


WEBINAR

**MANAJEMEN PENGGUNAAN PET-CT
DI RUMAH SAKIT**

 Selasa, 23 April 2024



Clinical Application of PET in Indonesia: Present and Future

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Three Pillars of Nuclear Medicine

01

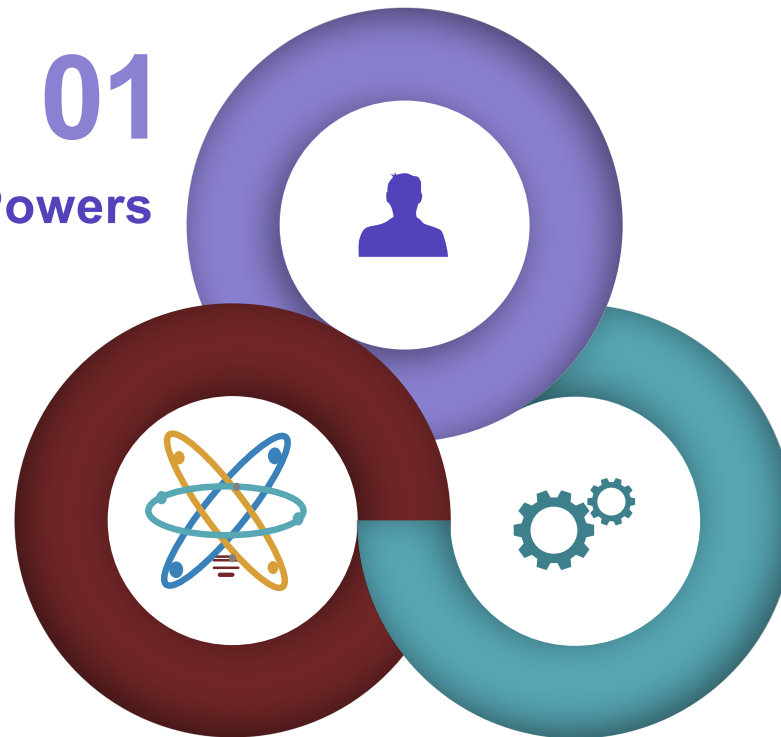
Man Powers

- NM Physicians
- Radiopharmasists
- Medical Physicists
 - Technologists
 - Nurses

02

Radiopharmaceuticals

- Generator
- Reactor
- Cyclotron



03

Equipments

- SPECT/CT
- **PET/CT**
- γ/β Counter

- Hotlab
- Radiation protection



Clinical Application of Nuclear Medicine



Diagnostics

In-Vitro (RIA/IRMA)

- **Thyroid Hormones**
 - T3
 - fT4
 - TSHs
- **Tumor Marker**
 - Thyroglobulin
 - ATA

In-vivo Imaging



Treatment

Malignant - Benign

- **Hyperthyroidism**
- **Thyroid Cancer**
- **Neuroblastoma**
- **Bone Pain Palliation**
- **Keloid**
- **Haemangioma**
- **Prostate cancer**
- **NET**

Nuclear Medicine

- Cerebrovascular disease
- Alzheimer's disease
- Schizophrenia, Epilepsy
- Neurotransmitter study

- V/Q Scan --> PE
- Regional lung function

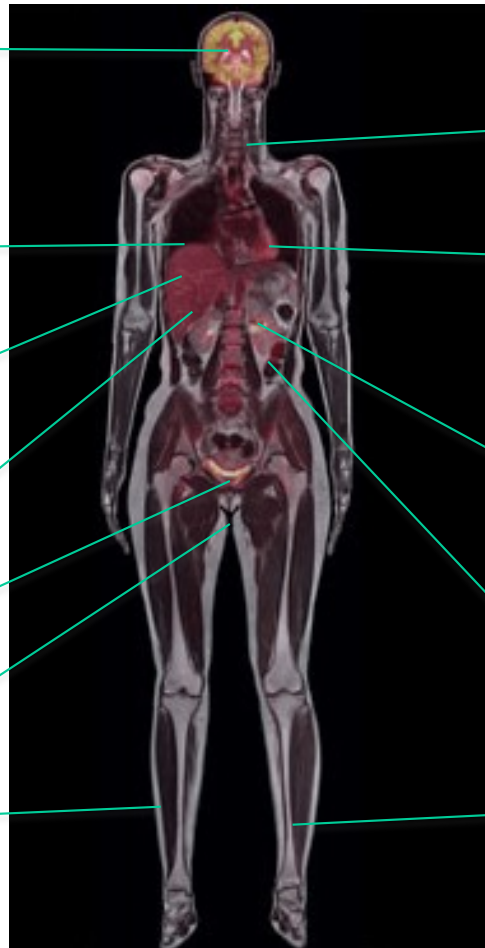
- Scintimammography
- Sentinel node detection

- Hepatobiliary scan

- Cystography

- Testicular scan

- Flebography
- Venography
- Lymphoscintigraphy



- Thyroid Scan
- Thyroid Uptake
- Neonatal hypothyroidis

- Myocardial Perfusion
- Viability Study → risk stratification
- Neuroreceptor imaging
- Prevention of restenosis
- Cardiac function

