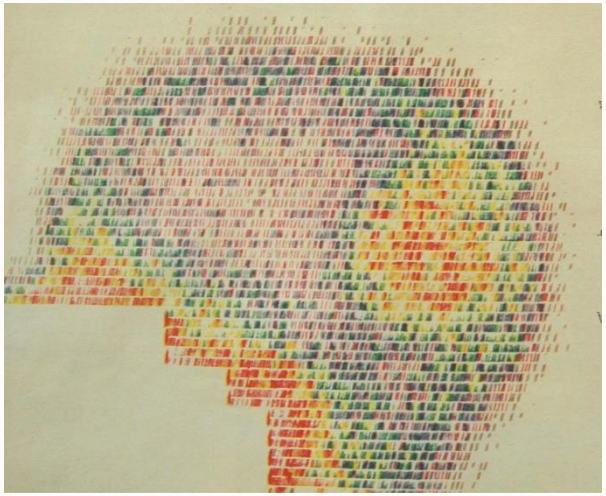
A brief history of nuclear medicine

van impressionisme naar surrealisme

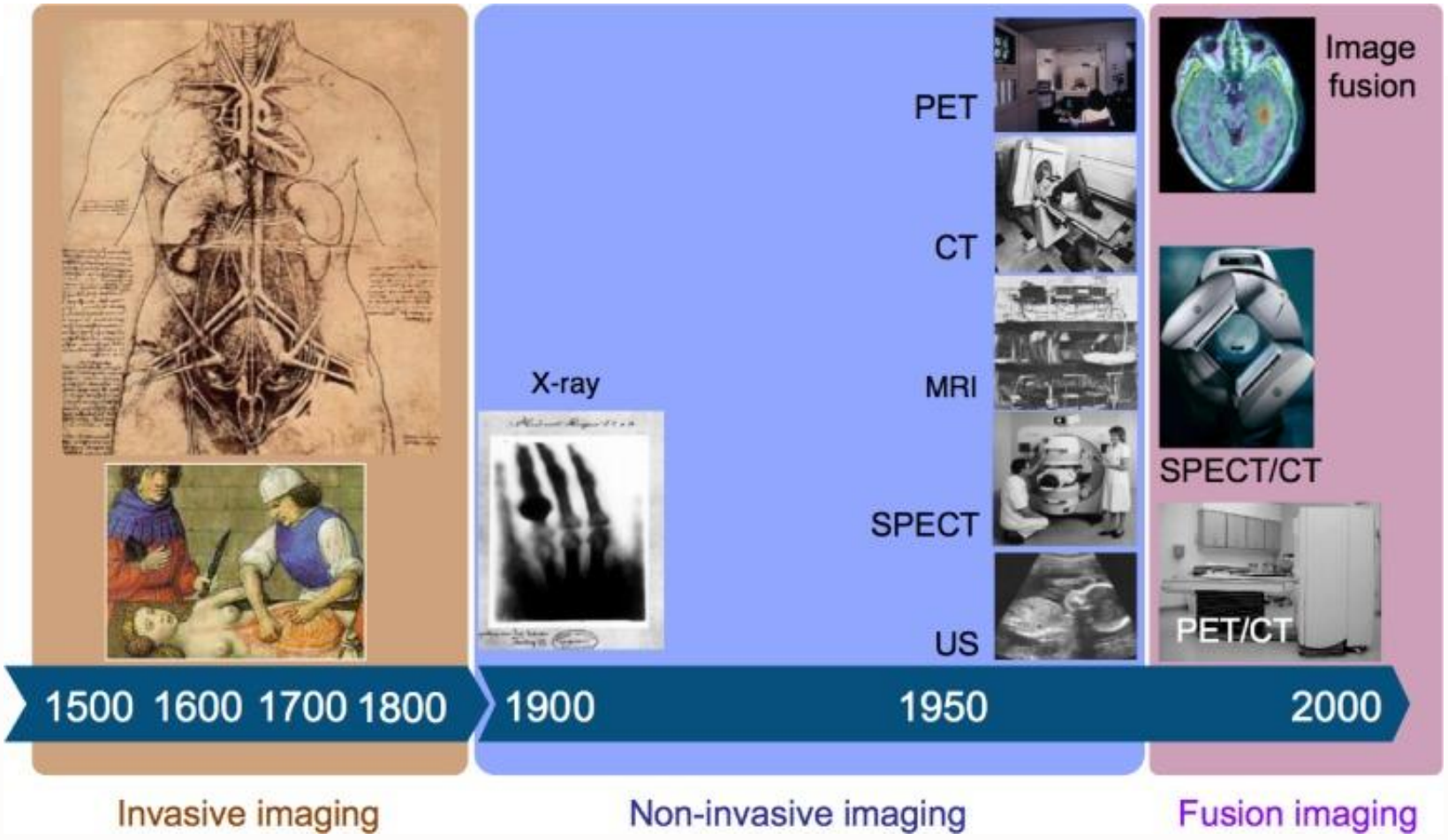




14 november 2026
KARVA

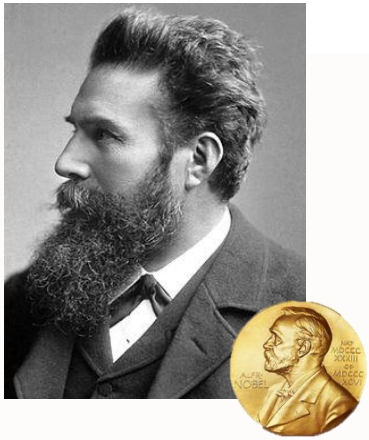
Dr. Filip Homans
ZAS nucleaire geneeskunde

ZIEKENHUIS aan de STROOM



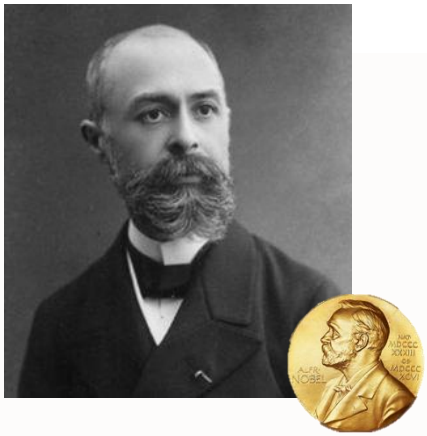
ZIEKENHUIS aan de STROOM

De drie pioniers van ‘radioactiviteit’



Wilhelm Röntgen
(1845-1923)

Ontdekker van
‘X’-stralen (1895)
(kathodebuis)



Henri Becquerel
(1852-1908)

Ontdekker van
spontane straling uit
uraniumzouten (1896),
geladen partikels



Marie Curie
(1867-1934)

Ontdekking van Radium,
Polonium (1898)

Voerde de term
‘radioactiviteit ‘ in

ZIEKENHUIS aan de STROOM



Irène en Fréderic Joliot-Curie

1934 ontdekking van
artificiële radio-activiteit
(irradiatie met α)



Ernest O. Lawrence
1936 ontwikkeling van eerste
cyclotron in Berkeley

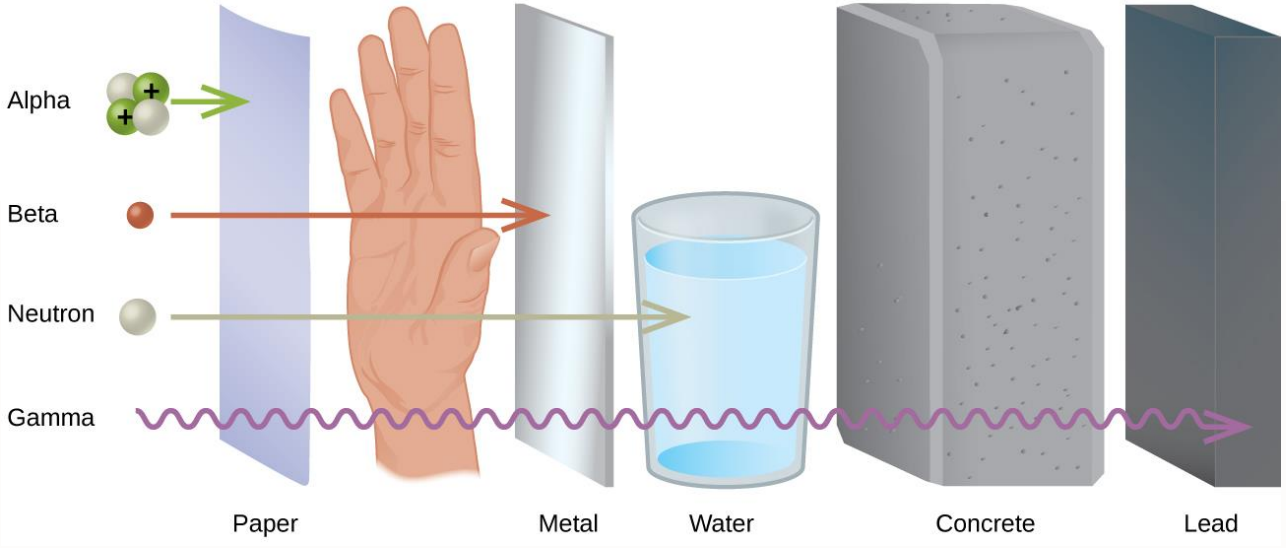
ontdekking van oa C^{11}, P^{32}, I^{131}
Tc^{99m} en F^{18}

ZIEKENHUIS aan de STROOM

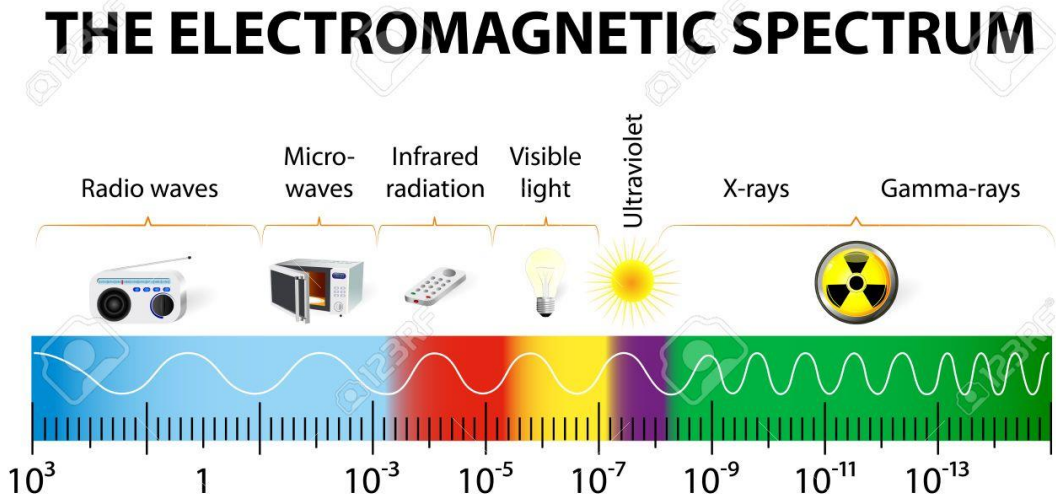
In the 1920s a drink called RadiThor was sold as an energy booster and cure for ailments like impotence. It was radium dissolved in water, slowly poisoning its buyers. It never became a public health crisis because only the rich could afford it.



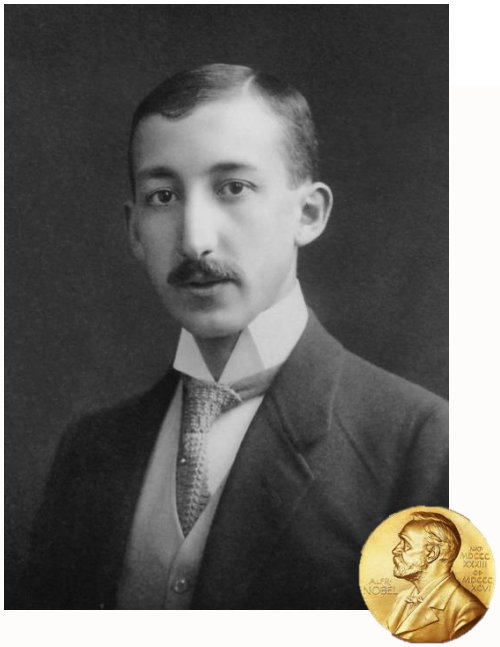




Alpha particle	$^{4}_{2}He$ or $^{4}_{2}\alpha$	
Beta particle	$^{0}_{1}e$ or $^{0}_{-1}\beta$	
Positron	$^{0}_{+1}e$ or $^{0}_{+1}\beta$	



Het tracerprincipe



Georg Karl von Hevesy (1885 –1966)
Hongaarse radiochemicus

was de grondlegger van het '**tracer-principe**'
bestudeerde de botanische fysiologie dmv oa Pb^{210}
"radiofarmaca kunnen participeren in biologische processen zonder deze te verstoren"



ZIEKENHUIS aan de STROOM

In vivo biochemistry

Dr Saul Hertz, MIT 1936

The fact that iodine is selectively taken up by the thyroid gland when injected into the body makes it possible to hope that iodine which is made radioactive ... will be a useful method of therapy in cases of overactivity of the thyroid gland



Hertz and his colleague Doris Darby demonstrate the use of a multicounter to measure the amount of radioactive iodine absorbed by a patient's thyroid gland, ca. early 1940s. *Courtesy of the Dr. Saul Hertz Archives.*



—SEIDLIN ET AL. J. A. M. A. Dec. 7, 1946

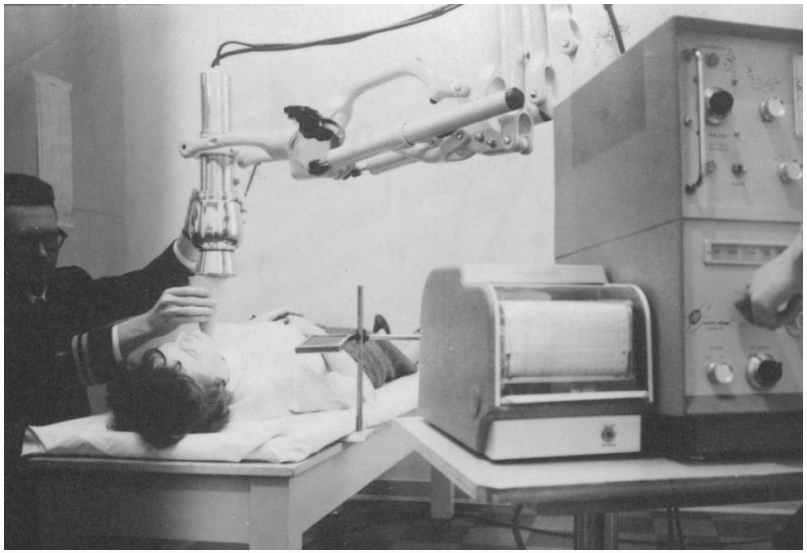
RADIOACTIVE IODINE THERAPY

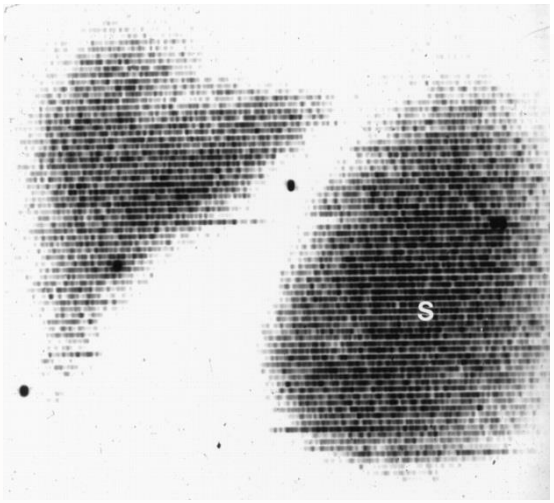
Effect on Functioning Metastases of Adenocarcinoma of the Thyroid

