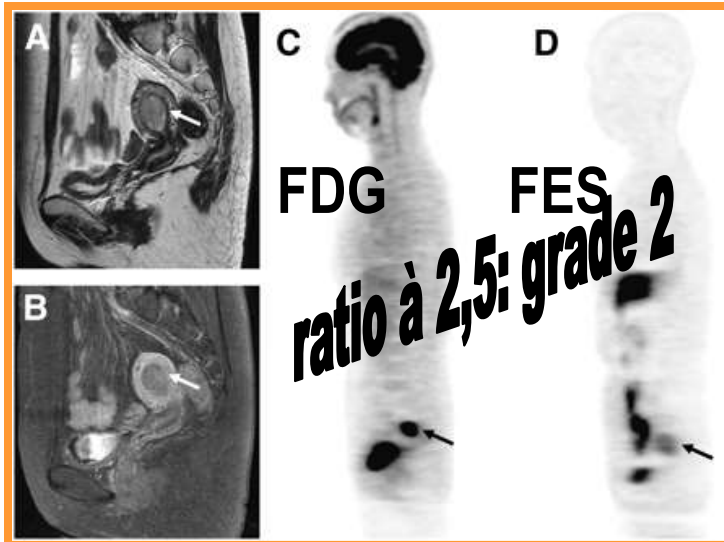
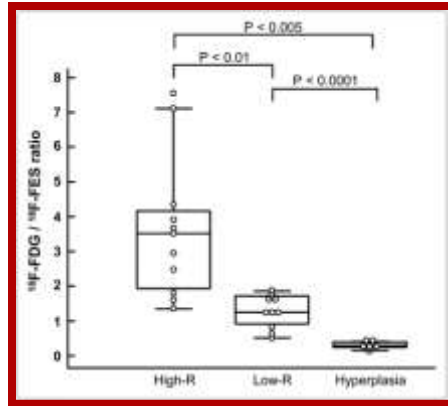
- Sensibilité variable
- Complémentarité des traceurs
- Valeur pronostique du FDG