- Oesophageal TT
- Gastric emptying time
- G-E reflux

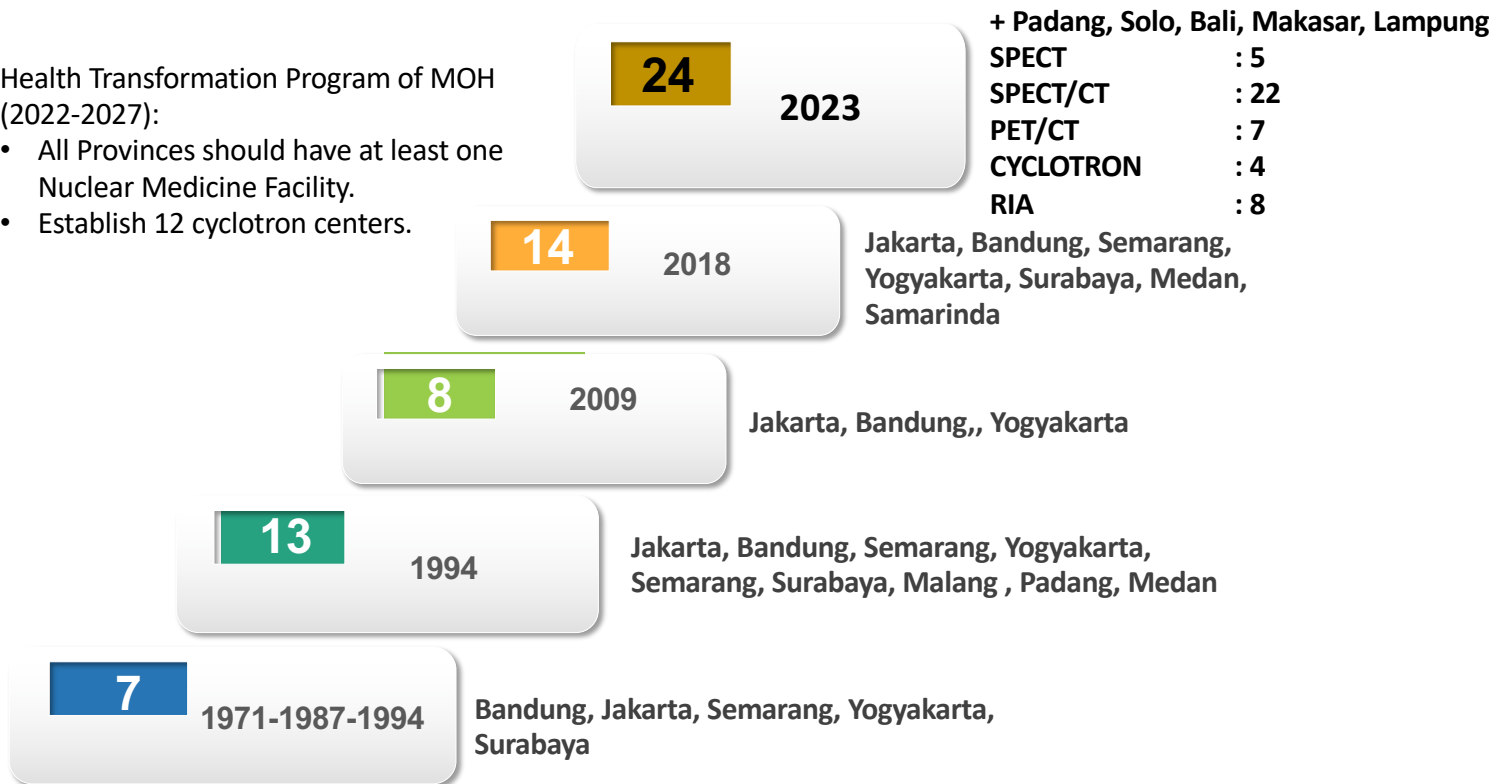
- Renography
- GFR
- ERPF
- Renal scan

- Whole body scanning
 - Bone scan
 - **PET**
 - Infection scan

NUCLEAR MEDICINE IN INDONESIA

Health Transformation Program of MOH (2022-2027):

- All Provinces should have at least one Nuclear Medicine Facility.
- Establish 12 cyclotron centers.



Future of Nuclear Medicine

Cardiology

- Myocardial Perfusion Study, Viability Study
- Neuroreceptor imaging
- Vulnerable plaque

Oncology/Cancer

- Staging and monitoring
- Diagnosis
- Radionuclide – Radioimmunotherapy
- Follow up and Evaluation

Neurosciences

- Cerebrovascular disease
- Alzheimer's disease
- Schizophrenia, Epilepsy
- Neurotransmitter study