S. M. SEIDLIN, M.D.
L. D. MARINELLI, M.A.
and
ELEANOR OSHRY, B.S.
New York

ZIEKENHUIS aan de STROOM

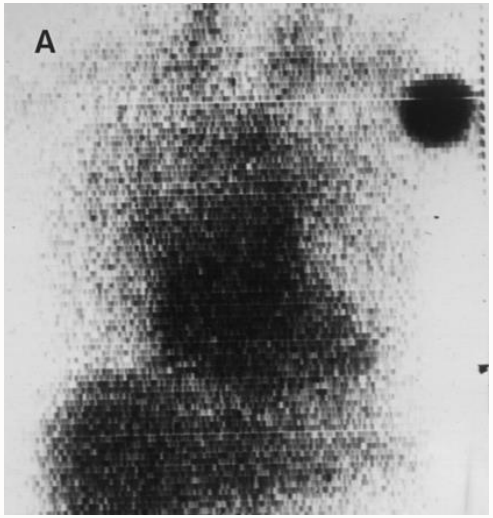
Rectilineaire scanner

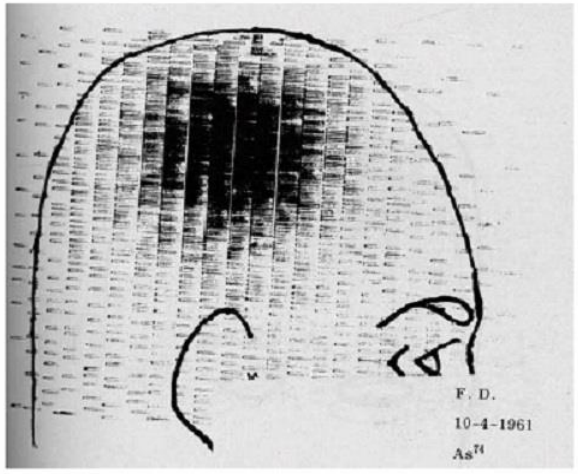




***Benedict Cassen* (1902-1972)**

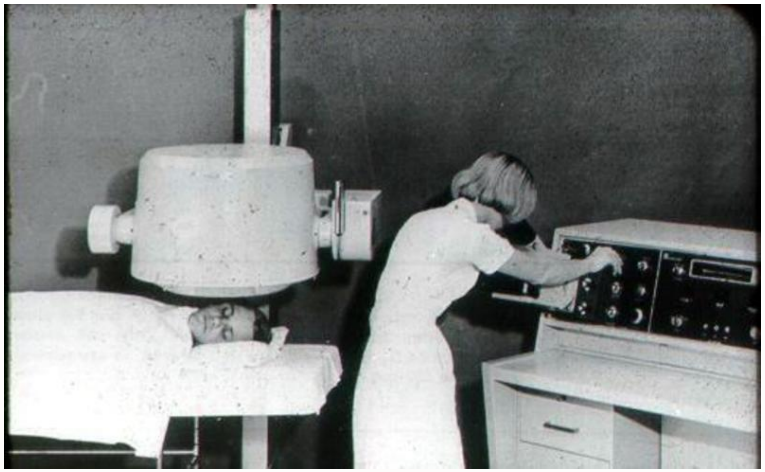
Amerikaanse biofysicus ontwikkelde de eerste **rectilineaire scanner** (1950)



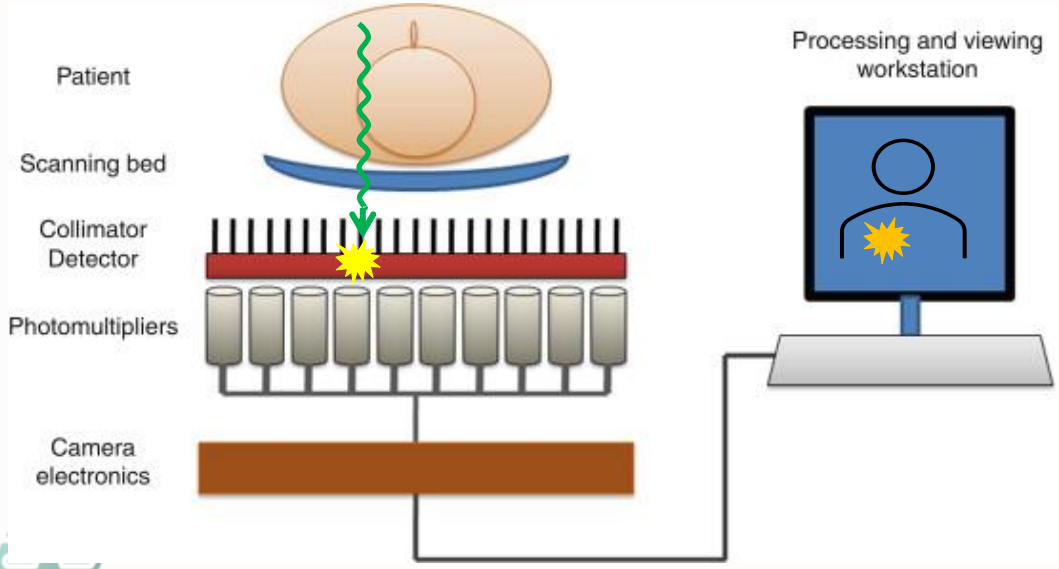


ZIEKENHUIS aan de STROOM

Gamma-camera







Hal Oscar Anger (1920 –2005)
Amerikaanse biofysicus
ontwikkelde in 1958 de eerste gammacamera:
'Anger scintillation camera'

ZIEKENHUIS aan de STROOM

PET-camera



A Brief History of Positron Emission Tomography (PET)

Henry N. Wagner, Jr

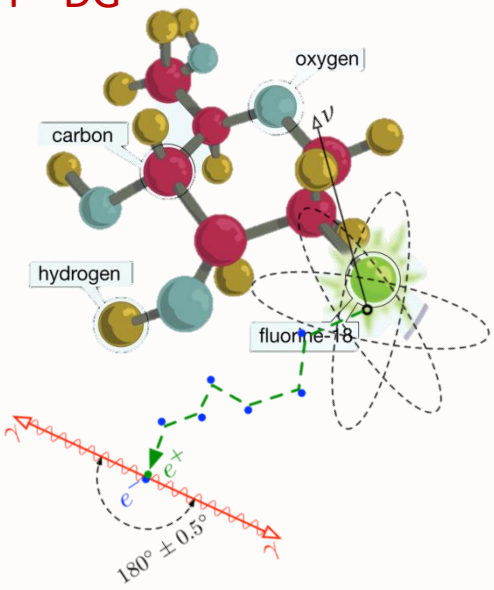
The development of positron emission tomography (PET) illustrates how advances in basic science translates into benefits for human beings. In 1930 Ernest Lawrence and co-workers conceived of the cyclotron. By 1938 Lawrence, Livingston, et al had designed a "medical cyclotron." The subsequent production of C-11, N-13, O-15, and F-18 found many uses in medical and physiologic research. The introduction of F-18 deoxyglucose represents another major step toward practical clinical use of positron-emitting tracers. We have now achieved the transition from the postulation of the existence of positrons to their use in a wide variety of diseases.

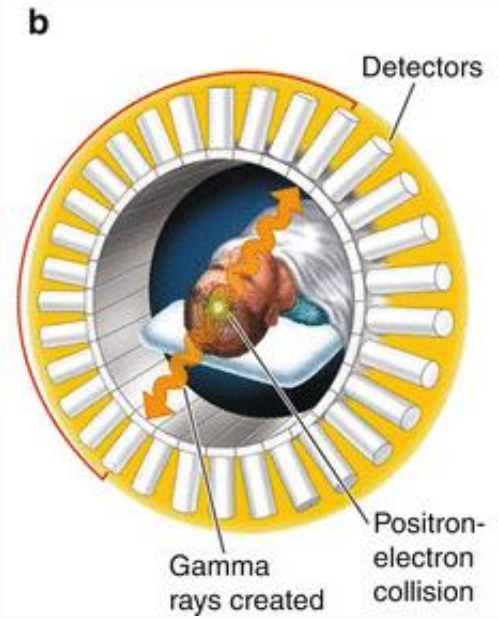
Copyright © 1998 by W.B. Saunders Company

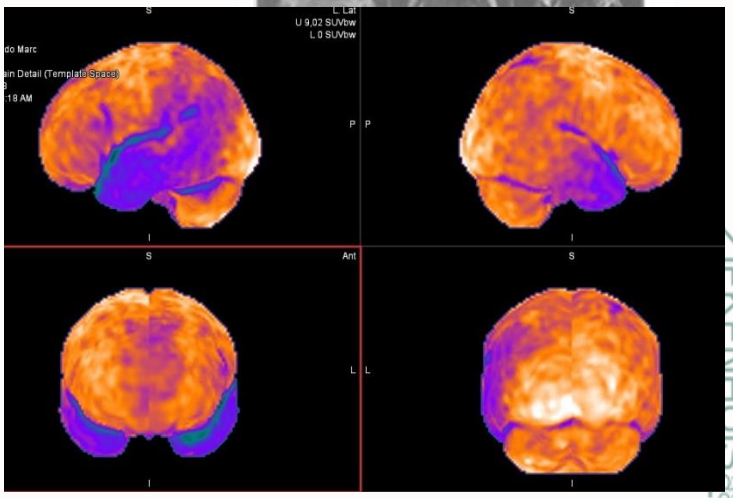
The Journal of Nuclear Medicine
JNM
Volume 32, Number 4 • April 1991



$F^{18}DG$







ZIEKENHUIS aan ROOM

Nucleaire geneeskunde in vivo

orgaan- of receptor-specifieke molecule



γ

gamma-camera





β^+

PET-camera

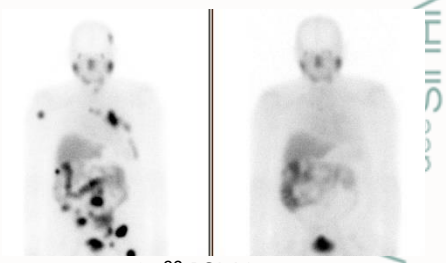




α

β^-

therapie



Lu^{90} PSMA

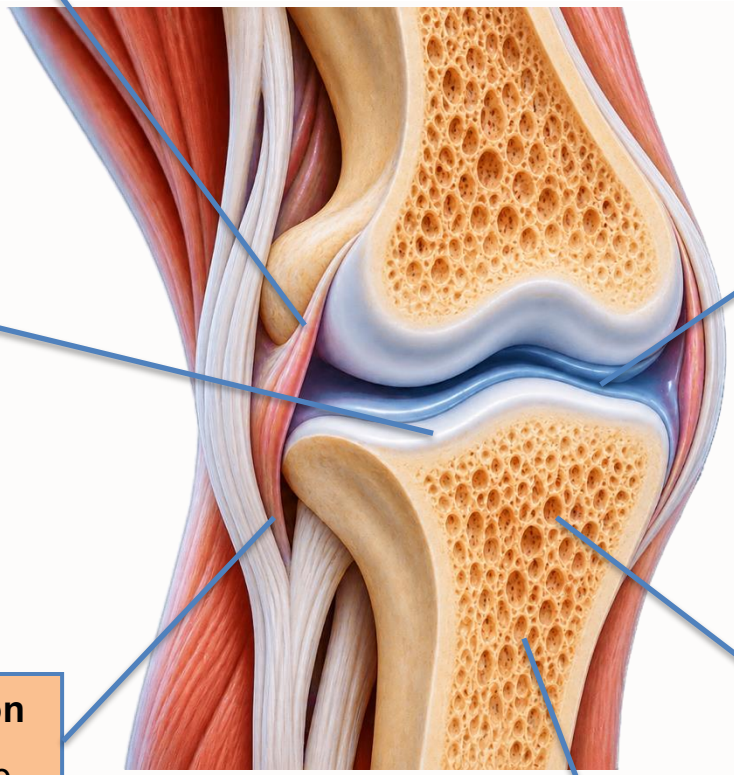
Bloodflow

Tc^{99m}-HSA

Still in study

Tc^{99m}-anti-CD3/4/20/TNFα

I^{124}-rituximab



Bone metabolism

Tc^{99m}-MDP/DPD

F^{18}-NaF

Somatostatine receptor

In^{111}-octreotide

Leucocyte concentration

Tc^{99m}-labeled WBC or Ab

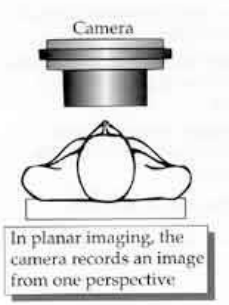
Glucose-metabolisme

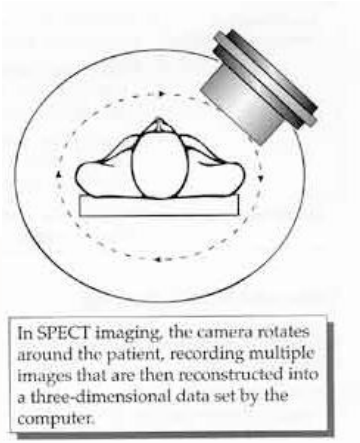
F^{18}-FDG

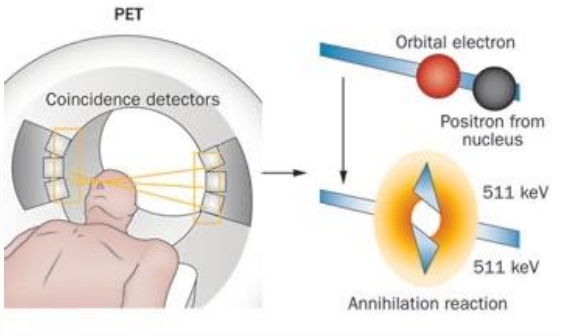
Bone marrow

Tc^{99m}-nannocolloid

ZIEKENHUIS aan de STROOM







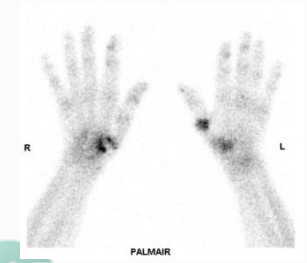
2D PLANAIR

whole body

dynamic



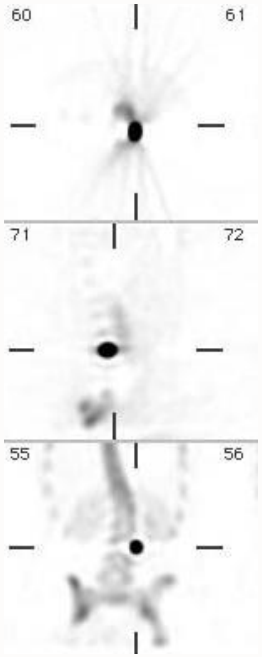
static





3D SPECT

single photon emission computed tomography



3D PET

positron emission tomography

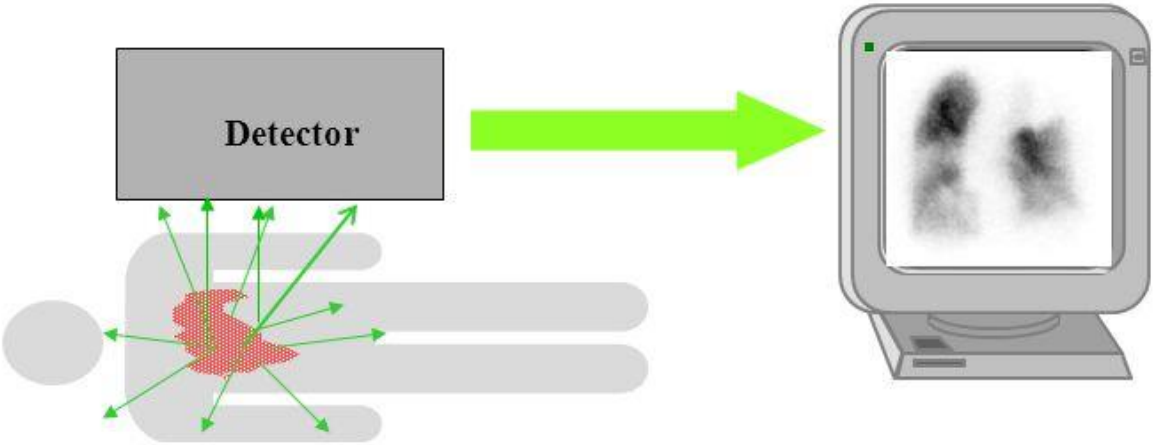


ZIEKENHUIS aan de STROOM

Emission vs. Transmission Imaging

Nuclear Medicine methods : Emission Imaging

Measure concentration and distribution of radiopharmaceutical in the body ➔ PHYSIOLOGY (Organ Function, not structure)



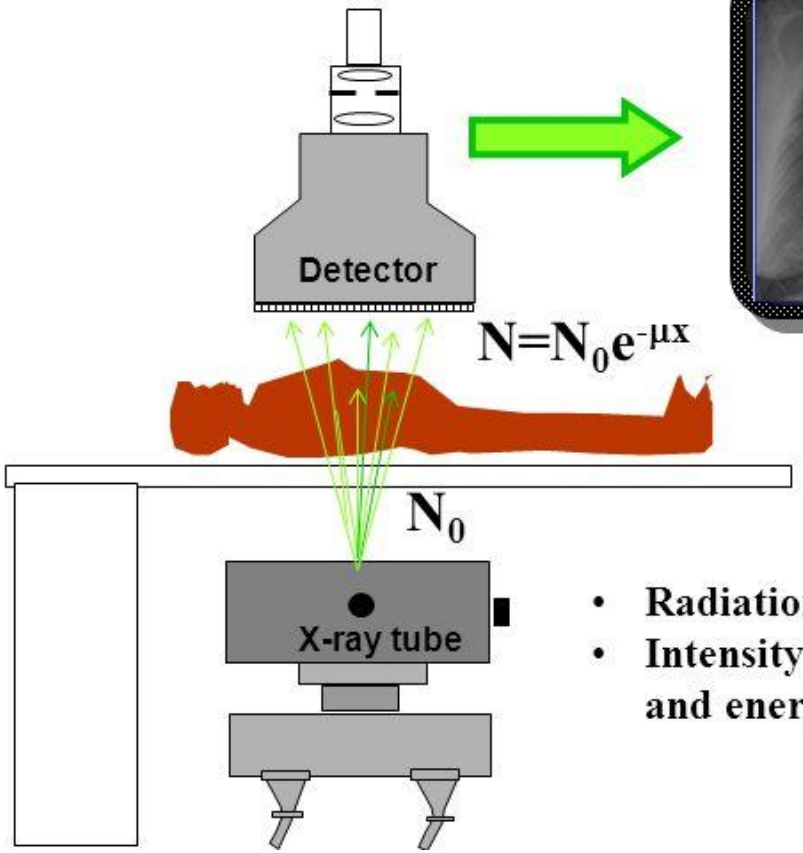
- **Radiation position (direction) is NOT known**
- **Intensity of source is NOT known**
- **Energy is known**