# TE digestive de bas grade FDG/Octreoscan



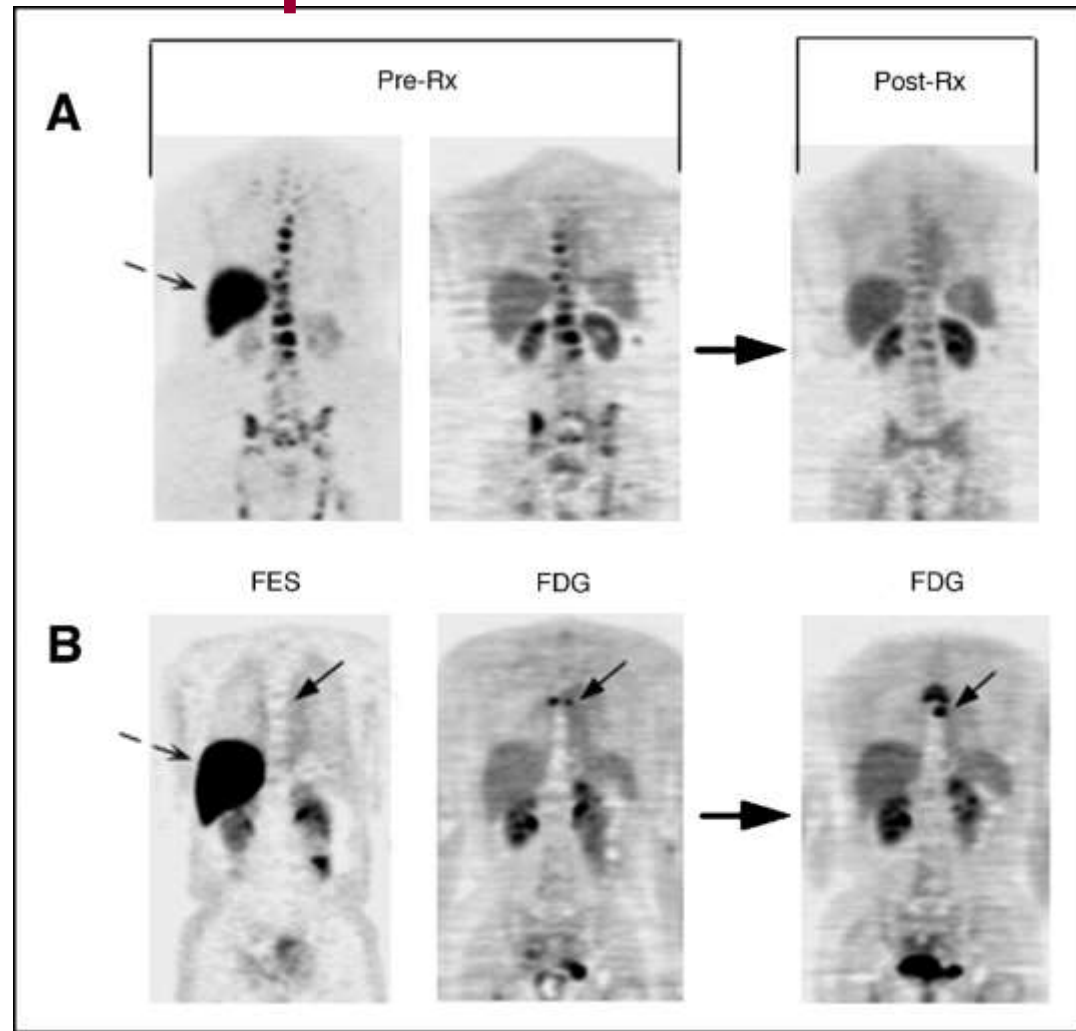


# FDG/FES ratio dans les tumeurs de l'endomètre



# Evaluation du statut hormonal : récepteur aux oestrogènes

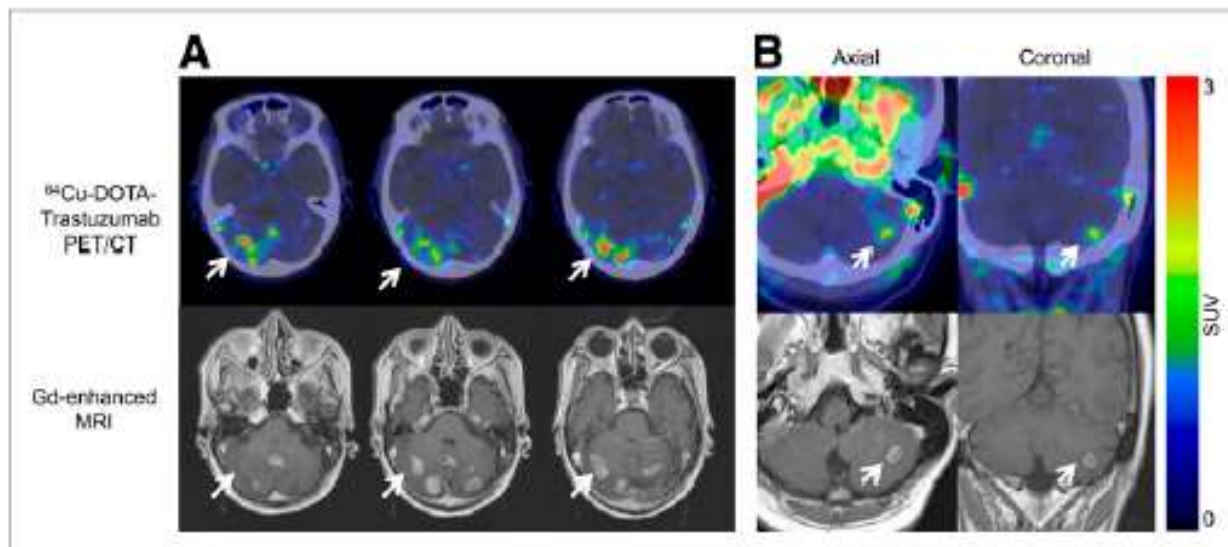
## Prédire la réponse à l'hormonothérapie



SAB October 16, 2006

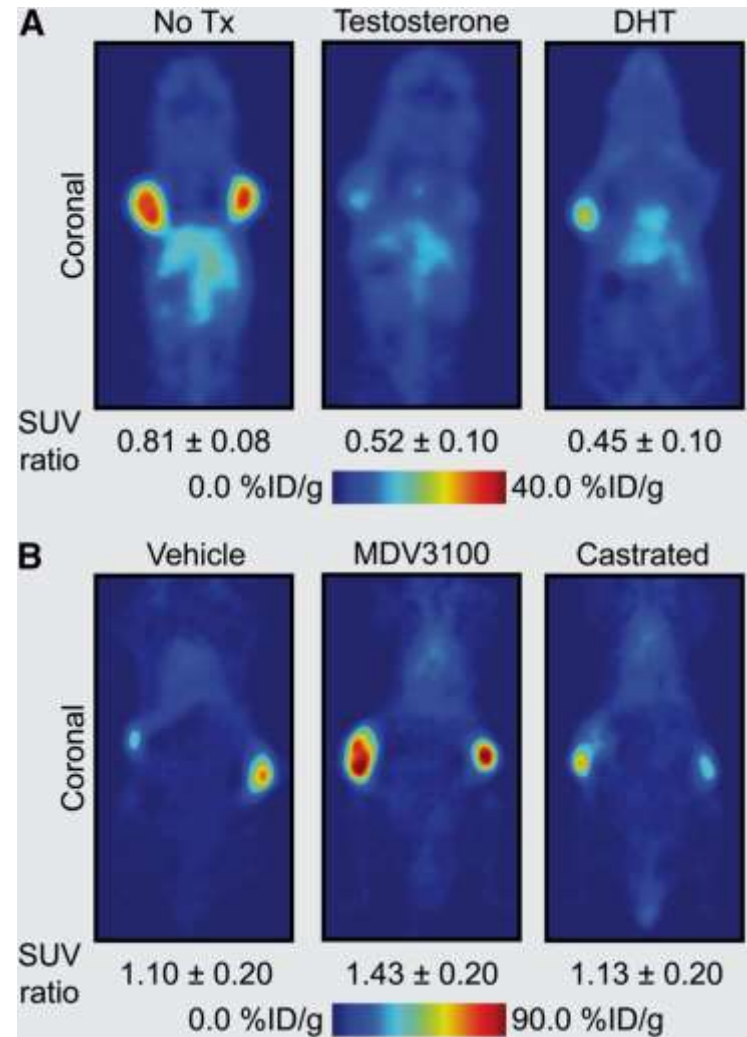
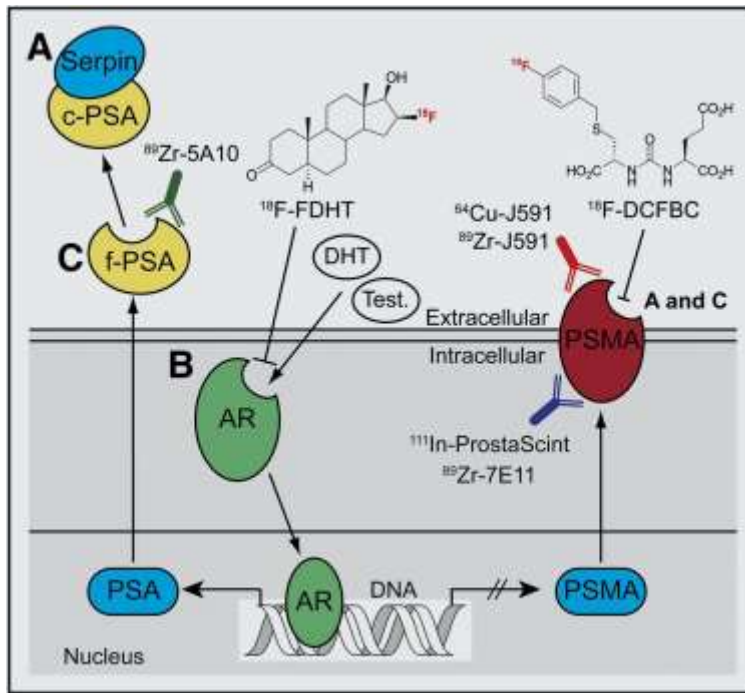
Linden, H. M. et al. J Clin Oncol; 24:2793-2799 2006

# $^{64}\text{Cu}$ -DOTA-Trastuzumab PET Imaging in Patients with HER2-Positive Breast Cancer



**FIGURE 4.**  $^{64}\text{Cu}$ -DOTA-trastuzumab PET images of HER2-positive metastatic brain lesions (arrows). (A) Brain metastases were clearly visualized by  $^{64}\text{Cu}$ -DOTA-trastuzumab PET in patient 1. Significant uptake values were found in areas corresponding to brain metastatic lesions that were detected by MR imaging. Some brain metastases could not be detected on conventional CT. (B) In patient 4,  $^{64}\text{Cu}$ -DOTA-trastuzumab PET imaging could detect solitary brain metastasis that had also been identified in similar location by MR imaging.