Others

- Molecular Radiation Treatment Planning

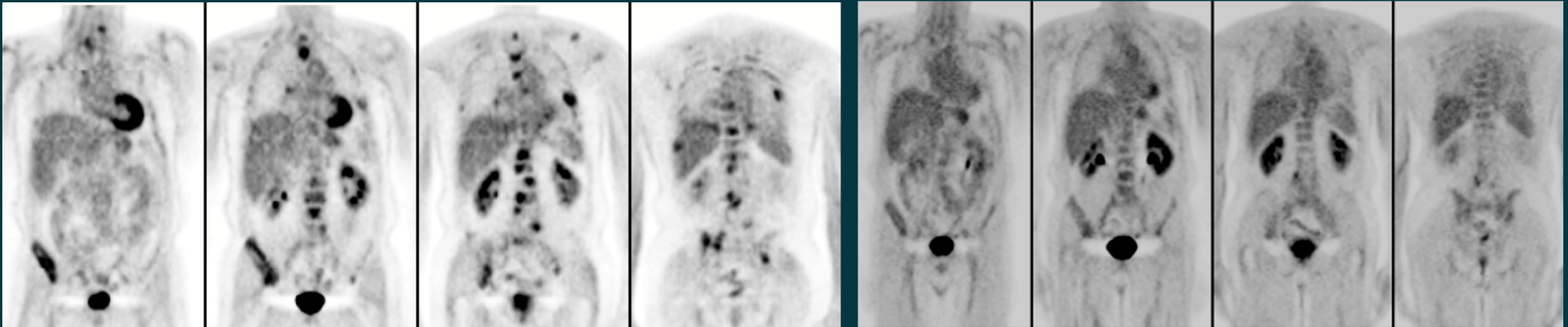
Oncology/Cancer

Staging and monitoring

**¹⁸F-
FDG**

FDG-PET 4/7/99 PSA= 75 ng/ml

FDG-PET 7/9/99 PSA=8.6 ng/ml



Herceptin followed by Taxol

RP Baum.icrt-jeju 2013

Oncology/Cancer

Diagnosis

Theranostics

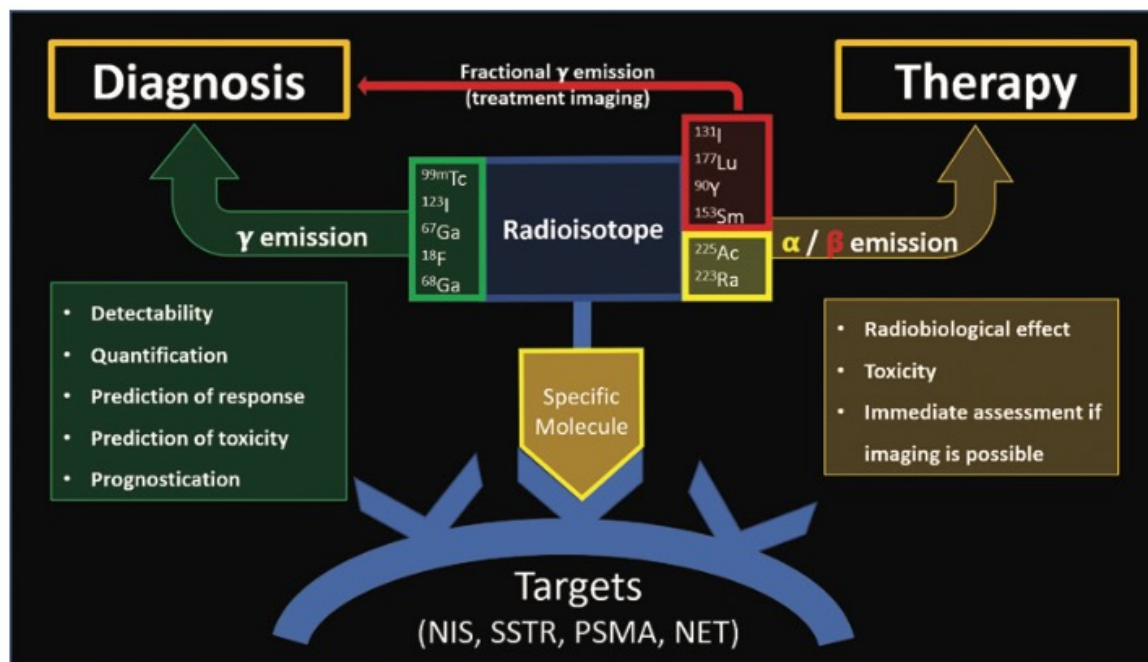
Radionuclide – Radioimmunotherapy

The combination of a *diagnostic* tool that helps to define the right *therapeutic* tool for a specific disease

- The principle is to identify the right molecular probe for the right patient in order to:
 - maximize treatment outcome and minimizing toxicity.
 - stratifies future responders from non-responders,
 - preventing unnecessary treatments,
 - Avoid the usual trial and error approach,
 - saving unnecessary drug costs

RADIONUCLIDE THERANOSTIC PAIRS

RG • Volume 40 Number 6



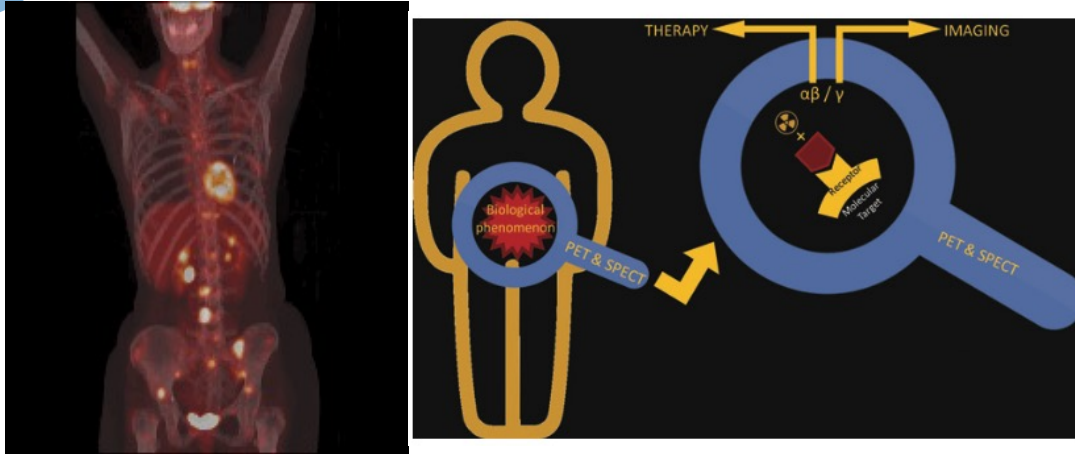
The motto:

See what you treat and *treat* what you see, *at a molecular level*

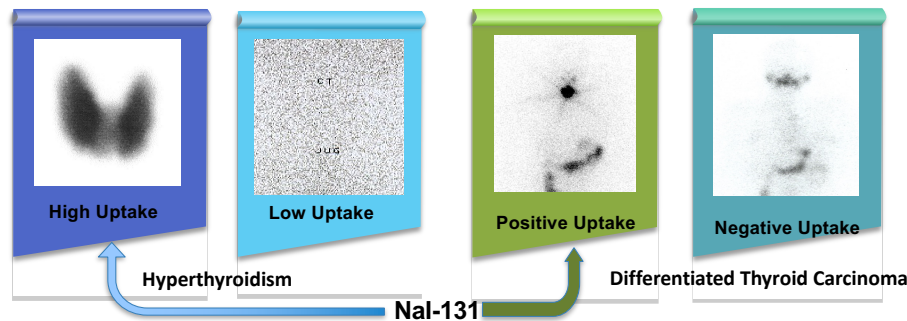
The concept:

- implies diagnosis and treatment of cells *using the same molecule*,
- guaranteeing a **targeted cytotoxic approach** of the imaged tumor cells while **sparing healthy tissues**.