ZIEKENHUIS aan de STROOM

Emission vs. Transmission Imaging

X-ray methods : Transmission Imaging

Measure attenuation coefficient → ANATOMY





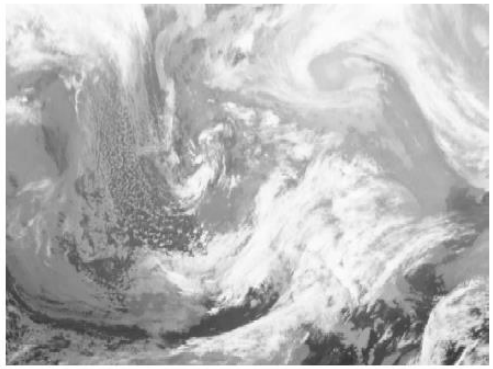
- Radiation position (direction) is known
- Intensity of source is known (known flux (mAs) and energy (kVp))

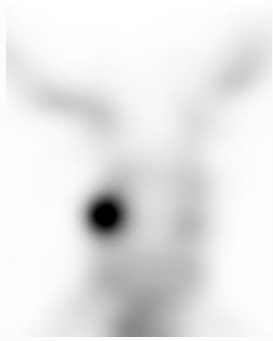
ZIEKENHUIS aan de STROOM





RX CT US MRI



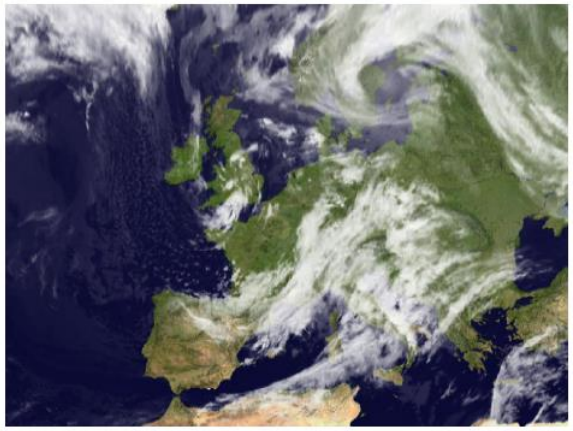


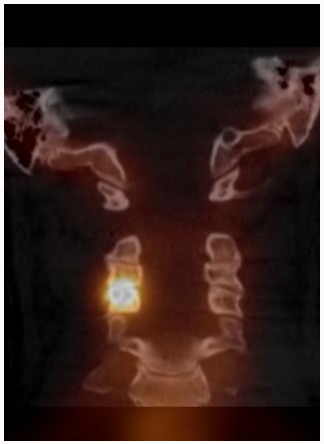
MRdiff scintigrafie SPECT PET

Morfo-structurele beeldvorming

Functionele beeldvorming

Hybride beeldvorming





ZIEKENHUIS aan de STROOM

SPECT/CT in ZAS Augustinus



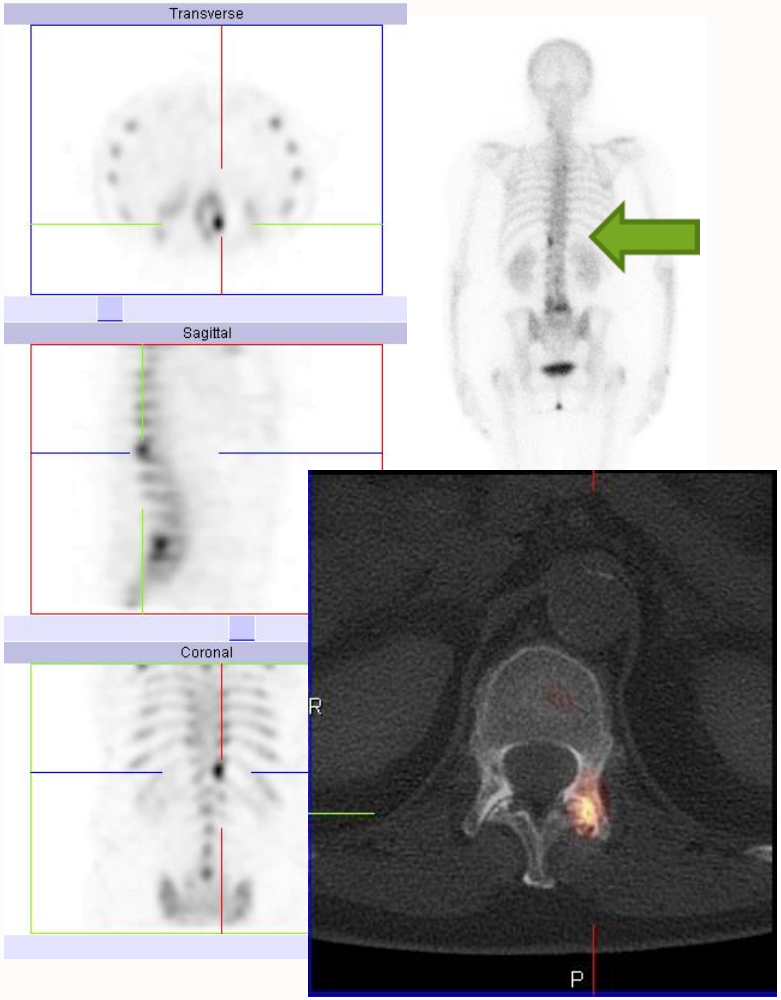
PET/CT in ZAS Augustinus



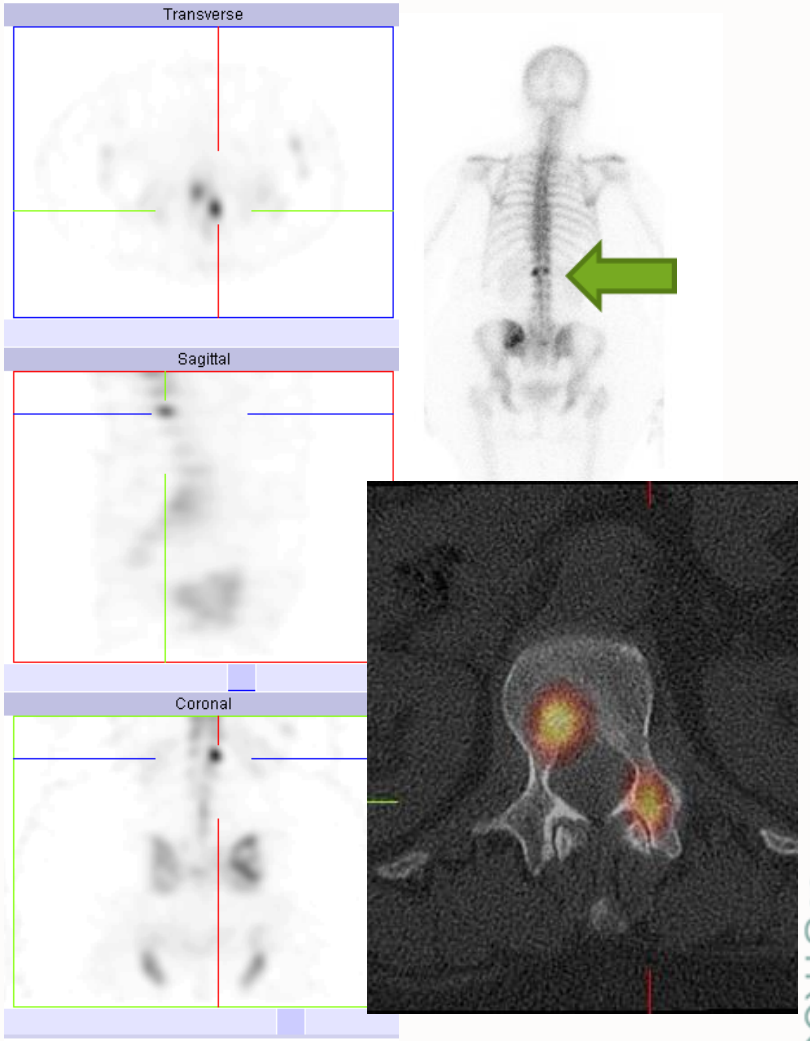


Diagnostische meerwaarde