$^{64}\text{Cu}$ -J591 immuno-PET images demonstrating use of PSMA as pharmacodynamic biomarker of changes in AR signaling in prostate cancer



PET of Signal Transduction Pathways in Cancer

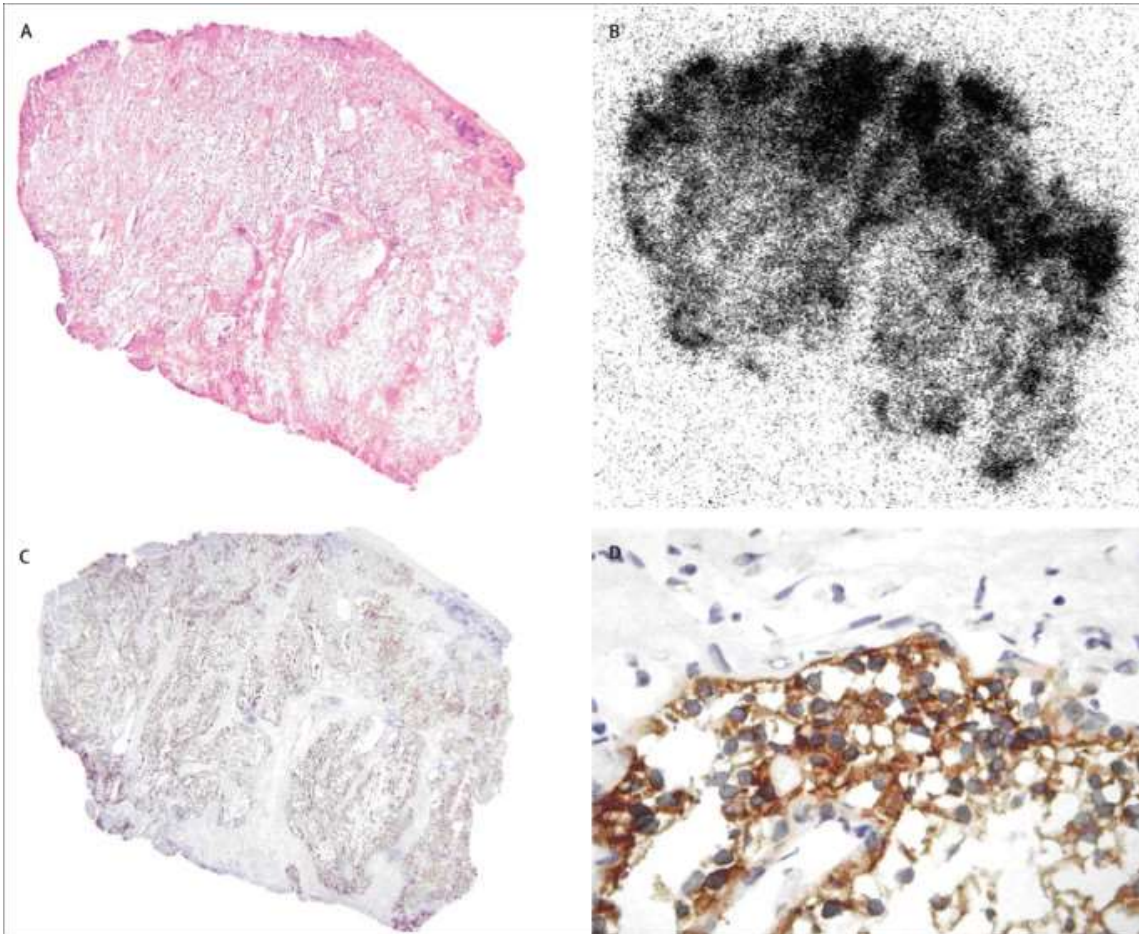
Jason P. Holland<sup>1,2</sup>, Paul Cumming<sup>3</sup>, and Neil Vasdev<sup>1</sup>

r 16,

J Nucl Med 2012; 53:1333–1336  
DOI: 10.2967/jnumed.112.105387



# AcM chimérique cG250-<sup>124</sup>I: anti-carbonic anhydrase-IX (CAIX)



*94% d'expression  
du CAIX par les CR à  
cellules claires*

SAB October 16, 2006 *Lancet Oncol.* 2007 8(4):304-10.

# Positron Emission Tomography/Computed Tomography Identification of Clear Cell Renal Cell Carcinoma: Results From the REDECT Trial

Chaitanya R. Divgi, Robert G. Uzzo, Constantine Gatsonis, Roman Bartz, Silke Treutner, Jian Qin Yu, David Chen, Jorge A. Carrasquillo, Steven Larson, Paul Bevan, and Paul Russo

## A B S T R A C T

### **Purpose**

A clinical study to characterize renal masses with positron emission tomography/computed tomography (PET/CT) was undertaken.

### **Patients and Methods**

This was an open-label multicenter study of iodine-124 (<sup>124</sup>I)-girentuximab PET/CT in patients with renal masses who were scheduled for resection. PET/CT and contrast-enhanced CT (CECT) of the abdomen were performed 2 to 6 days after intravenous <sup>124</sup>I-girentuximab administration and before resection of the renal mass(es). Images were interpreted centrally by three blinded readers for each imaging modality. Tumor histology was determined by a blinded central pathologist. The primary end points—average sensitivity and specificity for clear cell renal cell carcinoma (ccRCC)—were compared between the two modalities. Agreement between and within readers was assessed.