Radionuclide theranostics

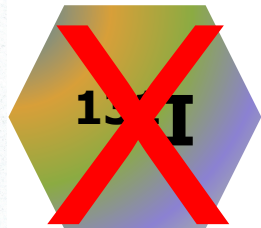
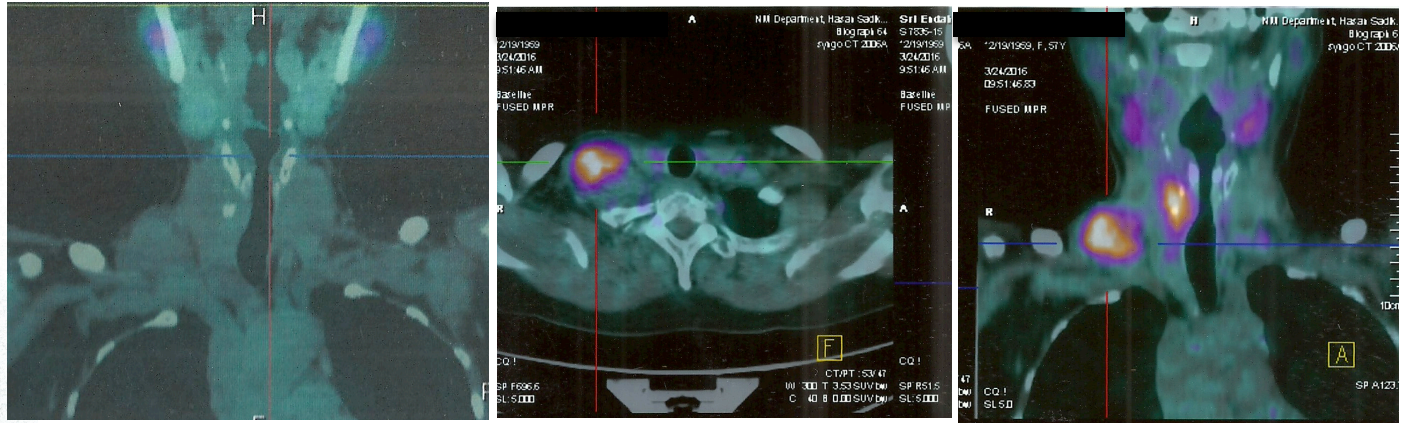
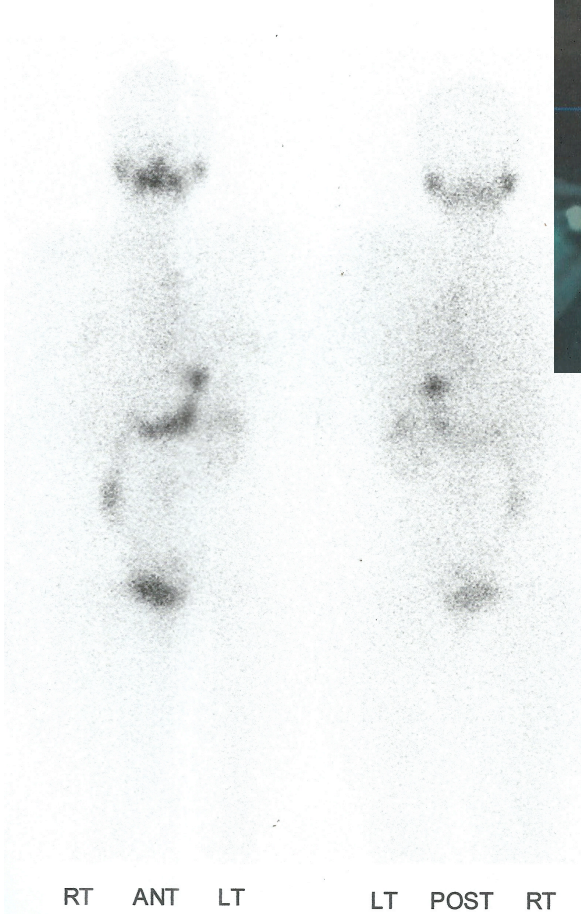


- early detection of disease,
- disease staging,
- assessment of tumoral molecular heterogeneity by imaging,
- therapy selection,
- treatment planning, and
- subsequent targeted and tailored treatment based on the diagnostic molecular imaging results.



: SST DIAGNOSTIK

Study Date: 3/23/2016



F 56 yrs papillary thyroid ca
Post Total Thyroidectomy and ^{131}I ablation (100 mCi)

- **Negative ^{131}I - scan**
- **Tg : 18.5 ng/dL**
- **Anti-Tg : > 3000 U/mL**

A 74-year old patient with hormone and chemo-refractory prostate cancer underwent PSMA PET/CT.

Oncology/Cancer

Theranostics

^{67}Ga
PSMA



(A) :showed diffuse abdominal and iliacal lymph node metastases.

The PSA level 790 ng/ml

^{177}Lu -
PSMA

5.7 GBq

(B): A partial response 7 weeks after RLT
the PSA level was 293 ng/ml
(decline 63%)



Oncology/Cancer

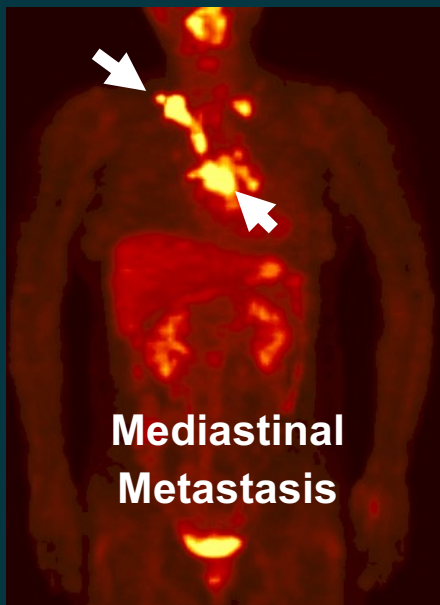
Cervix Cancer

Pretreatment
('01.7.25.)

Post-chemotherapy
('01.12.14.)