Rugpijn bij borstcarcinoom

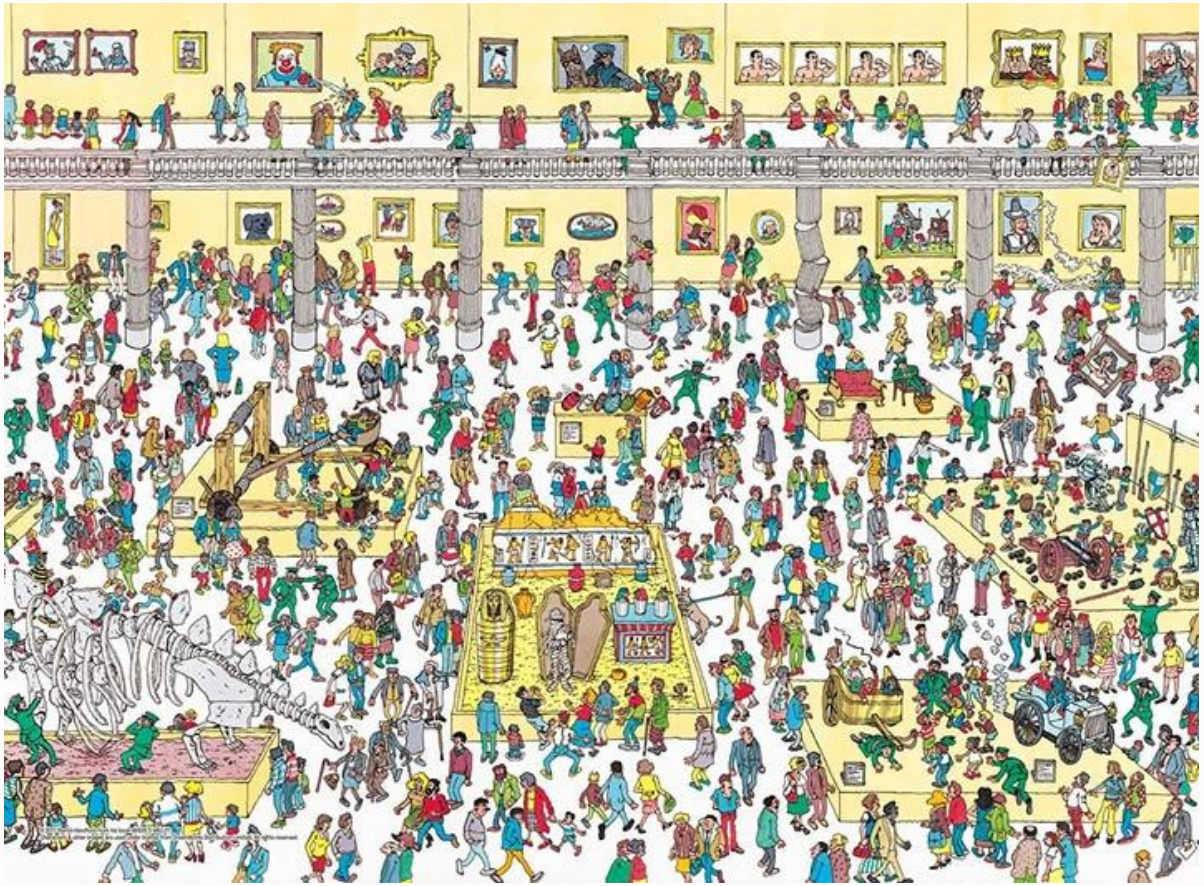


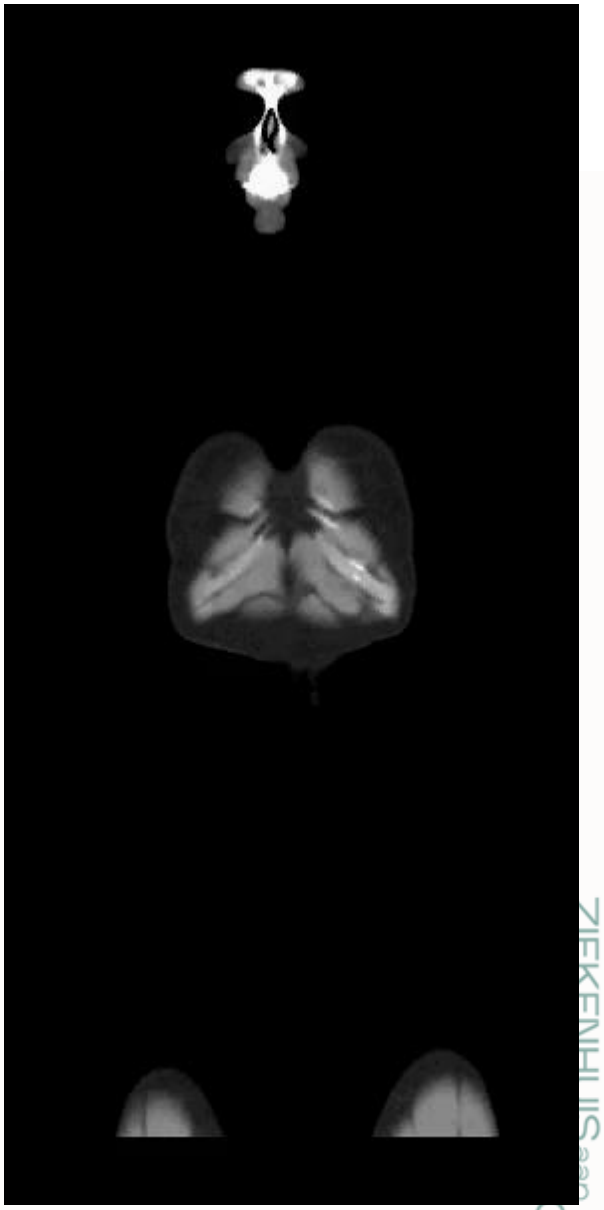
facetartrose



botmetastase

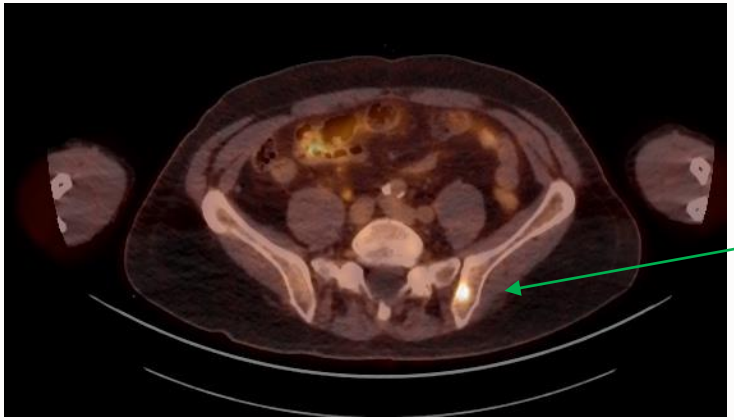
ZIEKENHUIS aan de STROOM

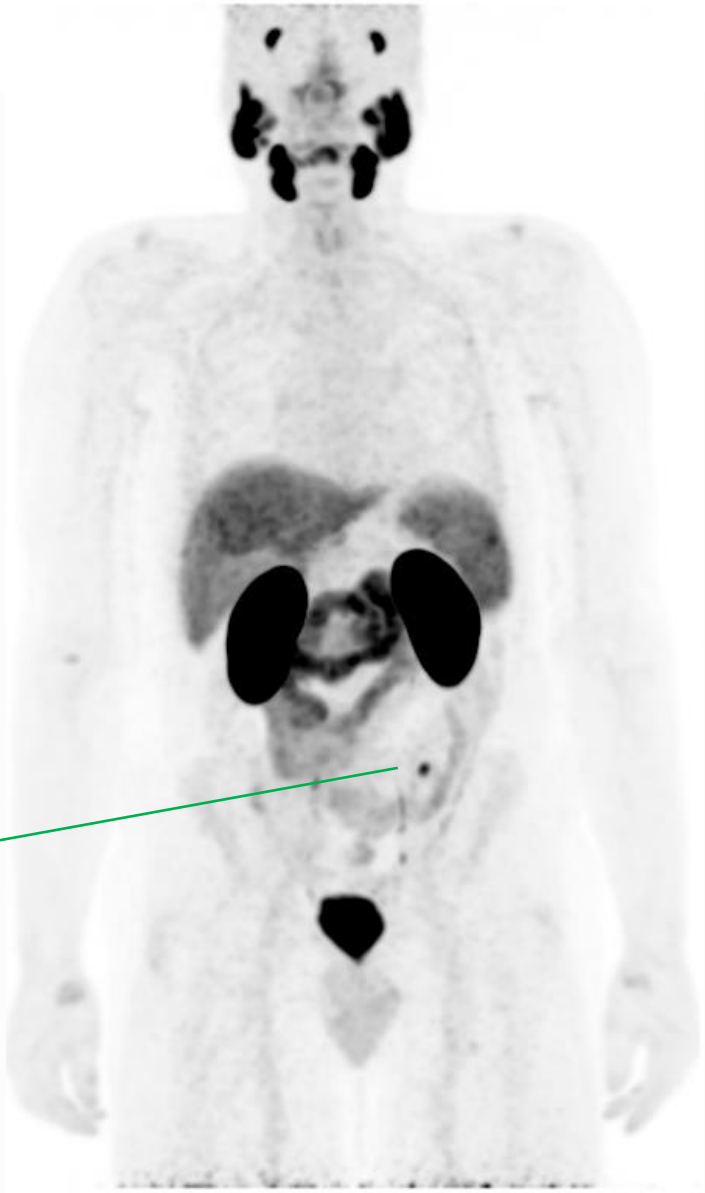




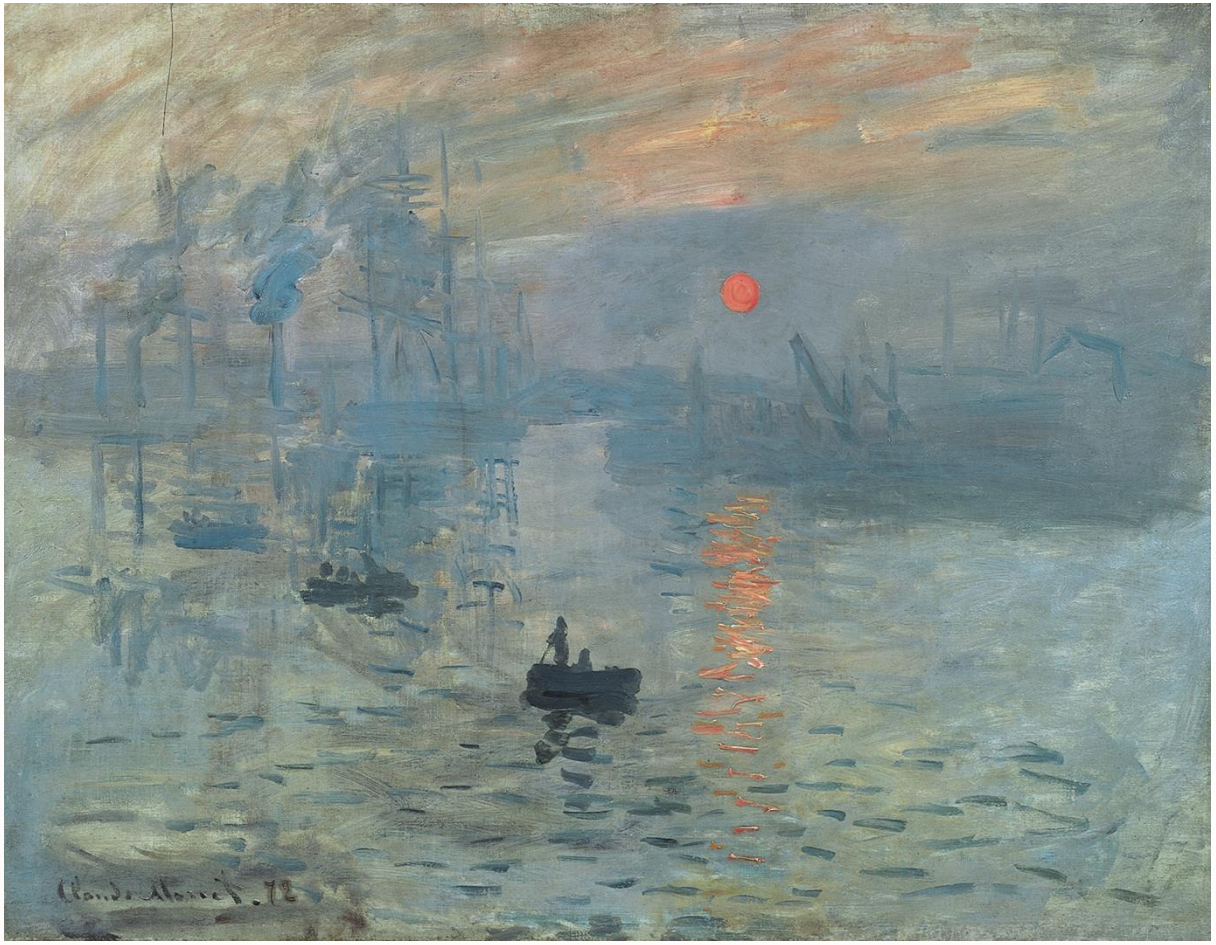
ZIEKENHUIS.com



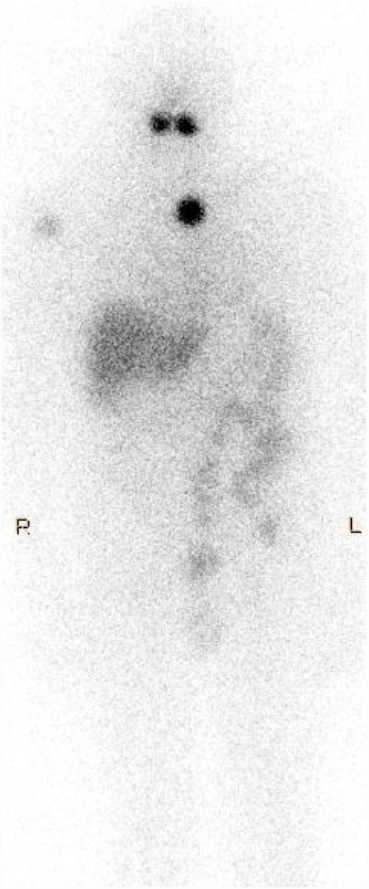




ZIEKENHUIS aan de STROOM

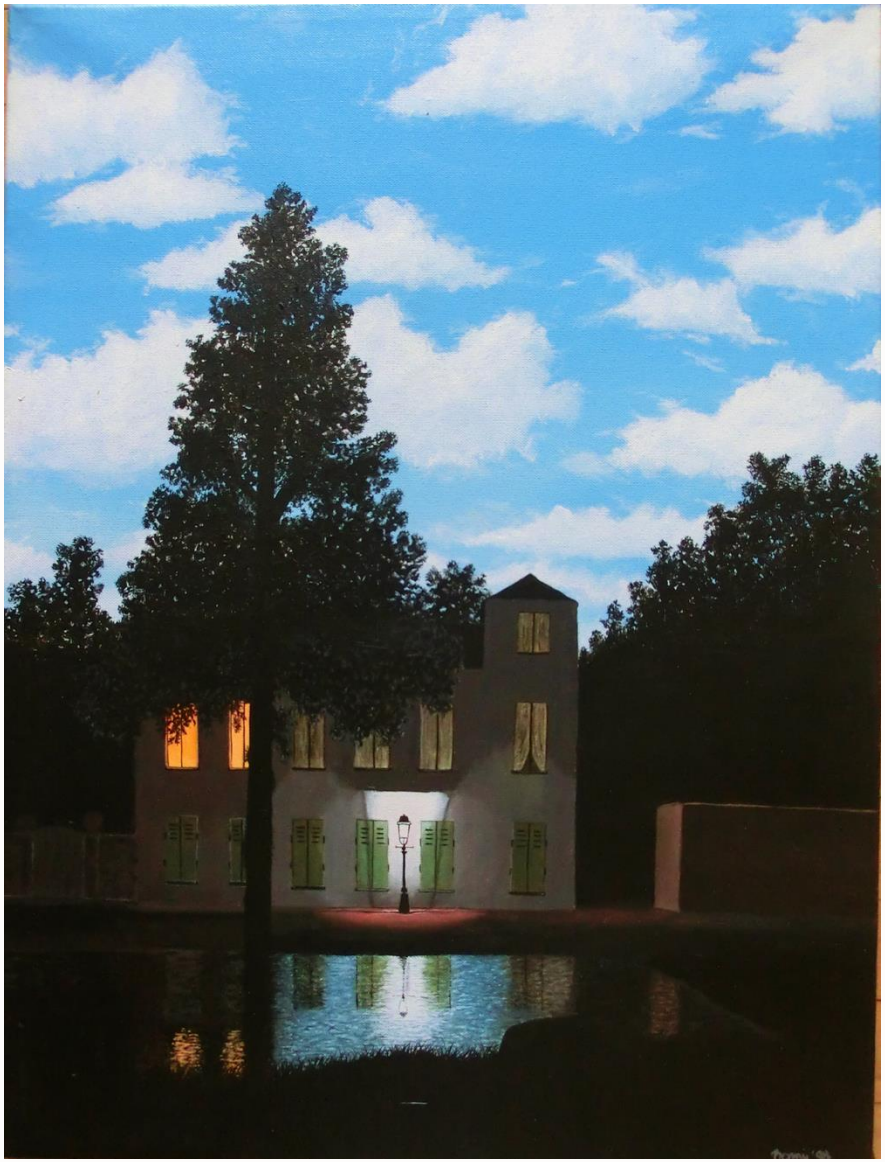


Impression, soleil levant - C. Monet 1872



I131-scintigraphy
GZA 2014

ZIEKENHUIS aan de STROOM

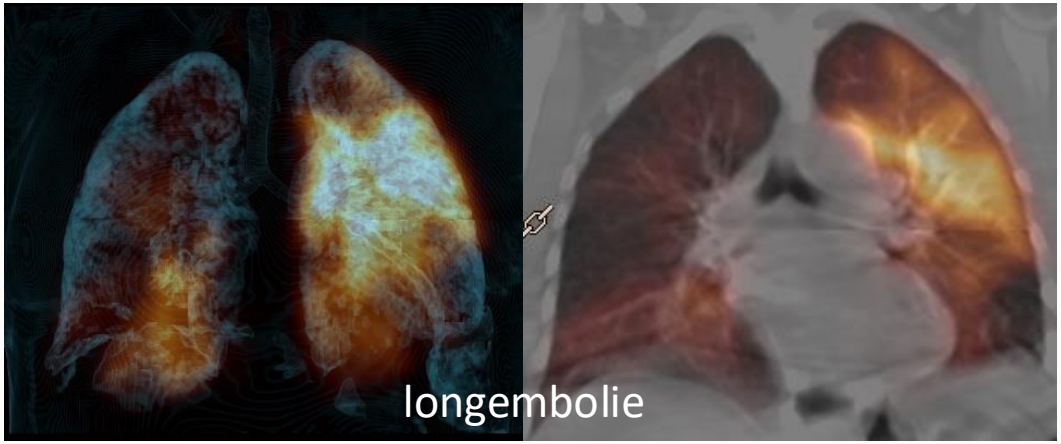


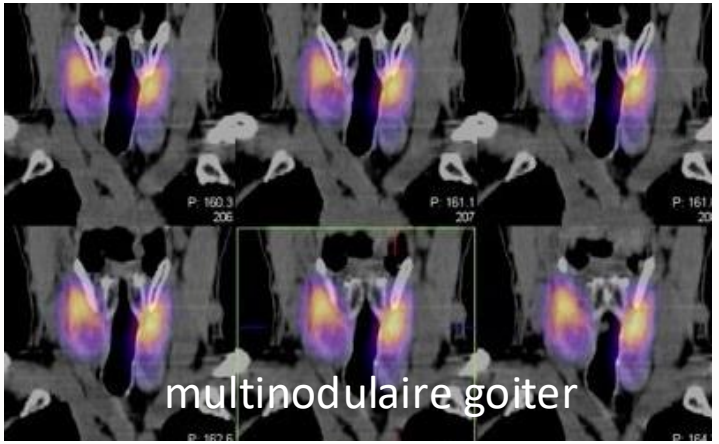
L'Empire des lumières - R. Magritte 1954

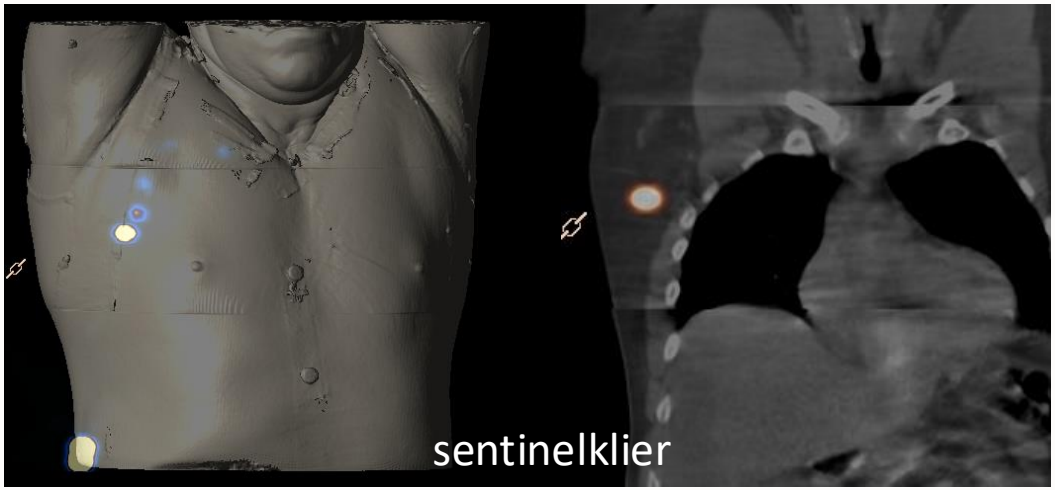


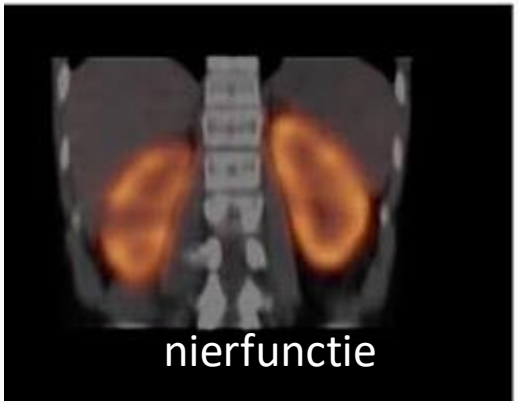
thyroidcarcinoma bone meta
GZA SPECT/CT 2014