### **Results**

<sup>124</sup>I-girentuximab was well tolerated. In all, 195 patients had complete data sets (histopathologic diagnosis and PET/CT and CECT results) available. The average sensitivity was 86.2% (95% CI, 75.3% to 97.1%) for PET/CT and 75.5% (95% CI, 62.6% to 88.4%) for CECT ( $P = .023$ ). The average specificity was 85.9% (95% CI, 69.4% to 99.9%) for PET/CT and 46.8% (95% CI, 18.8% to 74.7%) for CECT ( $P = .005$ ). Inter-reader agreement was high ( $\kappa$  range, 0.87 to 0.92 for PET/CT; 0.67 to 0.76 for CECT), as was intrareader agreement (range, 87% to 100% for PET/CT; 73.7% to 91.3% for CECT).

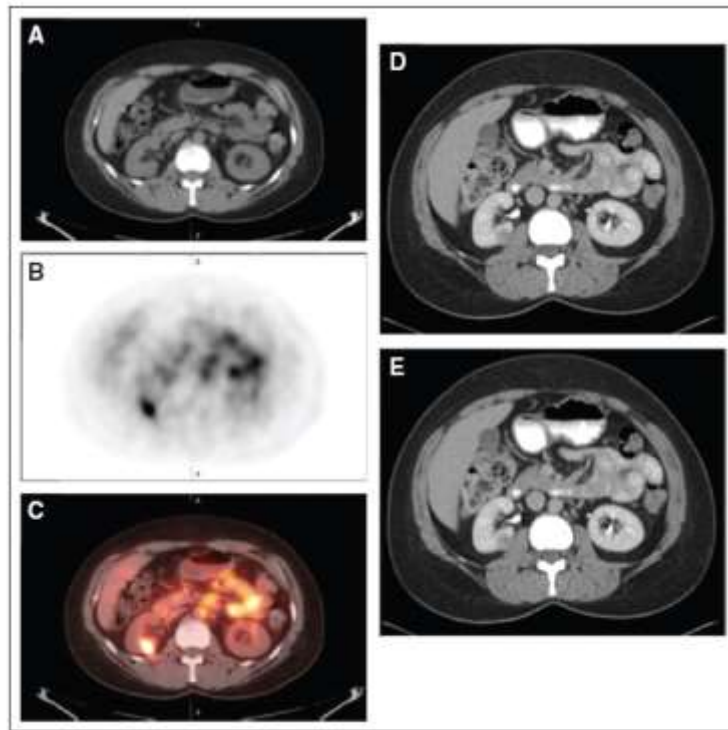
### **Conclusion**

This study represents (to the best of our knowledge) the first clinical validation of a molecular imaging biomarker for malignancy. <sup>124</sup>I-girentuximab PET/CT can accurately and noninvasively identify ccRCC, with potential utility for designing best management approaches for patients with renal masses.

*J Clin Oncol* 31:187-194. © 2012 by American Society of Clinical Oncology

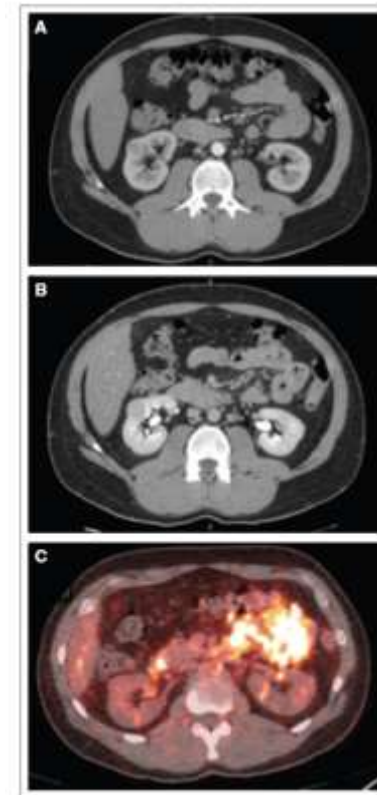
# Positron Emission Tomography/Computed Tomography Identification of Clear Cell Renal Cell Carcinoma: Results From the REDECT Trial

*Chaitanya R. Divgi, Robert G. Uzzo, Constantine Gatsonis, Roman Bartz, Silke Treutner, Jian Qin Yu,  
David Chen, Jorge A. Carrasquillo, Steven Larson, Paul Bevan, and Paul Russo*



Tumeur positive

SAB October 16, 2006



Tumeur négative



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**Table 2.** Average Diagnostic Performance Data of PET/CT and CECT

Imaging Modality	Primary Efficacy Variables				Secondary Efficacy Variables		
	Sensitivity*	95% CI†	Specificity*	95% CI†	PPV*	NPV*	Accuracy*
PET/CT	0.862	0.753 to 0.971	0.859	0.694 to 0.999	0.944	0.694	0.862
CECT	0.755	0.626 to 0.884	0.468	0.188 to 0.747	0.796	0.410	0.679
Difference (PET/CT-CECT)	0.107	0.024 to 0.190	0.391	0.195 to 0.587	0.148	0.284	0.183
P‡	.023		.005		N/D	N/D	N/D

Abbreviations: CECT, contrast-enhanced computed tomography; N/D, not done; NPV, negative predictive value; PET/CT, positron emission tomography/computed tomography; PPV, positive predictive value.

\*Average estimate of three independent, blinded central readers per imaging modality.

†95% CIs for averages and differences of averages were derived via a mixed model approach to account for correlations in the data; 95% CIs for differences of averages not calculated for secondary efficacy variables.

‡Two-sided *P* values; calculated only for primary efficacy variables.