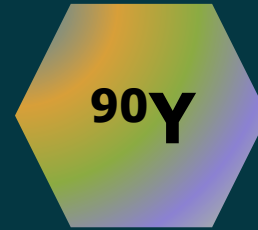
Recurrence
('02.4.16.)

Follow up and Evaluation

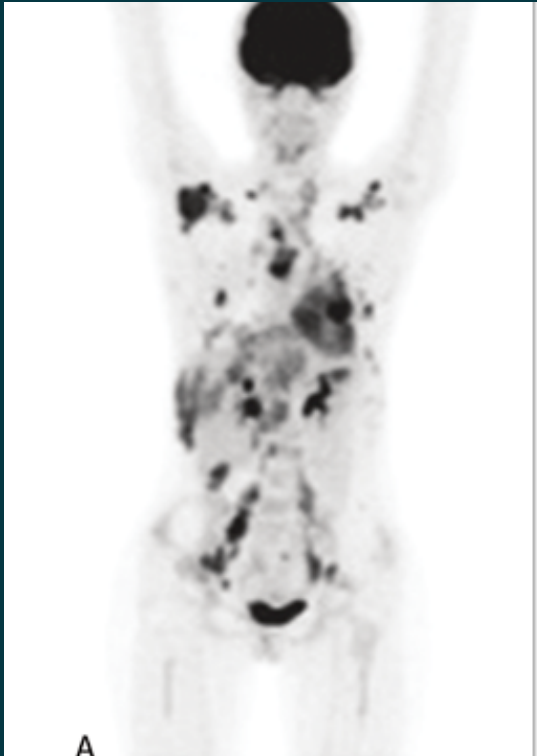


(Images courtesy of G Mariani, Pisa University Medical School, Italy.)

Oncology/Cancer



Treatment of non-Hodgkin's lymphoma with radio-immunotherapy (Y-90-ibritumomab tiuxetan (Zevalin)).

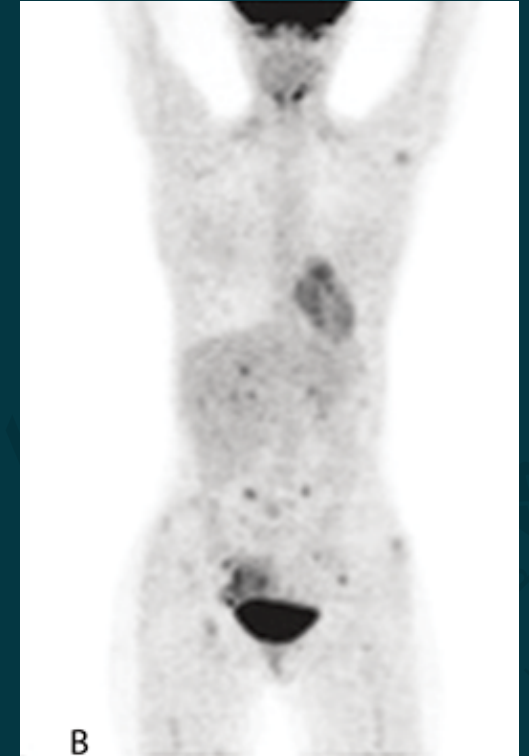


A. FDG- PET/CT before treatment:

Follow up and Evaluation

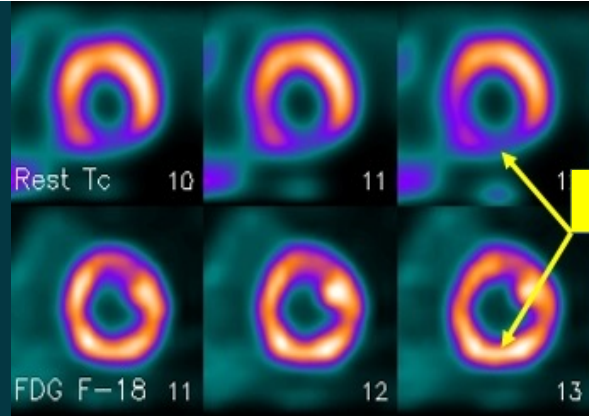


B. FDG-PET/CT after two administrations of Zevalin. no evidence of disease activity.



Use of positron-emitting isotopes

- oxygen-15,
- carbon-11,
- nitrogen-13, and
- fluorine-18,



Perfusion-Metabolism Mismatch

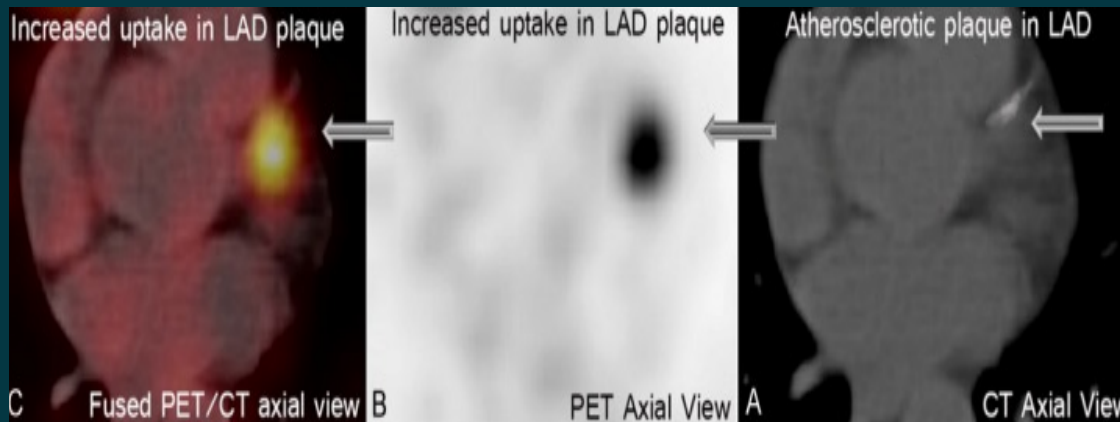
- *hibernating*
- *scarred*
- *stunning.*