ZIEKENHUIS aan de STROOM

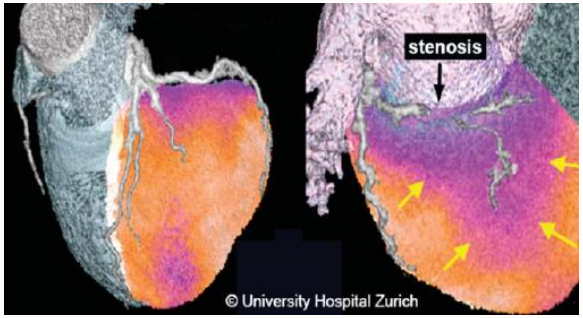


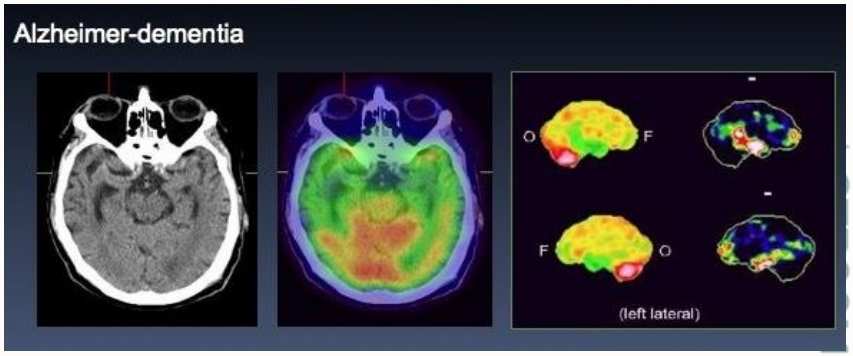






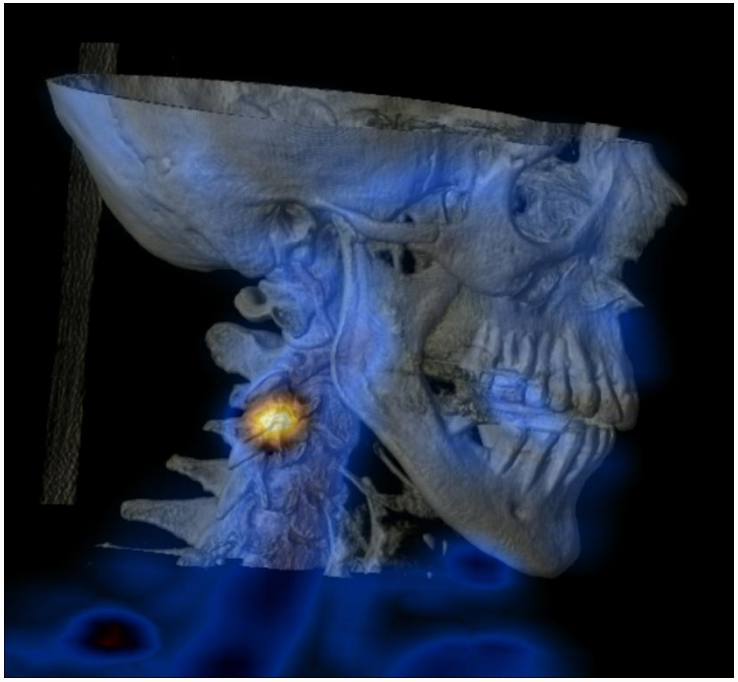






ZIEKENHUISaan

Hybride beeldvorming



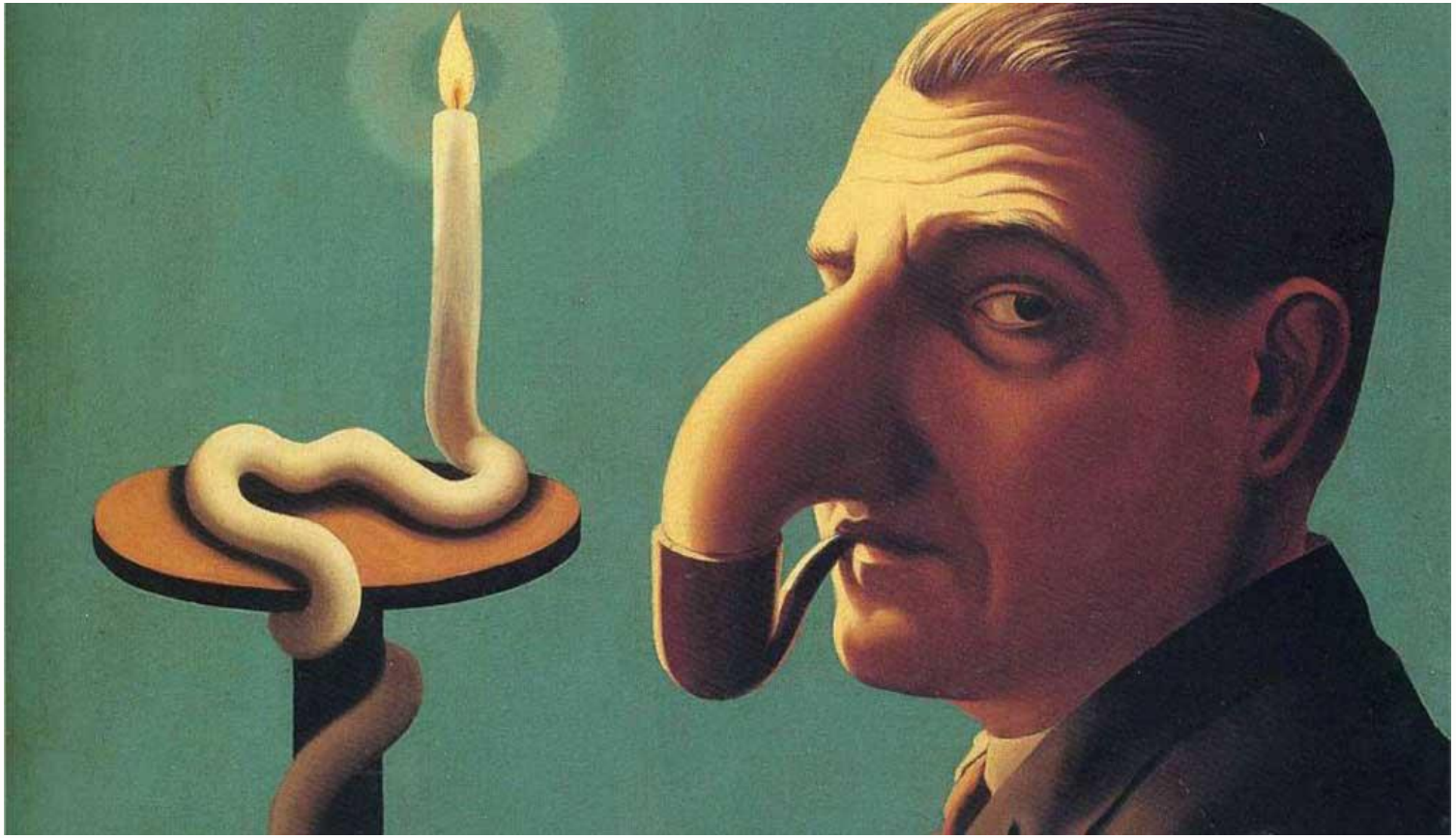
Meerwaarde voor functionele BV:

- anatomische lokalisatie
- specificiteit
- verbetering van resolutie

Meerwaarde voor structurele BV:

- pathofysiologie
- sensitiviteit (‘oplichten’ van letsels in grote data-volumes)
- functionele significantie

ZIEKENHUIS aan de STROOM



ZIEKENHUIS aan de STROOM

Radioprotectie

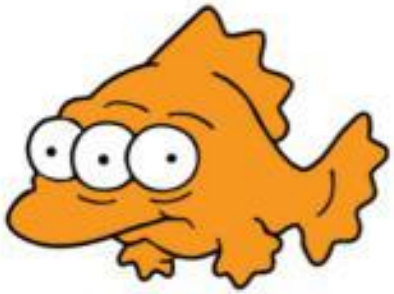
SIMPSONS GUIDE TO RADIATION



Bequerel [Bq]
How brightly your Cesium glows



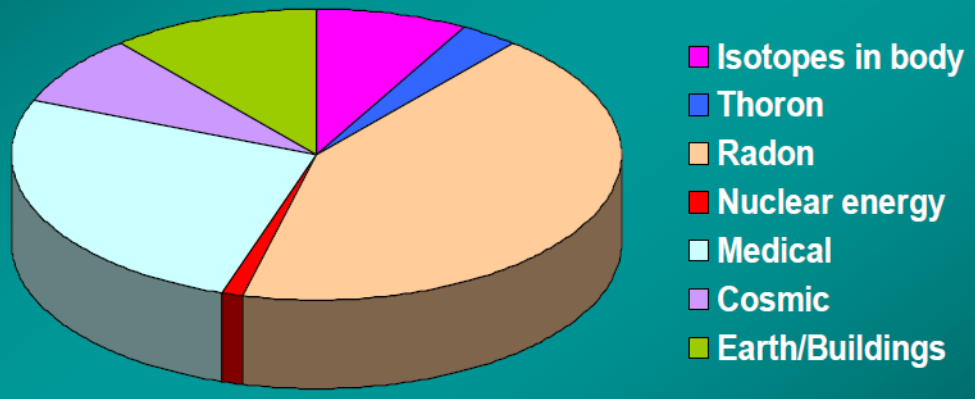
Gray [Gy]
How brightly Cesium will make you glow



Sieverts [Sv]
How many extra eyes will you have after glowing?

ZIEKENHUIS aan de STROOM

SOURCES OF BACKGROUND RADIATION IN BELGIUM



Total average dose in Belgium: 4.3 mSv / year

>30 mSv:

Ramsar, Iran:	260 mSv
Kerala, India:	35 mSv
Guarapari, Brasil	35 mSv

Transcontinental flights

0.1 mSv	America
0.25 mSv	Australia

ZIEKENHUIS aan de STROOM

Thorax	0.02 tot 0.1 mSv
Barium investigation	3 à 10 mSv
CT brain	2 mSv
CT abdomen/thorax	10 mSv

ref. fda.gov

Bone scan	3 mSv
PET-scan	7 mSv

On cancer incidence: 0.6 % per 100 mSv

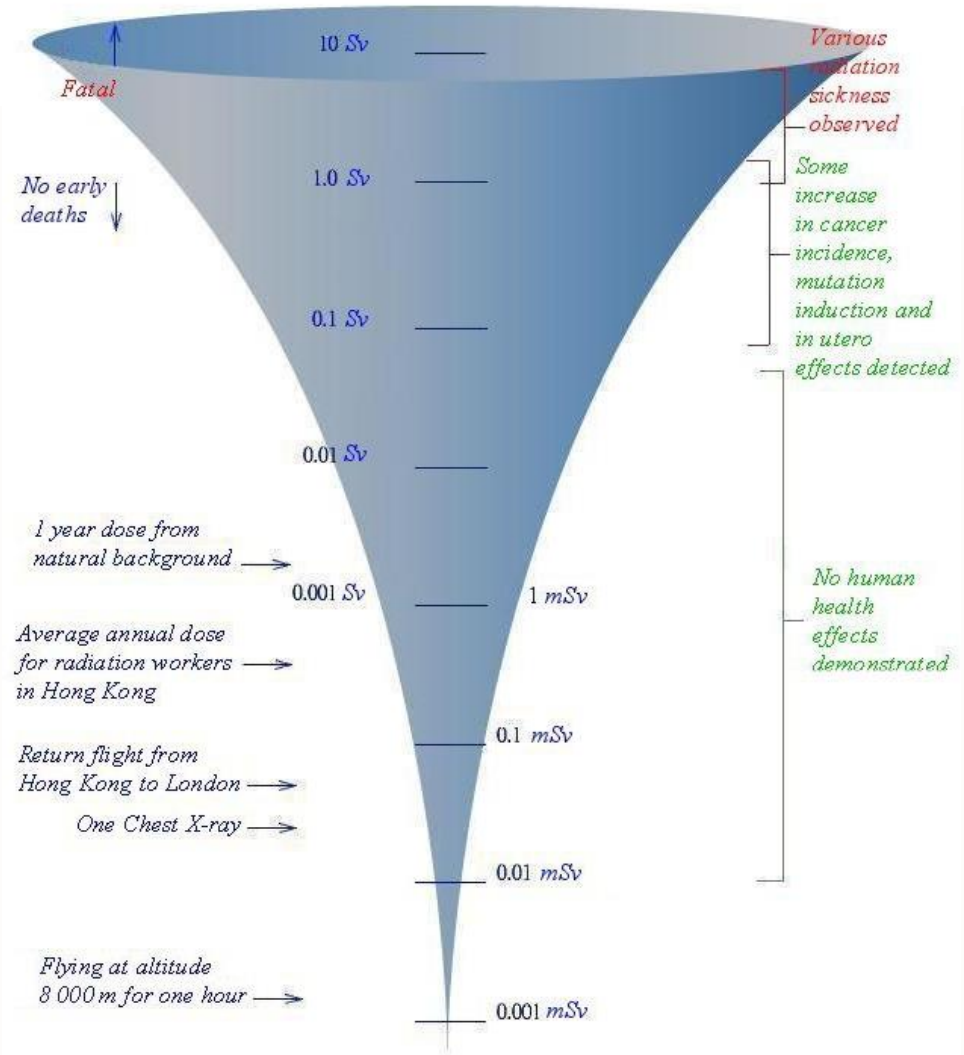
1 in 17 000/mSv, or "8501 i.s.8500…"

On congenital defects:

not under 100 mSv

above 100-200 mSv

probability x 2 per 1000 mSv



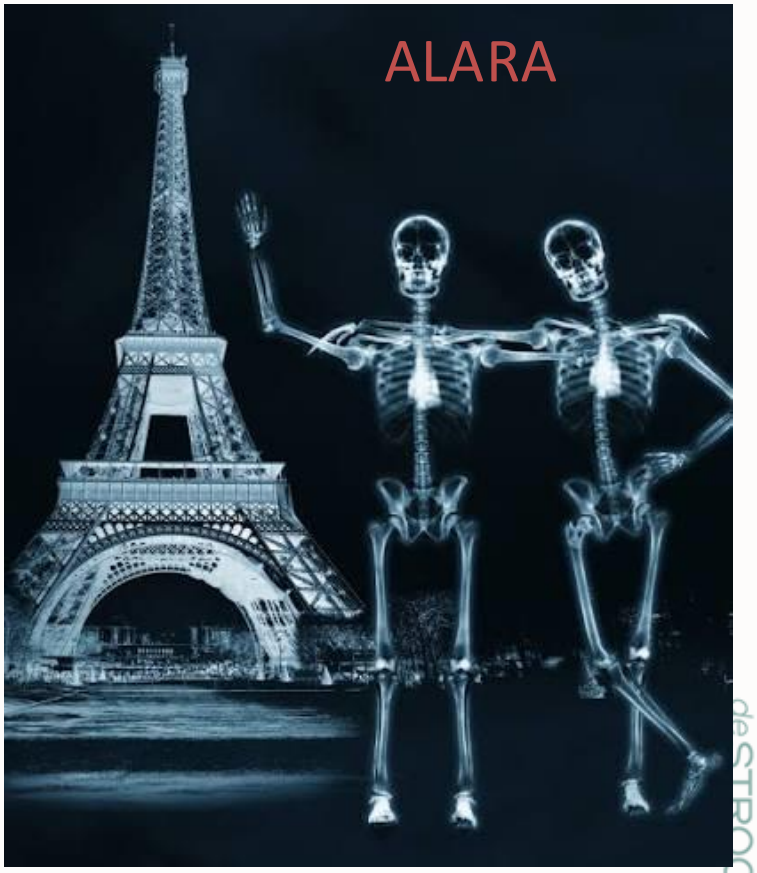
Een **stralingsdosis van 1 mSv** geeft een geschat **extra sterfterisico** van ongeveer 1 op 20.000 (**0,005%**) op een mensenleven.

Ter vergelijking heeft iedereen gedurende zijn leven sowieso al een basiskans van ongeveer 25-30% (1 op 3 à 4) om aan kanker te overlijden. Een dosis van 1 mSv verhoogt dit percentage van bv 30,000% naar 30,005%.