# Médecine nucléaire en 2015: outils de la médecine personnalisée

## Prognostic imaging: $^{18}\text{F}$ FDG

Staging, restaging, aggressiveness

## Predictive imaging:

FES, peptides (SSR), antibodies (HER2), new biomarkers,

New radionuclides:  $^{68}\text{Ga}$ ,  $^{64}\text{Cu}$ ,  $^{124}\text{I}$ ,  $^{89}\text{Zr}$

## Targeted therapies

Multimodality strategies

Minimal residual disease

Interim imaging:  $^{18}\text{F}$ FDG,  $^{18}\text{F}$ FLT  
prognosis

Patient outcome

# Problématique de l'évaluation thérapeutique

« *surrogate metrics for survival* »

- Essai clinique: le nouveau traitement est-il meilleur que le traitement de référence dans la population concernée?
  - Plus efficace?
  - Aussi efficace et moins toxique?
- Pratique clinique: le traitement a t-il un intérêt chez mon patient?

# Anatomic imaging and cancer therapy evaluation

- Mesure de la taille des lésions par CT ou MRI, 2 dimensions (WHO) ou 1 dimension (RECIST)



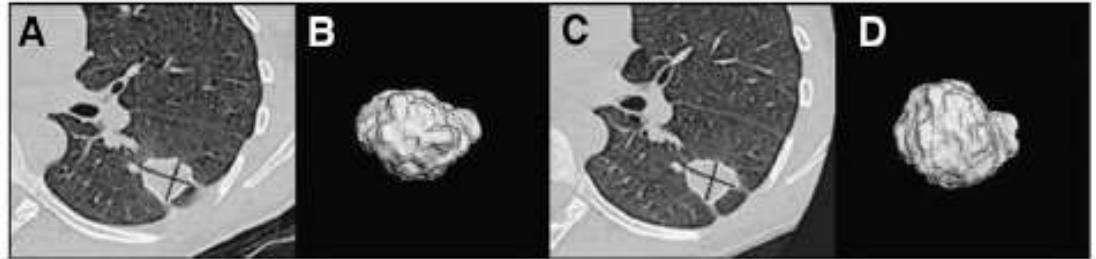
tober 16, 2

# Anatomic imaging and cancer therapy evaluation

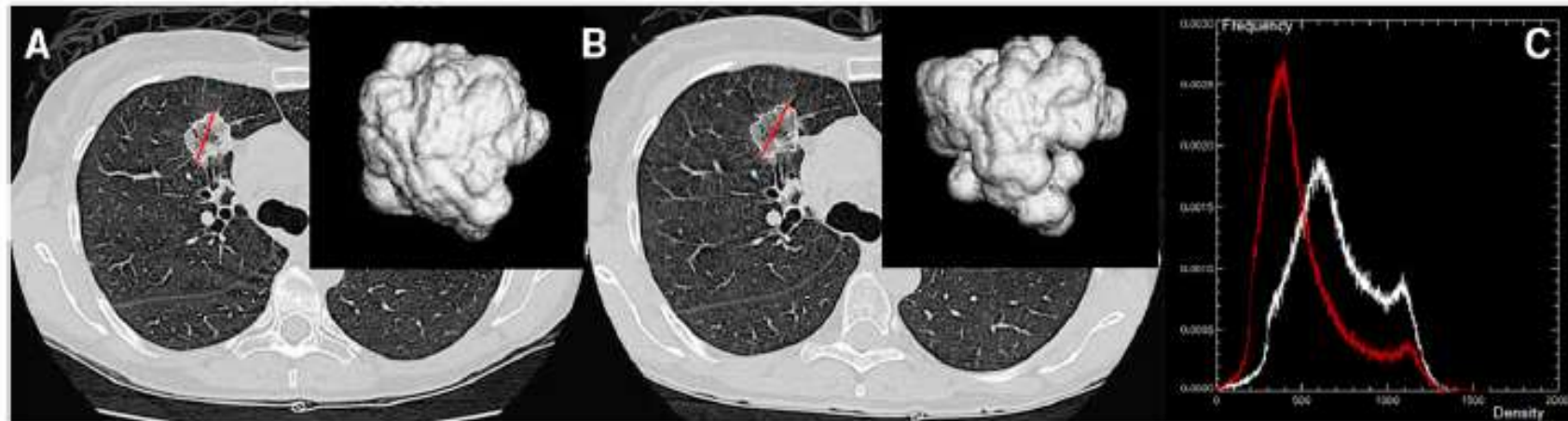
- Current anatomy-based methods have inherent limitations
  - Use of unidimensional or bidimensional measurements to quantify tumor volume changes
  - Choice of the cutoff values to classify tumor response
  - No information about changes in tumor density
  - Cannot distinguish viable tumor from dead tumor components.

# Exemple: Stabilité en 2D et progression en 3D

**FIGURE 1.** Images showing no changes in unidimensional or bidimensional measurements but enlargement of tumor along z-axis. (A) Baseline transverse CT image shows tumor contour (outlined in white), greatest diameter, and greatest perpendicular diameter (crossed lines in black) determined by semiautomated segmentation algorithm. (B) Three-dimensional view of segmented tumor on baseline. (C and D) On corresponding follow-up CT images obtained 24 d later, 3-dimensional tumor is seen from same angle along z-axis. Changes in unidimensional, bidimensional, and volumetric measurements are 0.4%, -4.4%, and 33.2%, respectively. (Reprinted with permission of (16).)