Myocardial Perfusion Study, Viability Study

Neuroreceptor imaging

Vulnerable plaque

Cardiology

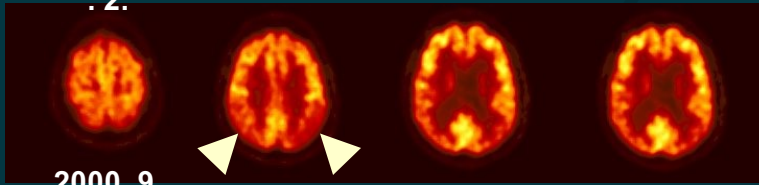
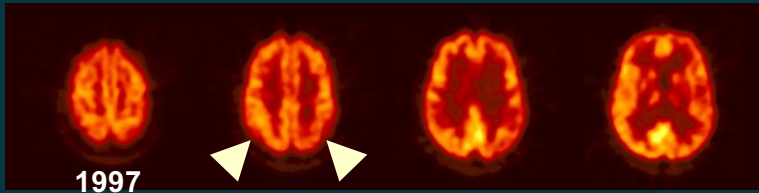


Am J Nucl Med Mol Imaging 2015;5(1):65-71
www.ajnmml.us / ISSN:2160-8407/ajnmml0001379

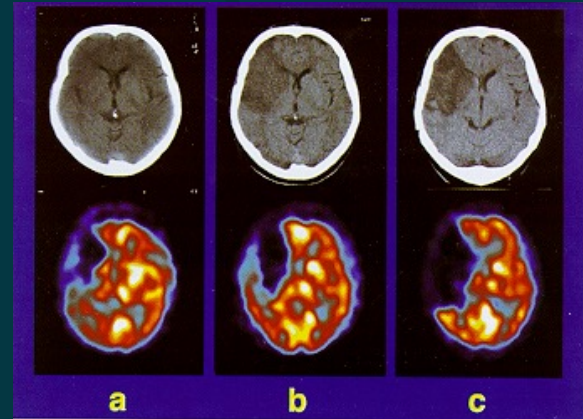
Original Article
Assessment of vulnerable atherosclerotic and fibrotic plaques in coronary arteries using ⁶⁸Ga-DOTATATE PET/CT

Allreza Mojtahedi^{1,2}, Abass Alavi³, Sanjay Thakur², Reza Amerinia¹, David Ranganathan⁴, Izabela Tworowska², Ebrahim S Dehpasand^{1,2}

- Activated Macrophage → somatostatin receptor-2 (SSTR-2) expression
- **⁶⁸Ga-DOTATATE** binds to SSTR-2 : High risk plaque detection
- Detect Inflammation and angiogenesis