Risk of dying 1 per million/year

- 90 km driving
- 2500 km train
- 4000 km flying
- 3 hrs work on fishing boat
- 1.5 hrs skiing
- 6 min canoeing
- 1.5 cigarette
- 2 days New York (air)
- 33 hrs at home

or once 1 mSv



ZIEKENHUIS aan de STROOM

Praktische aspecten en pitfalls

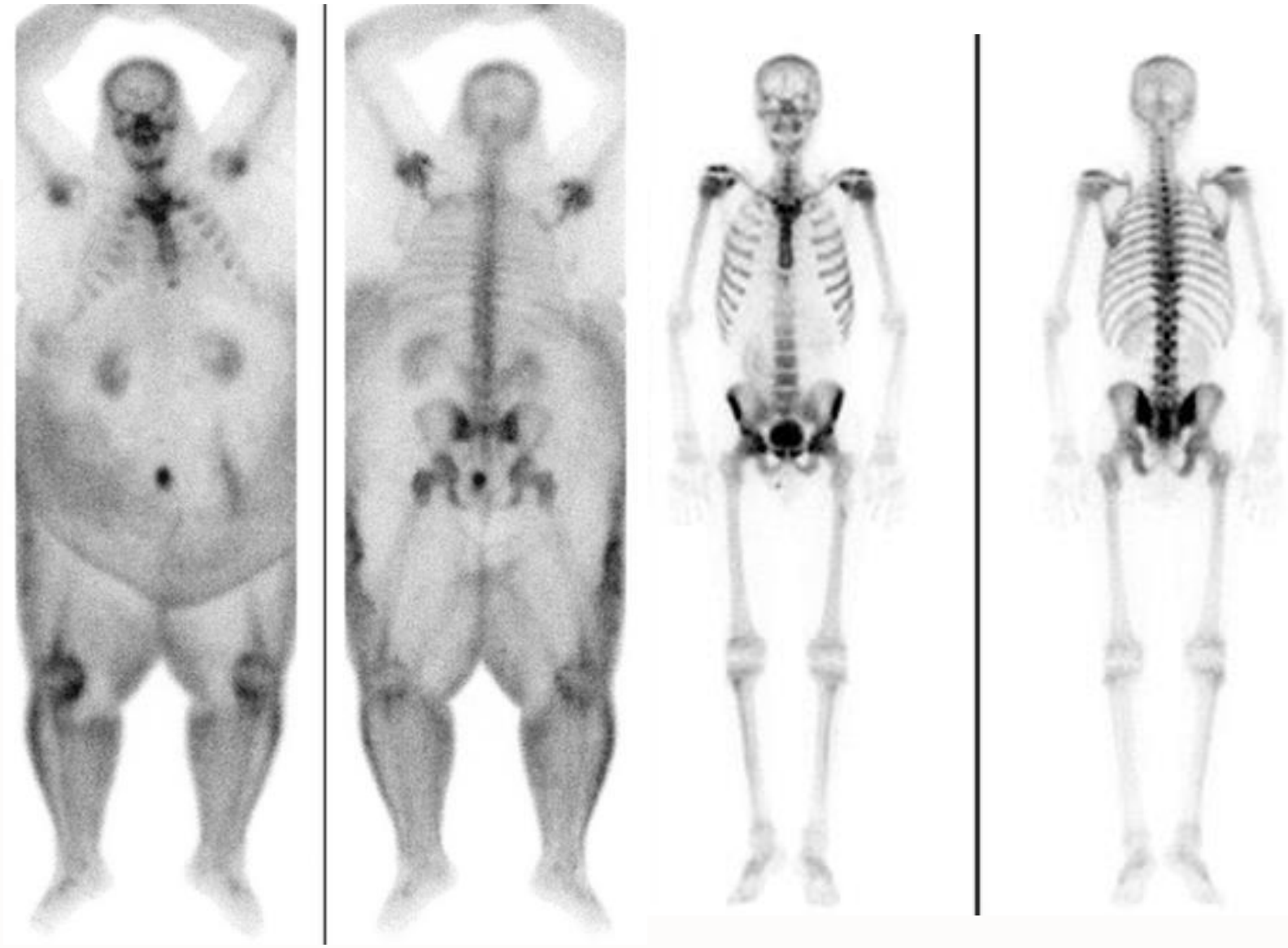


ZIEKENHUIS aan de STROOM



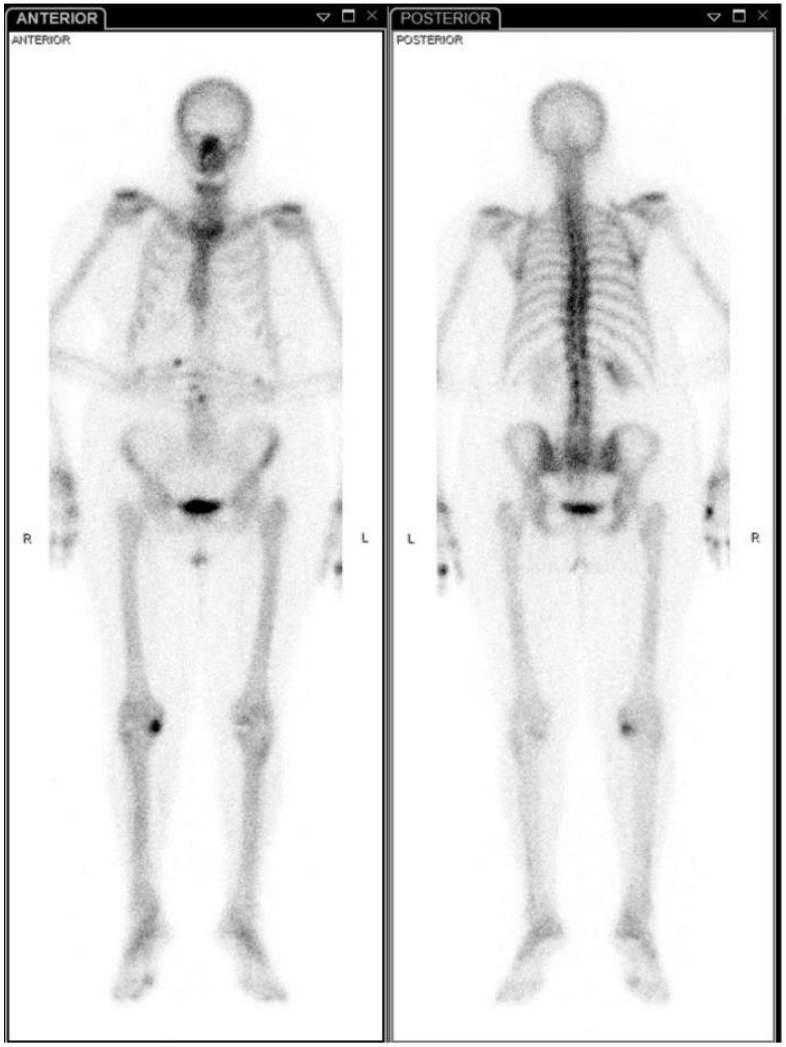


ZIEKENHUIS aan de STROOM



AFSTAND CAMERA-PATIËNT

ZIEKENHUIS aan de STROOM

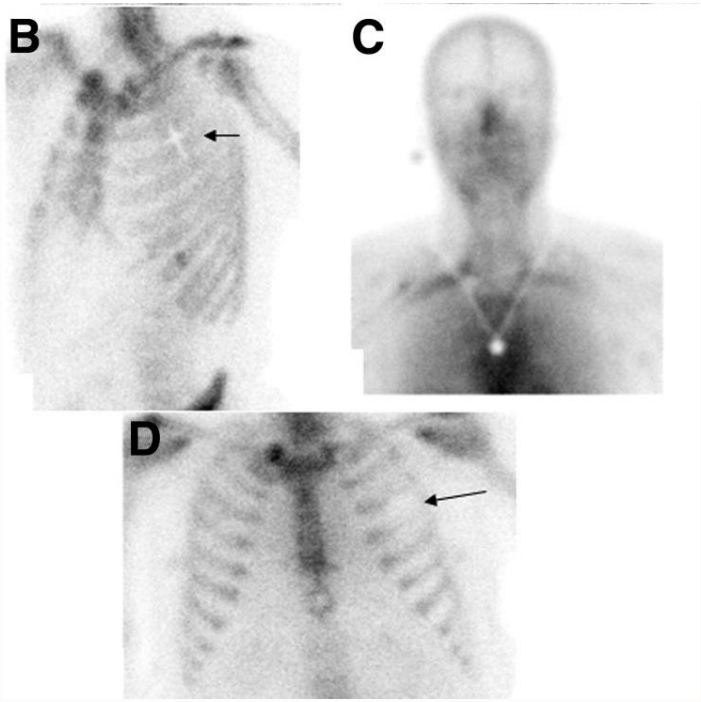


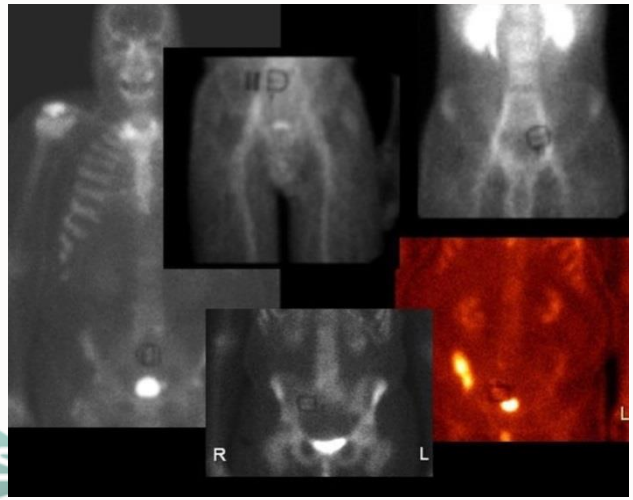


BEWEGING

ZIEKENHUIS aan de STROOM

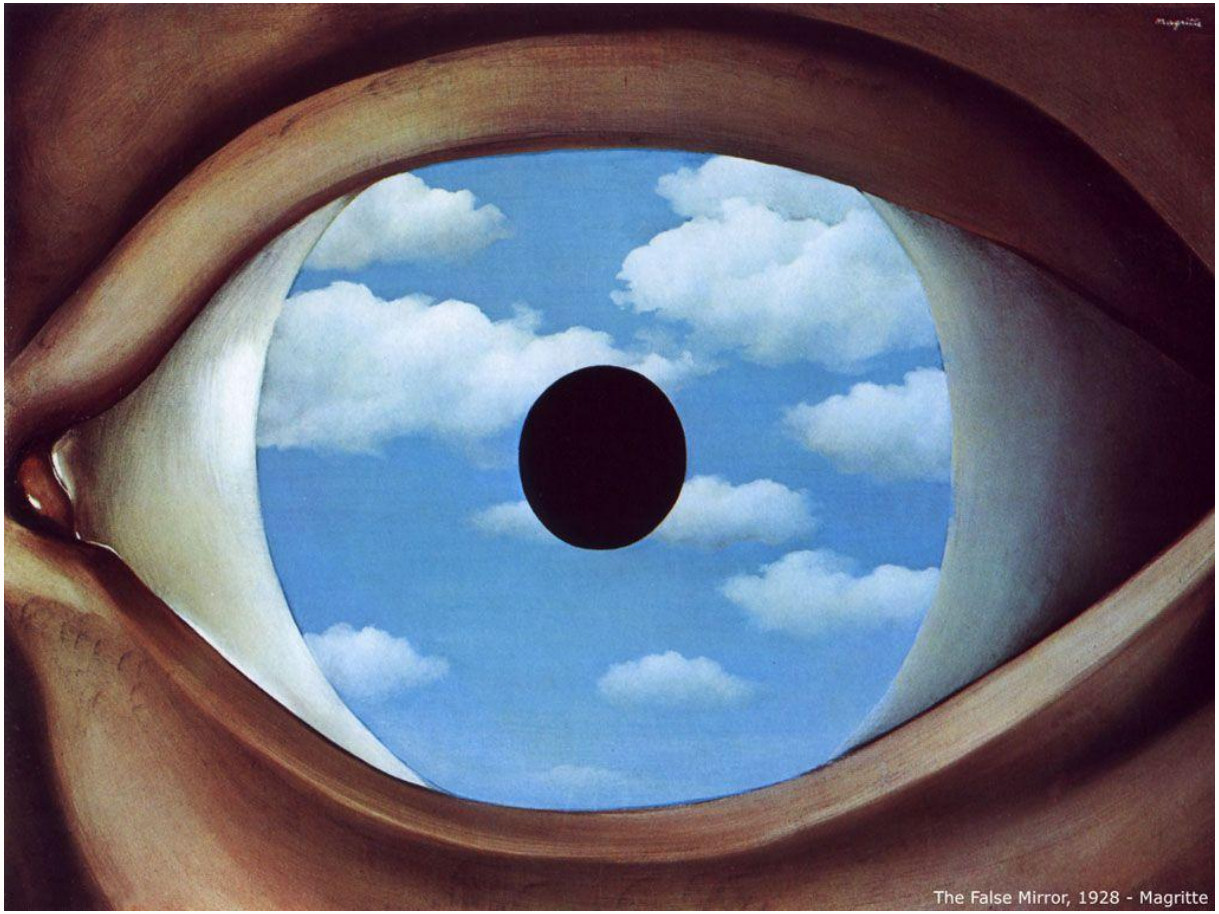
VERWIJDEREN STORENDE ELEMENTEN







Oorzaak en gevolg in 1 beeld

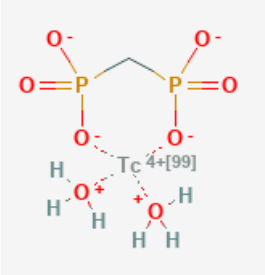


The False Mirror, 1928 - Magritte

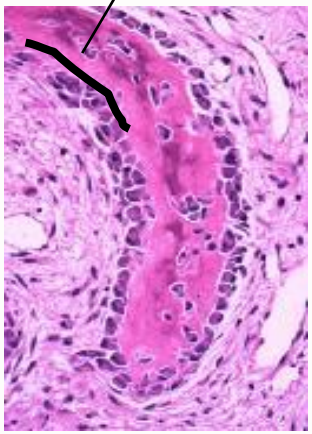
ZIEKENHUIS aan de STROOM

Botscintigrafie

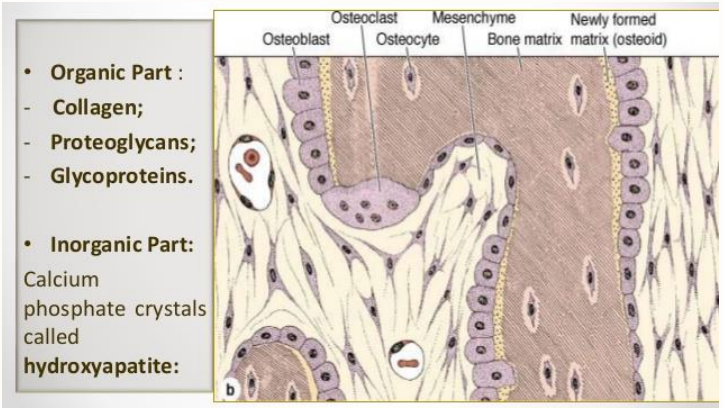
Tc99m coupled to **biphosponate**



HDP-Tc99m



- IV injectie
- absorptie op hydroxyapatiet
- goede hydratatie
- urinaire excretie
- uptake beïnvloed door beweging en R/
- scan na 2 à 4 uur
- contra-indicatie: zwangerschap
- geen allergie



ZIEKENHUIS aan de STROOM

- verhoogde tracerstapeling

  bv. fractuur, osteoartrose, artritis, osteomyelitis, tumor, Paget

  toegenomen nieuwe botformatie

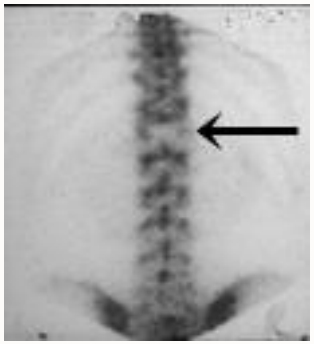
  (remodelling, enchondraal, reactief, neoplastisch)

  toegenomen doorbleeding / activiteit



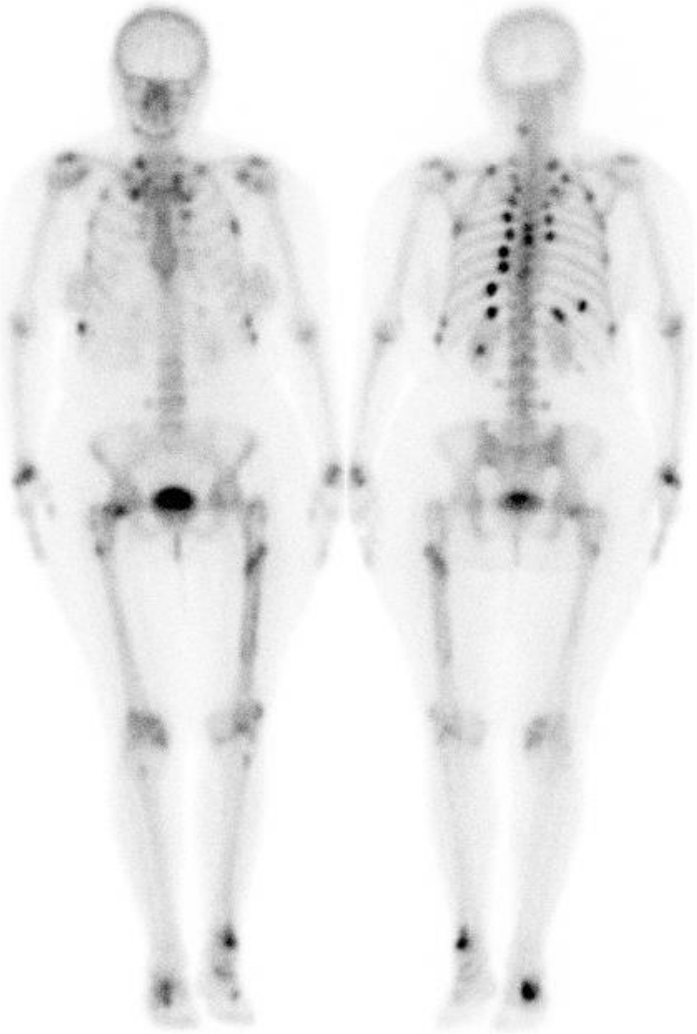
- verlaagde tracerstapeling (osteolyse)