# Exemple: Pas de modification de taille mais modification de densité



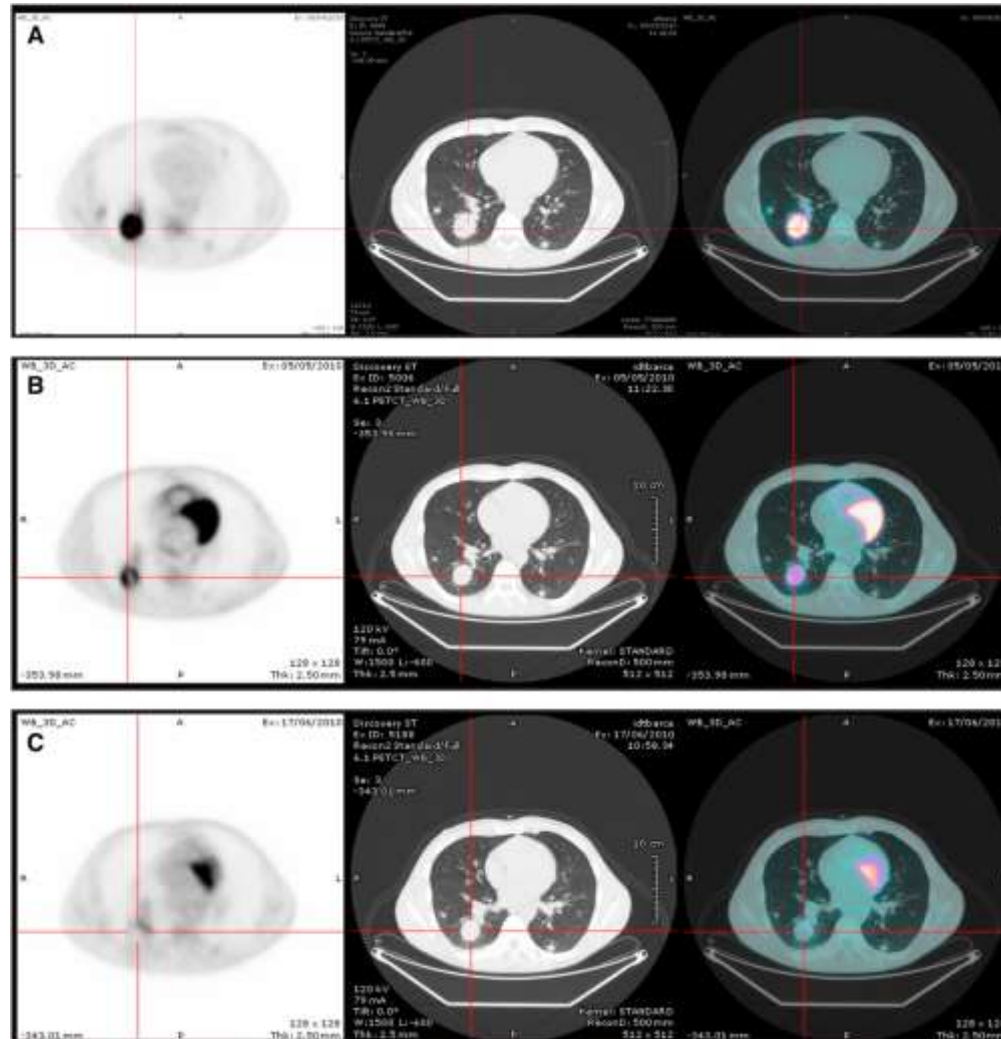
**FIGURE 2.** Images showing no change in tumor size but decrease in tumor density (ghost scenario). (A) Baseline transverse CT image with computer-generated tumor contour, greatest diameter, and 3-dimensional view. (B) On corresponding follow-up CT image obtained 21 d later, tumor is seen from same angle along z-axis. (C) Density histograms of tumor on baseline (white) and follow-up scans (red). Changes in unidimensional and volumetric measurements were 2.1% and  $-7.8\%$ , respectively. Change in tumor average intensity was  $-189$  Hounsfield unit.



# Anatomic imaging and cancer therapy evaluation

- Current anatomy-based methods have limitations to assess novel targeted therapy
  - new cancer therapies may be more cytostatic than cytoreductive, resulting in disease stabilization
  - Lack of progression may be associated with a good improvement in outcome, even in the absence of tumor size reduction

# Exemple: Tumeur pulmonaire sous TKI, réponse TEP FDG plus précoce réponse CT



SAB October 16, 2006

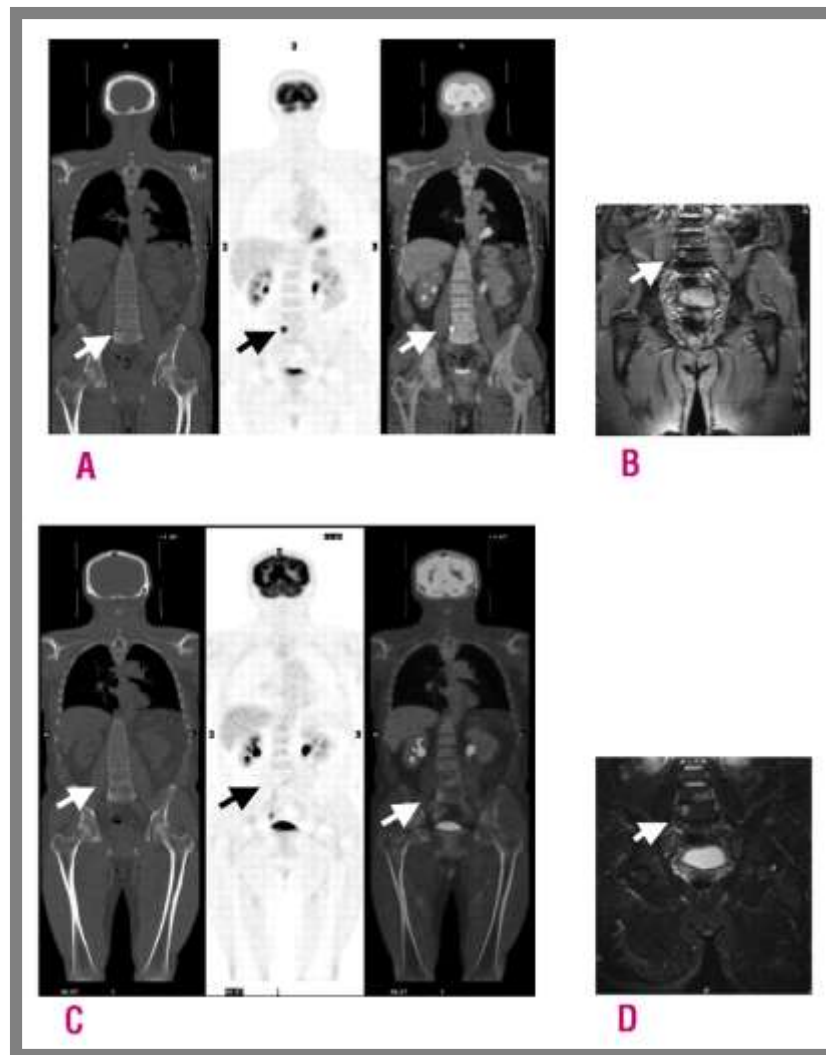
Kraeber-Bodéré, JNM, 2012

# La TEP au FDG permet d'évaluer la réponse plus précocement que l'imagerie conventionnelle

**Key Words:** molecular imaging; oncology; PET/CT; anatomic imaging; RECIST; response criteria; SUV; treatment monitoring .B October 16, 2006