Decreased Metabolism of bilateral parietal lobes

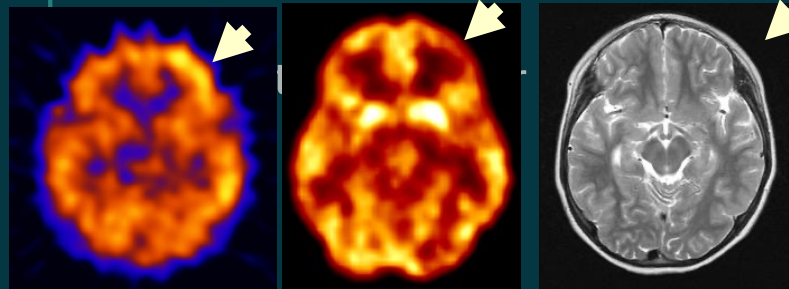


Neurosciences

Cerebrovascular disease

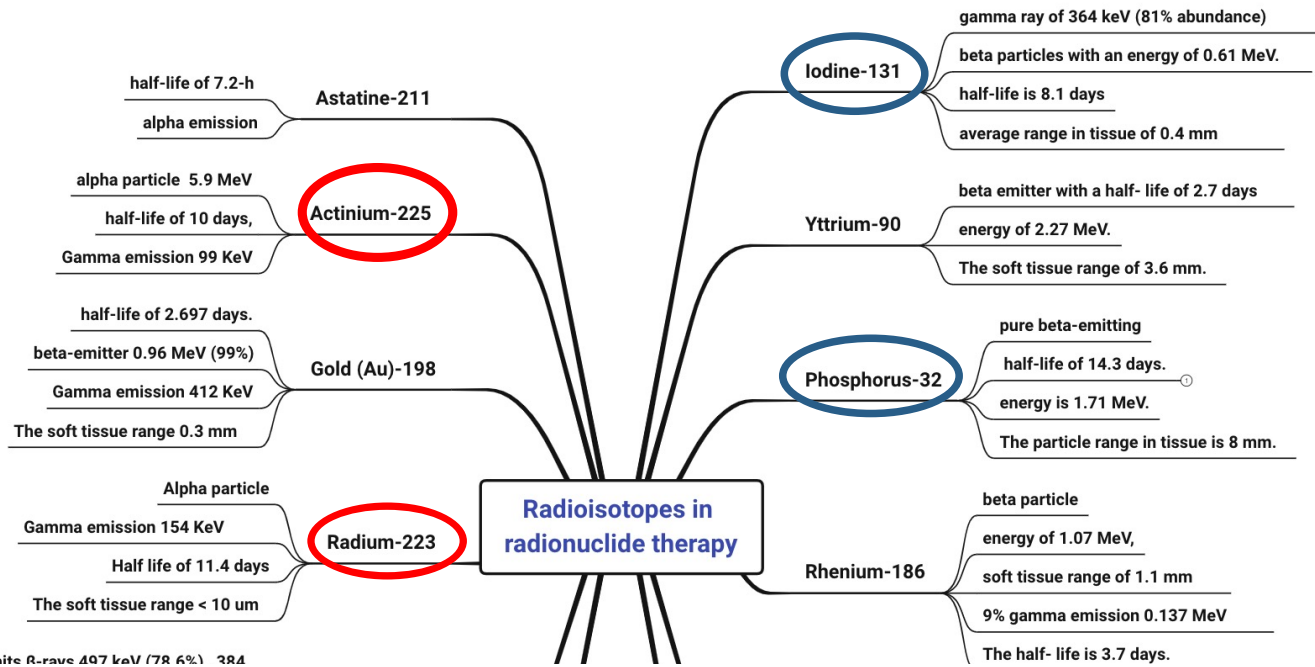
Alzheimer's disease

Schizophrenia, Epilepsy



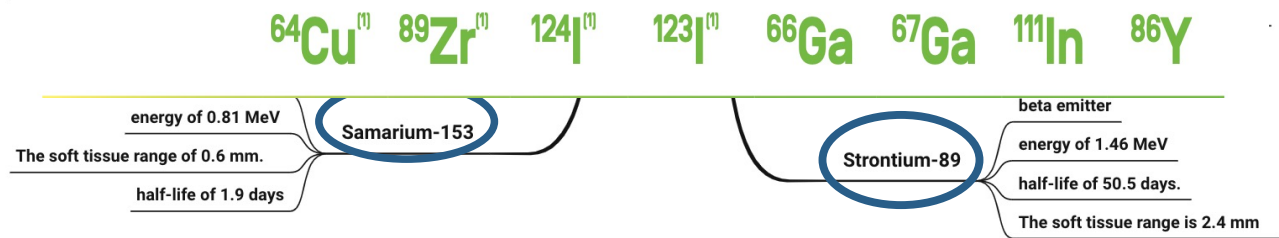
Future Developments in Theranostics

- The development of ***new molecular targets***,
- ***Dosimetry estimates***
- a ***combination of treatments*** in the early stage might have potential of achieving complete remission.
 - ^{177}Lu -DOTATATE combined with nivolumab in small-cell lung cancer:
 - ^{177}Lu -PSMA-617 with pembrolizumab in mCRPC
 - TRT with chemotherapy and radiation therapy.



emits β^- -rays 497 keV (78.6%) 384

g: **TYPICAL PRODUCTION WITH SOLID TARGETS – PET/SPECT ISOTOPES**



Targeted Drugs and Targeting Abnormal Metabolism of Cancer

Various targeted drugs developed

- designed to work on *specific molecular targets* in cancer cells,
- sparing non-target organs while retaining the therapeutic benefit
- the most advanced targeted drugs available
- as monotherapy or in combinations to overcome tumor heterogeneity,

• Various targeted drugs classes :

- small molecules,
- peptides,
- proteins,
- Antibodies
- **Various molecular targets** (generally cell signaling),
 - angiogenesis (VEGF, VEGFR, $\alpha v\beta 3$ integrin)
 - cell proliferation (EGFR, HER2)
 - specific receptors (folic acid receptors, biotin D, LDL, CD20, etc.)

An ideal molecular target

- should be highly cancer-specific (strictly available in cancer cells)
 - have simultaneous catastrophic impacts

TARGET

- Having a suitable biochemical mechanism to retain the Rph at the disease site.
- Ideally the targeting receptor or the antigen should not be present in normal tissues;

Various Targets

Peptides are related to specific receptors which are expressed/overexpressed in various type of cancers

HER2 Receptors

no identifiable ligand unless in dimerization with other growth factors.

a key oncogene in BC

Application of anti-HER2 mAb 'trastuzumab' is the most common procedure in treatment of BC

No competition radiolabeled trastuzumab in theranostic

Suhfynae RR1

Fatty Acid Synthase (FAS)

an enzyme required to regulate de novo biosynthesis of long-chain fatty acids.

High expression of FAS in cancer cell is a poor indicator in patients with breast, ovary and prostate cancer.

α -mangostin

compound of Garcinia mangostana.

potential ligand for cancer theranostic

can inhibit FAS at the acetyl binding site

Fibroblast activation protein (FAP)

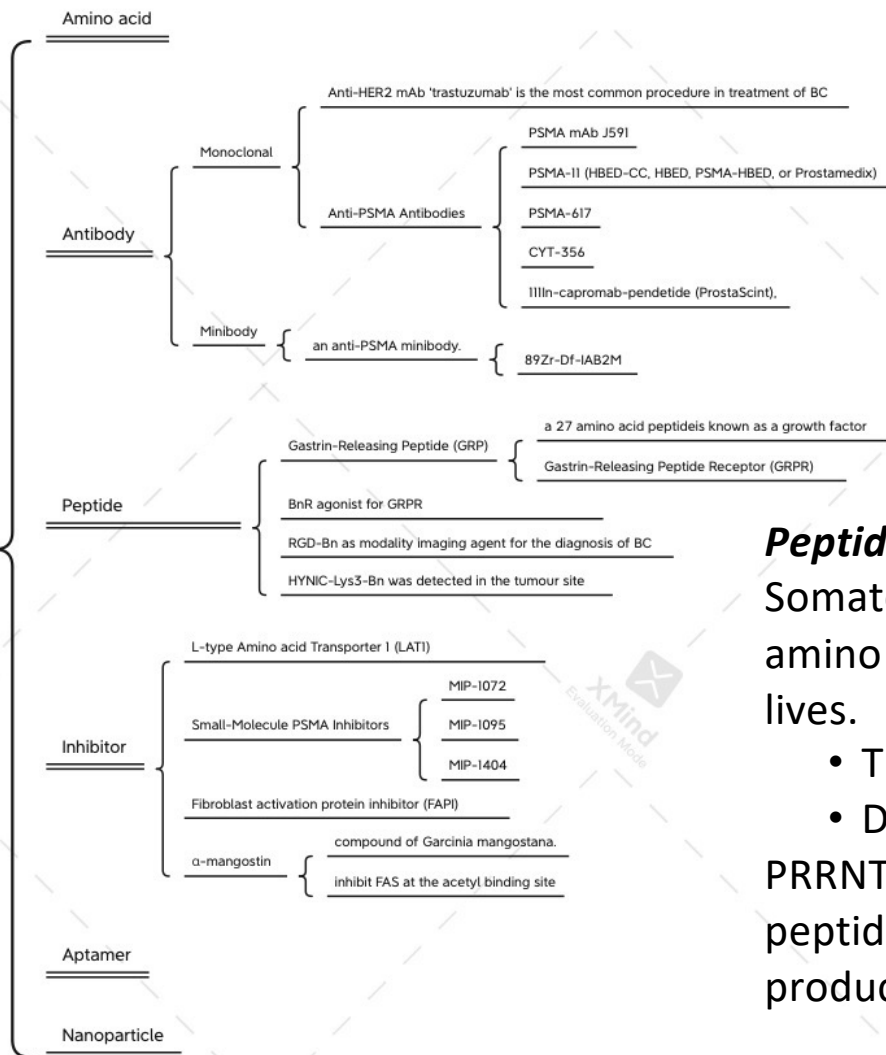
cancer-associated fibroblasts differ from normal fibroblasts