  bv. avasculaire necrose (vroeg), Kahler, metastase, radiotherapie



ZIEKENHUIS aan de STROOM





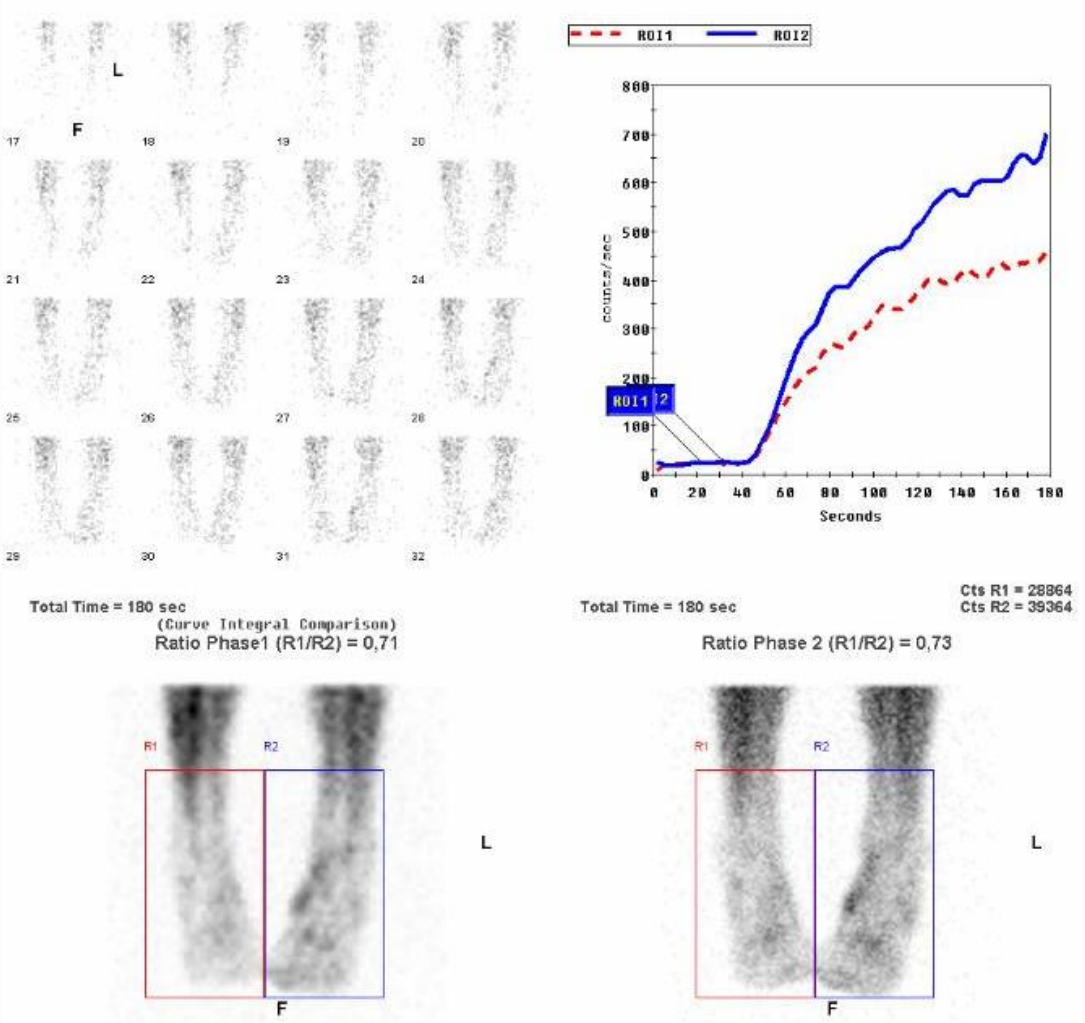
Dit is geen skelet.
Dit is een visuele voorstelling van de metabole functie van het bot.

ZIEKENHUIS aan de STROOM

Drie fasen botscan

Man, 57j

Indicatie : pijnklachten li middenvoet mediaal



Arteriële flow 3 min

Bloodpool 3 min

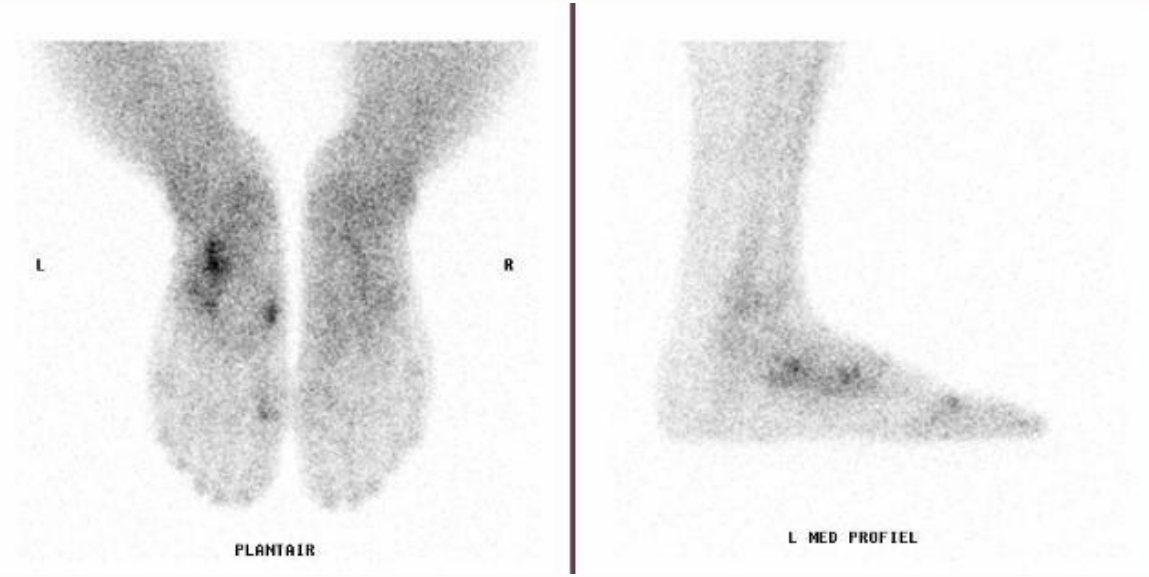
ZIEKENHUIS aan de STROOM



3-4 uur postinjectie **Whole Body scan** anterior en posterior
acquisitieduur 20 min 2 intensiteiten

ZIEKENHUIS aan de STROOM

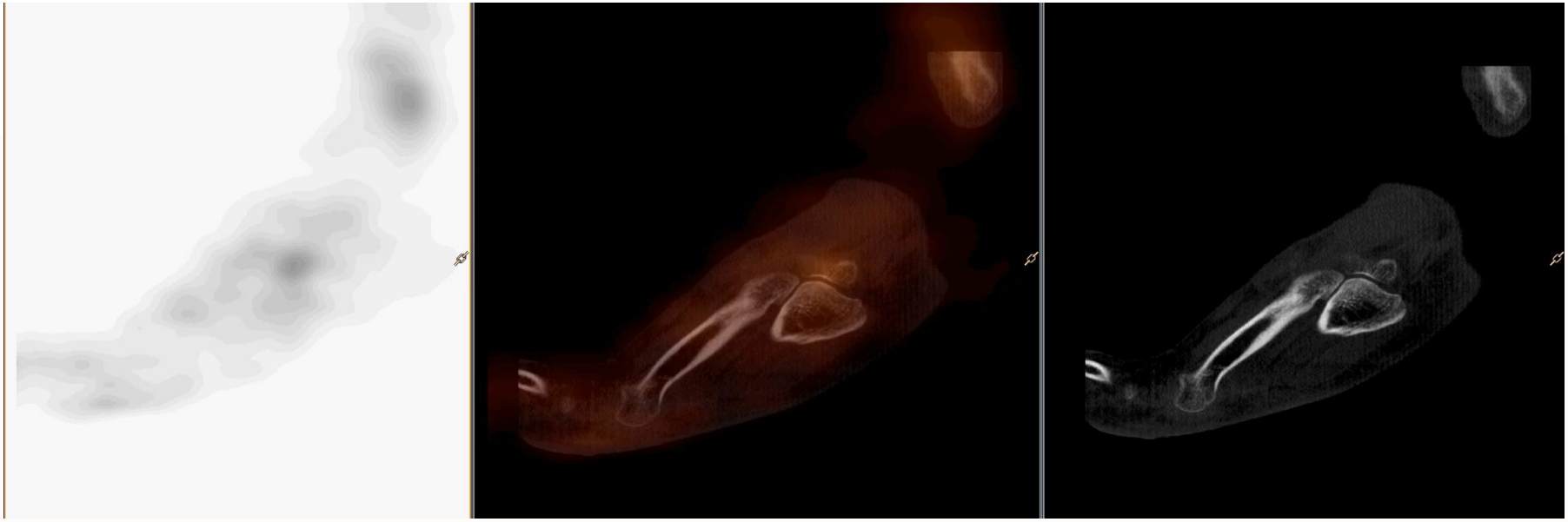
Na whole body: korte anamnese en keuze detailopnames en/of
SPECT +/- CT

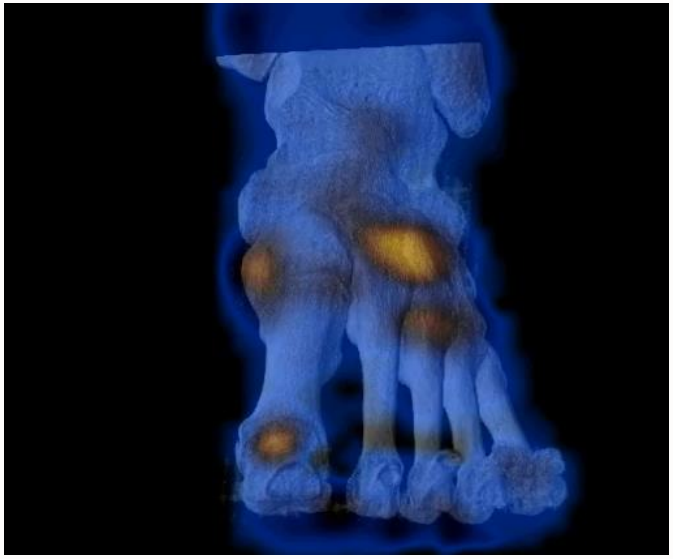


Gerichte planaire beelden : 3 min/scan

ZIEKENHUIS aan de STROOM
Sint-Augustinus

sagital slices





SPECT/CT

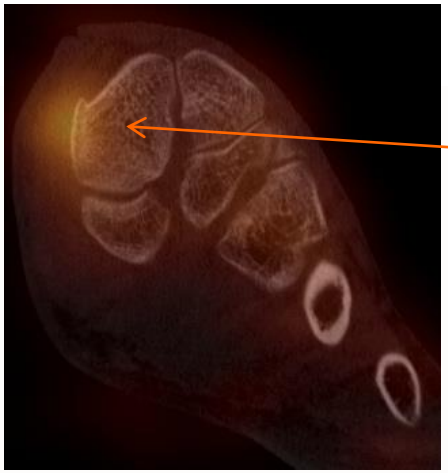
cone beam high resol CT 15x15cm (1 mSv)

acquisitieduur 15 min

ZIEKENHUIS aan de STROOM

coronal







Enthesopathie en tendinitis van tibialis anteriorpees.

sagital



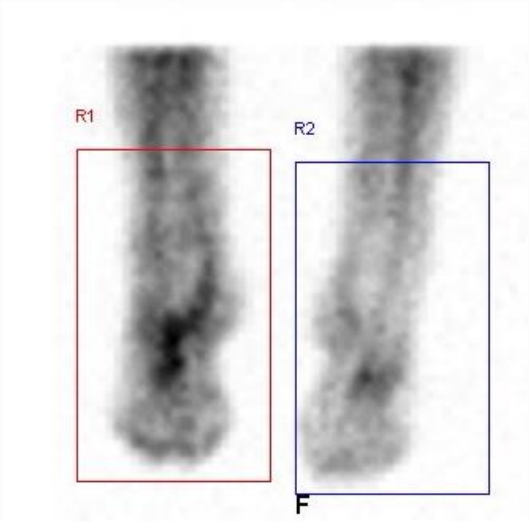


Calcaneocuboïdale osteoartropathie

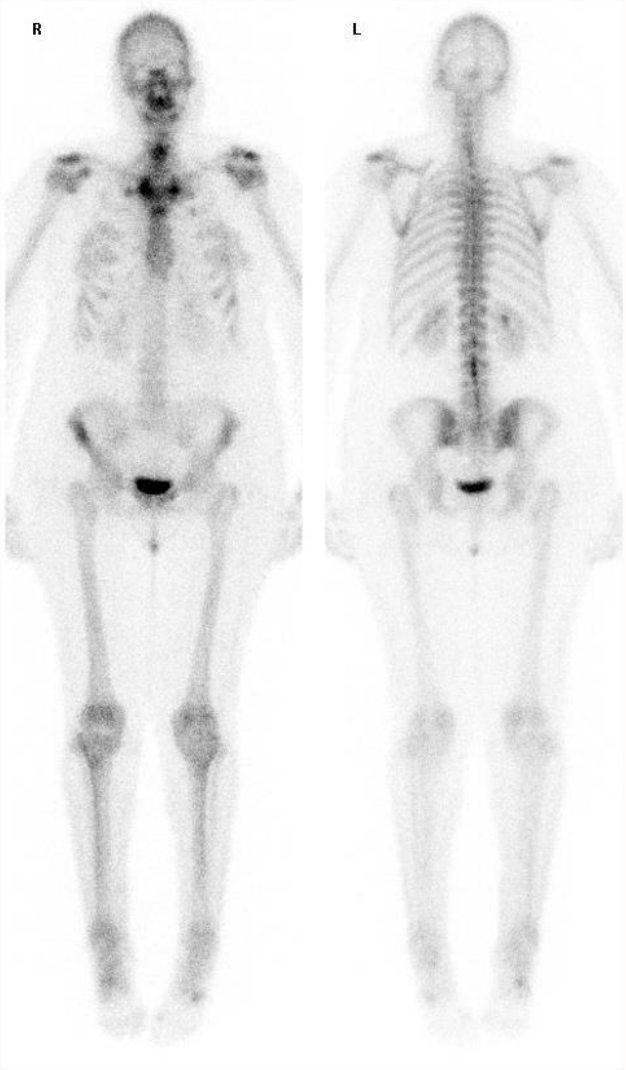
ZIEKENHUIS aan de STROOM
Sint-Augustinus

Vrouw, 55 j

Indicatie : pijnklachten re voet na trauma 3 md geleden. RX negatief. Occulte #?







ZIEKENHUIS aan de STROOM



POPS rechts





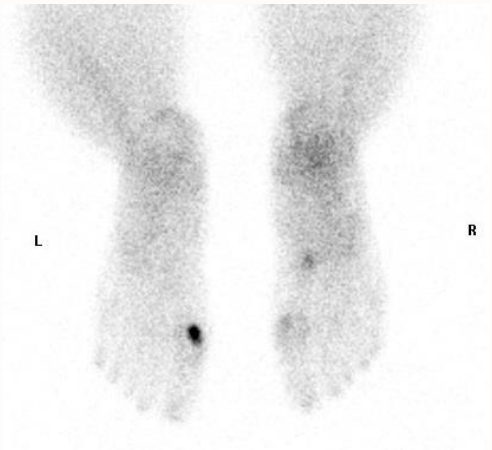
ZIEKENHUIS aan de STROOM



Man, 45j

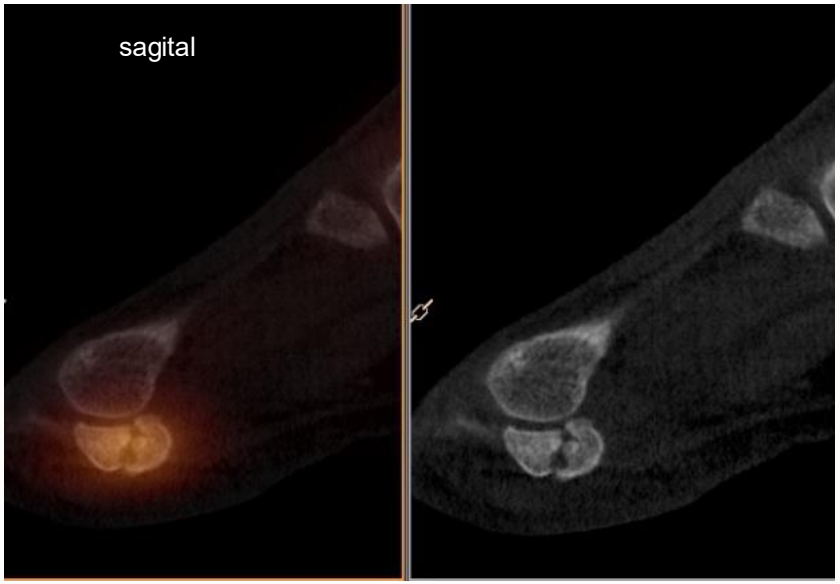
Indicatie : pijnklachten linkervoet (hallux)

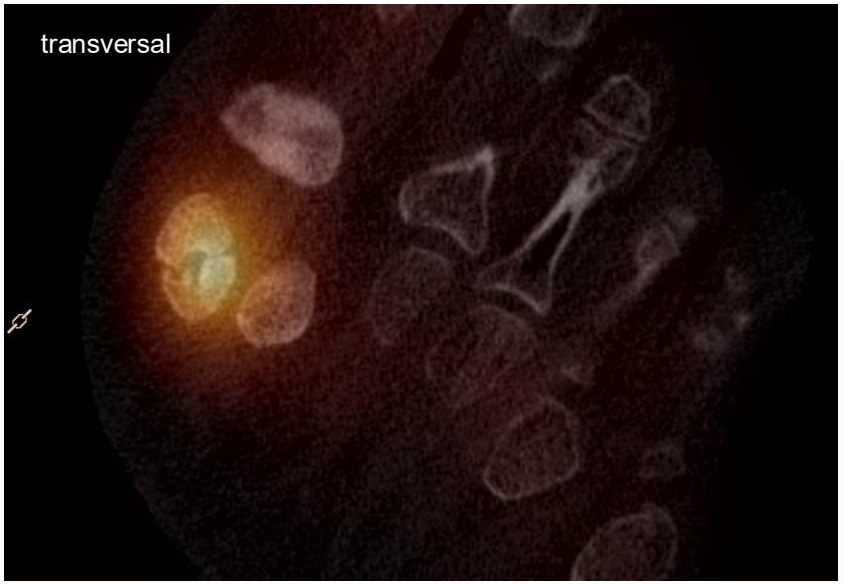
DD sesamoïditis, avasculaire necrose, fractuur?