**J Nucl Med 2009; 50:122S-150S**  
DOI: 10.2967/jnumed.108.057307

# Exemple d'évaluation thérapeutique d'un PS

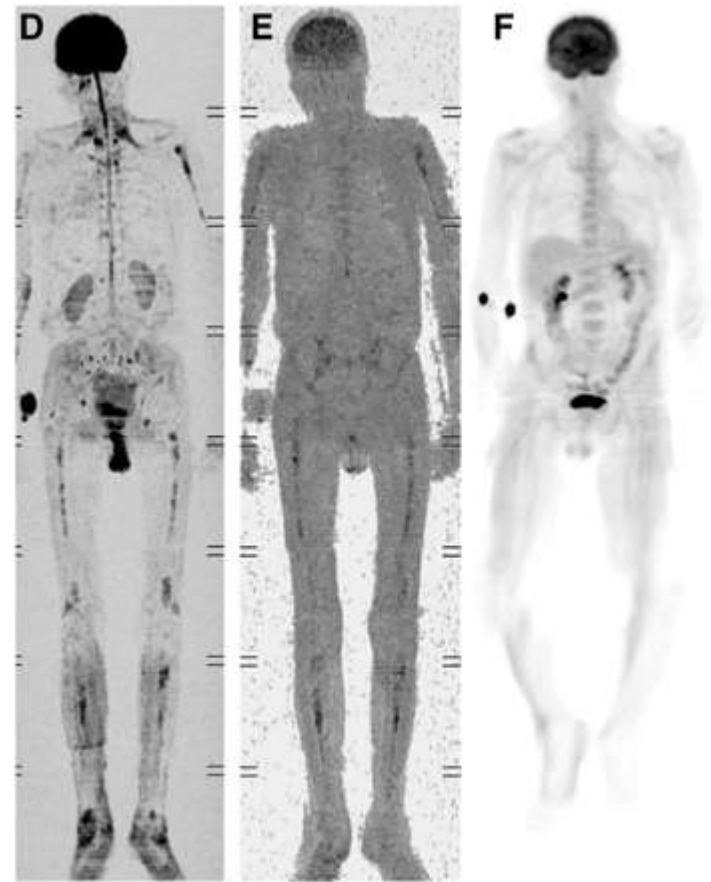
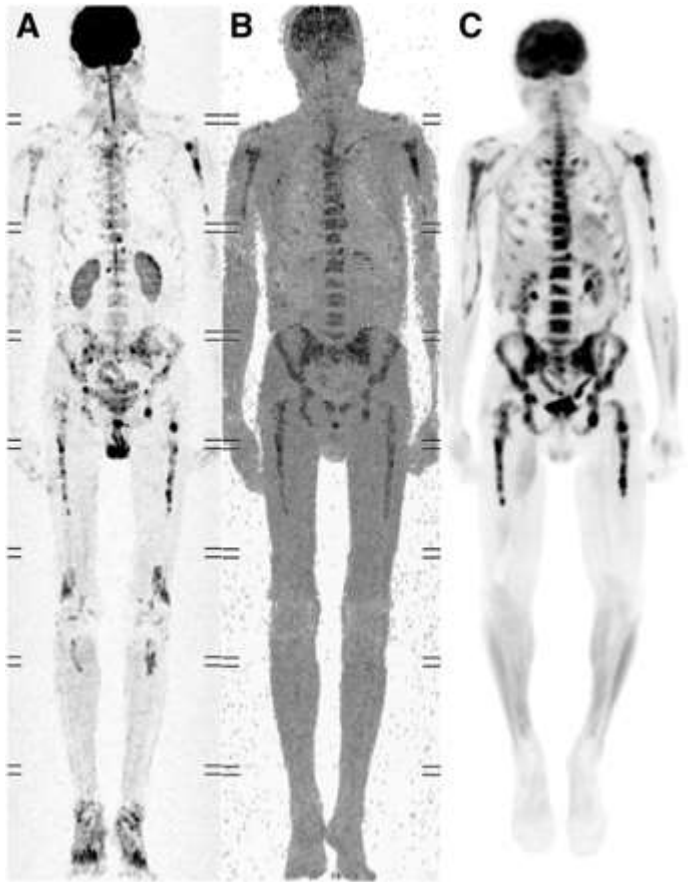


Salaun, P.-Y. et al. Haematologica 2008;93:1269-1271

SAB October 16, 2006

**Baseline:  
concordant**

**Après TTT:  
discordant**



**RC selon  
biomarqueurs**

## Prognostic relevance of 18-F FDG PET/CT in newly diagnosed multiple myeloma patients treated with up-front autologous transplantation

Elena Zamagni, Francesca Patriarca, Cristina Nanni, Beatrice Zannetti, Emanuela Englaro, Annalisa Pezzi, Paola Tacchetti, Silvia Buttignol, Giulia Perrone, Annamaria Brioli, Lucia Pantani, Carolina Terragna, Francesca Carobolante, Michele Baccarani, Renato Fanin, Stefano Fanti and Michele Cavo

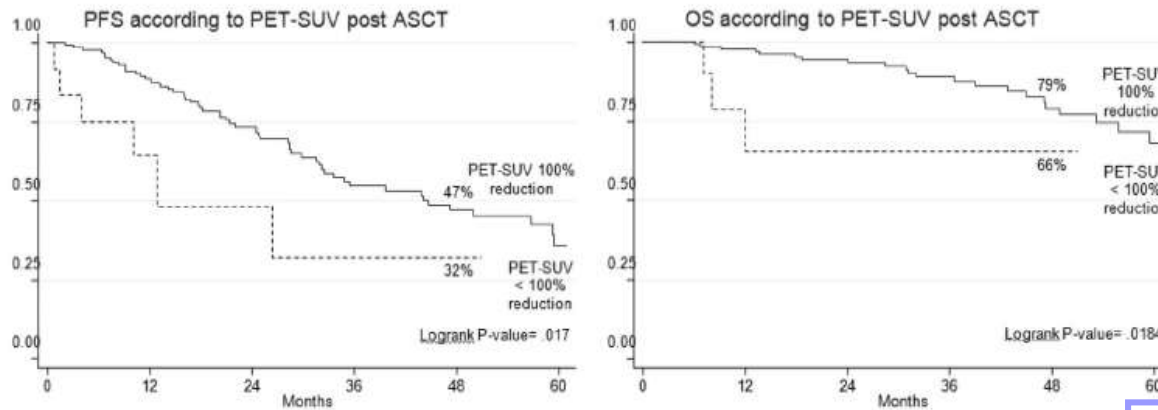


Figure 3. Outcome according to post-ASCT PET/CT.