FAP inhibitors (FAPis) have already been developed as cancer drugs

^{68}Ga -FAPi-PET/CT advantage over ^{18}F -FDG-PET/CT

L-type Amino acid Transporter 1 (LAT1)

Various ligand



Several next-generation anti-PSMA antibodies are now either fully human or humanized, thus making them even more likely to be diagnostically and therapeutically effective.

Peptide receptor radionuclide therapy (PRRNT)
Somatostatin analogues having lesser number of amino acids and having higher biological half-lives.

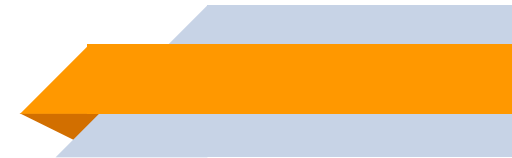
- The octapeptides, lanreotide,
- DOTATOC, -TATE, and -NOC

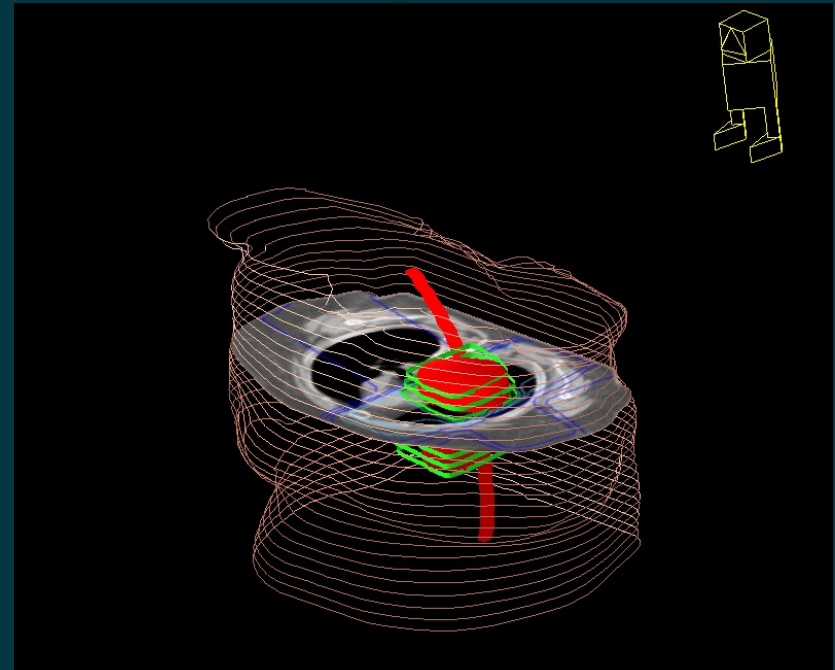
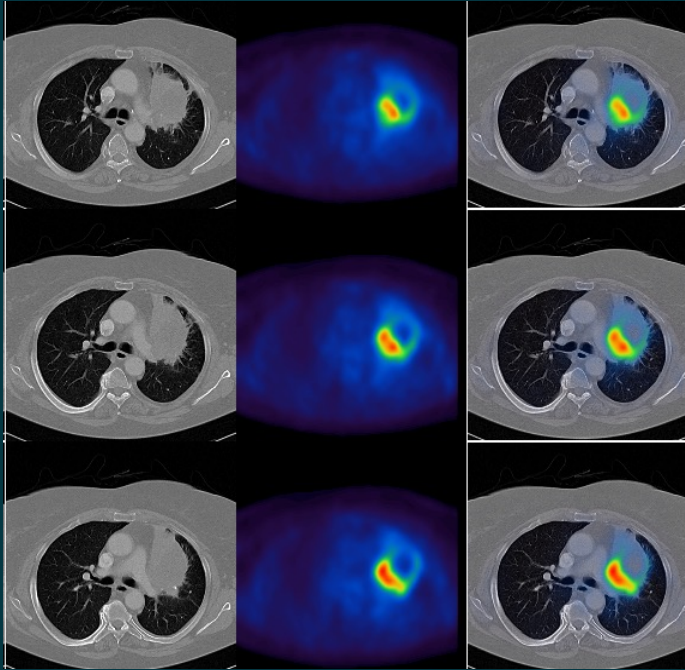
PRRNT is growing rapidly with many other peptides being tried for the development of new products.



Nuclear Medicine (PET)

- Diagnostic and therapy (**theranostic**) *Personalized medicine, targeted medicine*, and *precision medicine*
- Whole-body **target expression**
 - can be quantified
 - early predicting therapy response and progressive disease
- **The criteria** to define progressive disease:
 - the **WHO** criteria,
 - Response Evaluation Criteria in Solid Tumors (**RECIST**),
 - Positron Emission Tomography Response Criteria in Solid Tumors (**PERCIST**)
- **Endpoint biomarkers** in
 - oncology,
 - cardiology,
 - neurology, and
 - infectious and inflammatory disorders.
 - Degenerative disease





Others

**Molecular Radiation
Treatment Planning
(MRTP)**



Thank You
For Your Attention