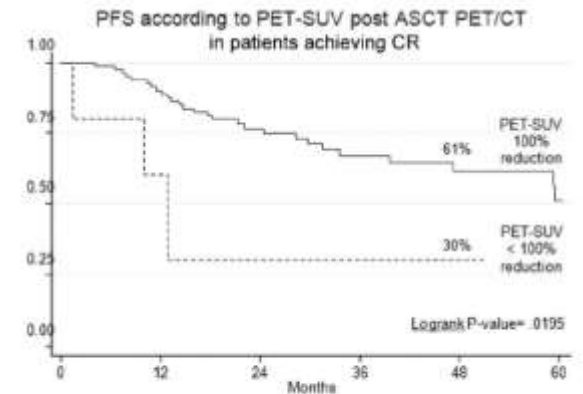
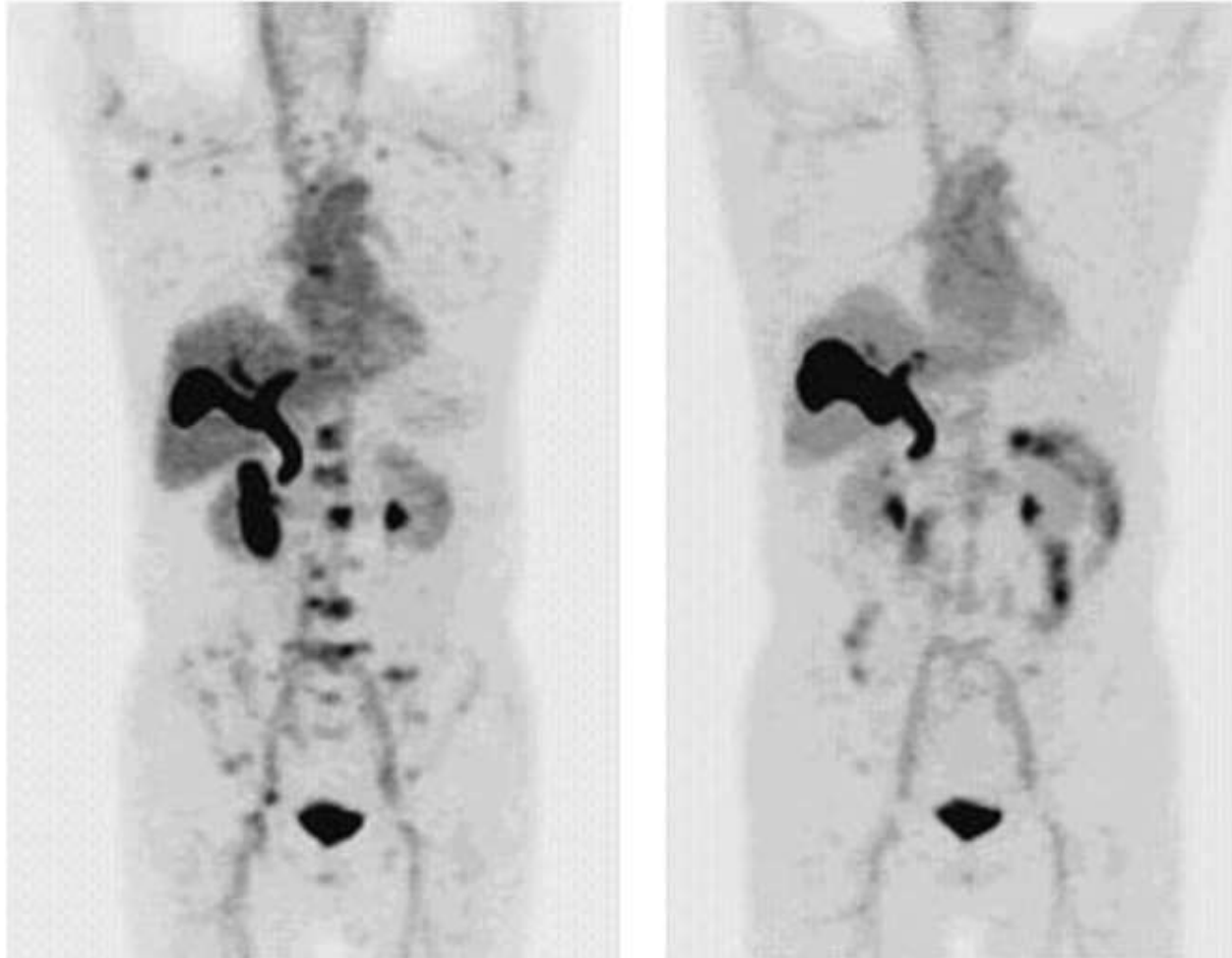


Figure 4. Outcome according to post-ASCT PET/CT in patients achieving conventionally defined CR.

# Evaluation thérapeutique : les autres traceurs



FDHT Jan 24 2008

FDHT Feb 25 2008

SAB October 16, 2000

Zhao, et al. *J Nucl Med.* 2009;50:239–249.



# En conclusion

- Nombre croissant de radiopharmaceutiques
- Cartographie corps entier d'un biomarqueur
- Imagerie pronostique: bilan initial, évaluation thérapeutique
- Imagerie prédictive: thérapie ciblée
- Outils de médecine personnalisée: théranostique, compagnon