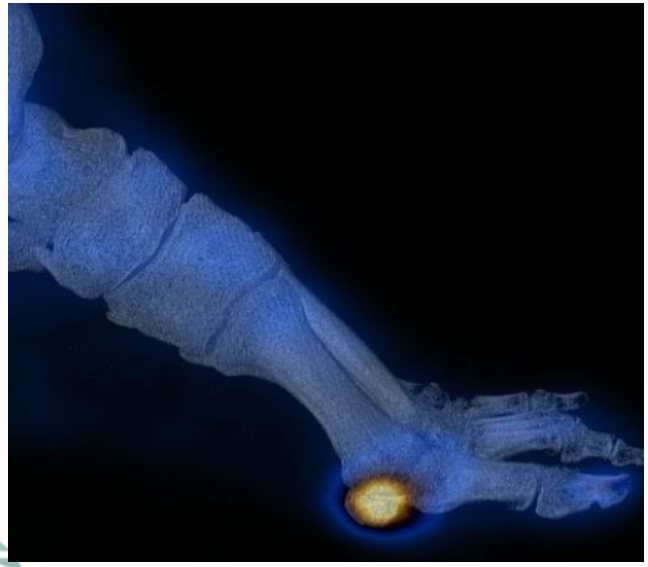




ZIEKENHUIS aan de STROOM





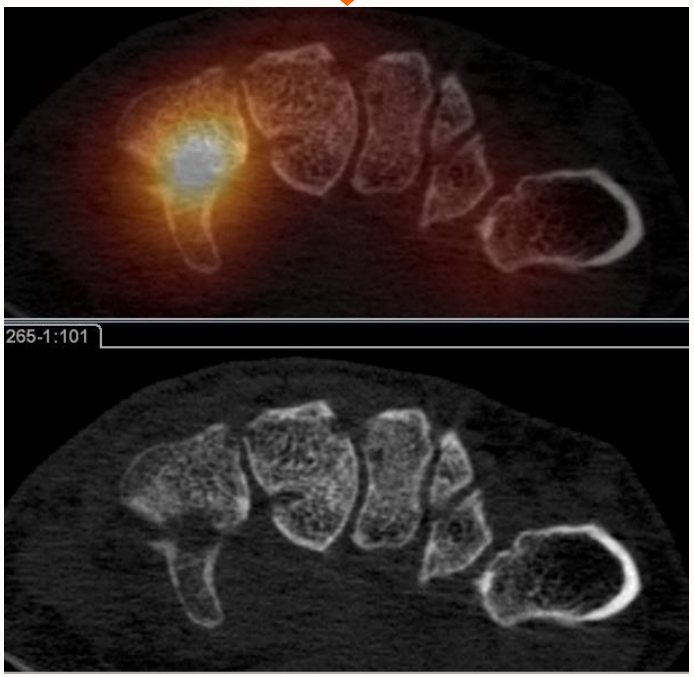


<u>Diagnose:</u> fractuur (met pseudartrose) van mediale os sesamoideum

ZIEKENHUIS aan de STROOM

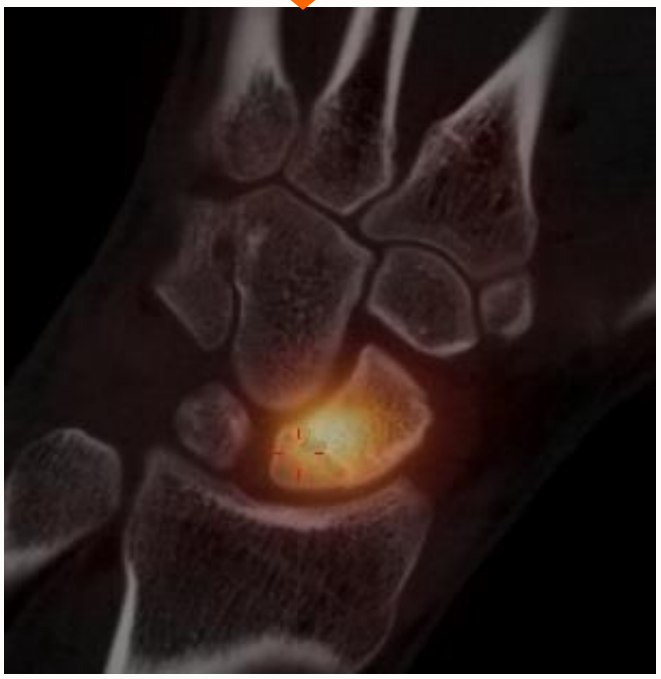
Polspijn na val ; RX negatief





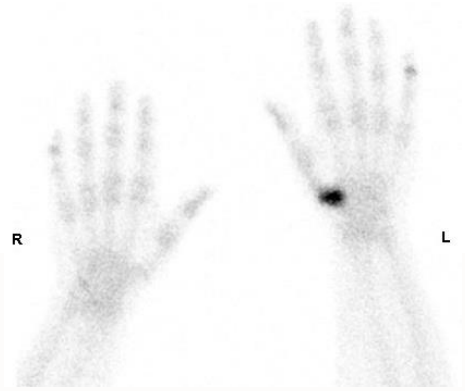
fractuur os hamatum

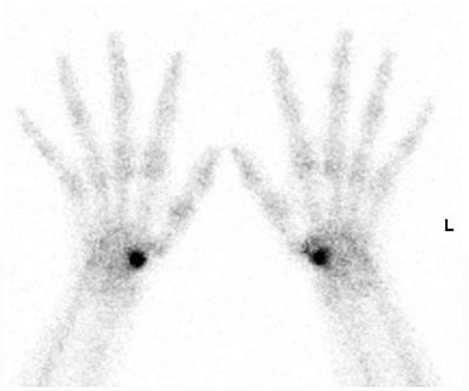




fractuur os scaphoideum

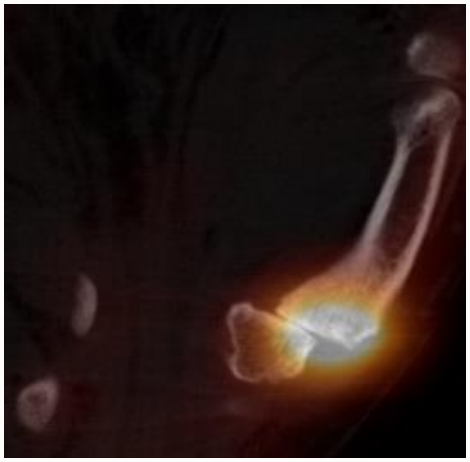
ZIEKENHUIS aan de STROOM



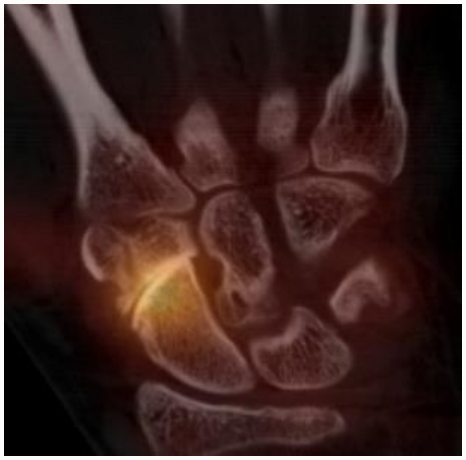








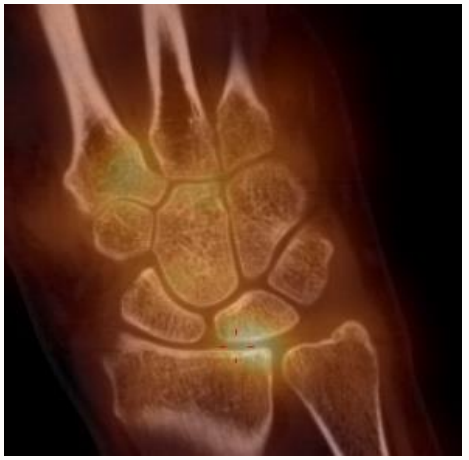
CMC-1 osteoartritis



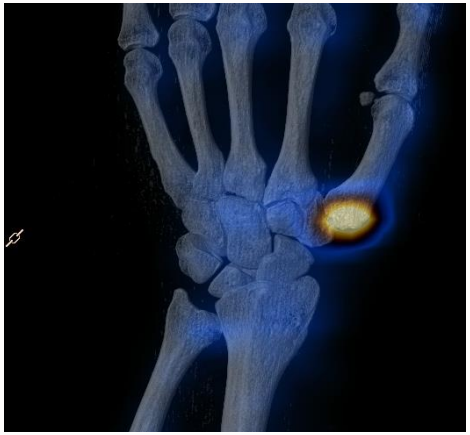
STT osteoartritis



CMC boss



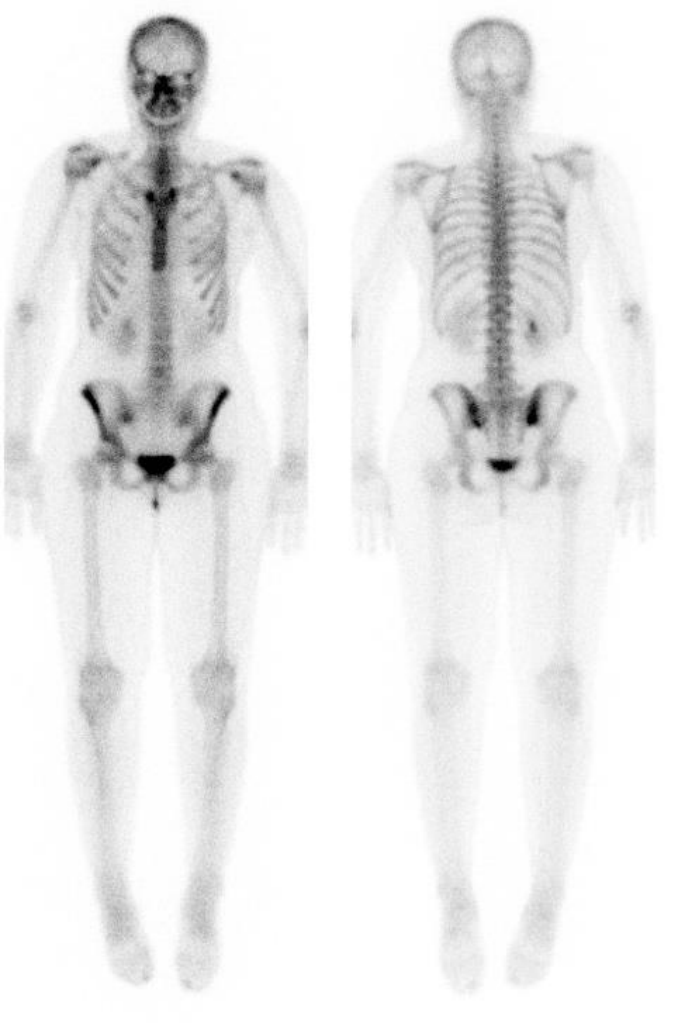
lunatoradiale osteoartritis











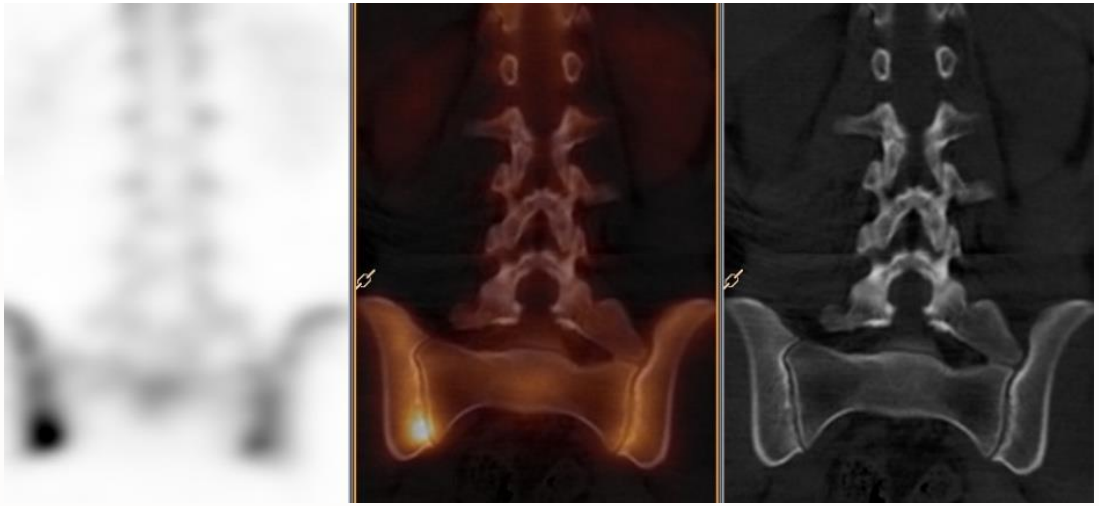
Vrouw, 21j

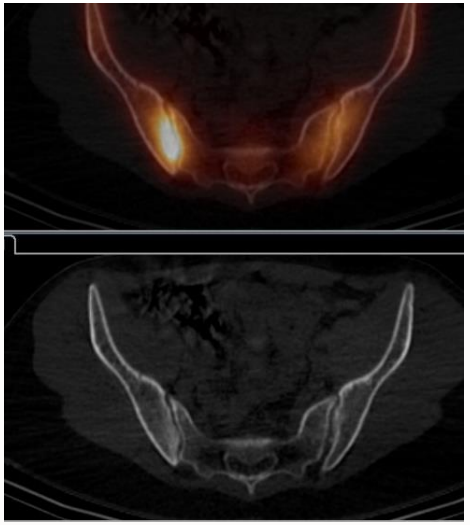
Indicatie : lage ruglast

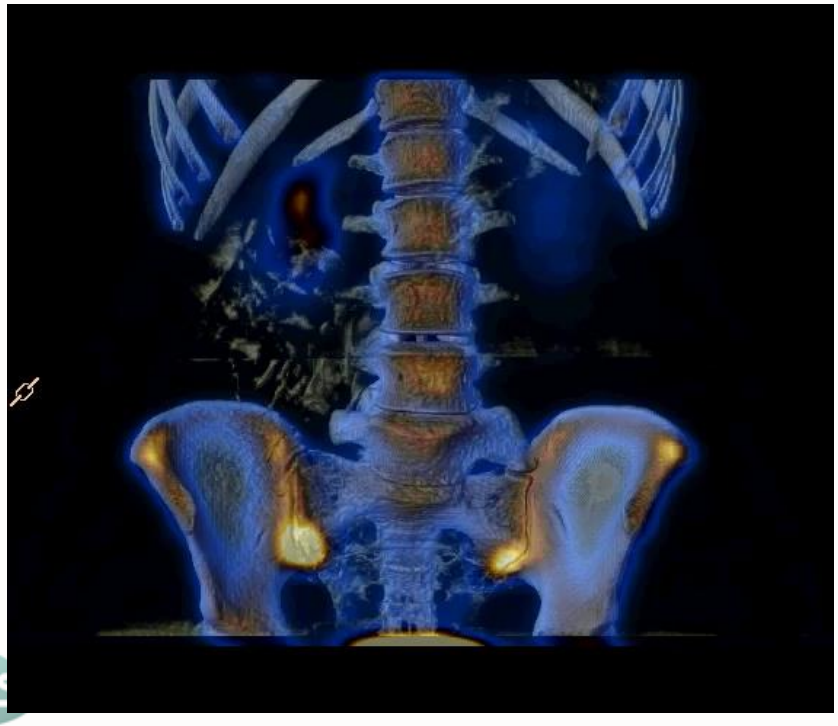
DD. facettair, discogeen, sacroiliacaal



ZIEKENHUIS aan de STROOM







<u>Diagnose:</u> sacroiliitis (re>li)

congenitaal hypertrofe processus transversus L5 li
(lumbosacrale transitiewervel Castellvi IIa)
geen facetartritis

ZIEKENHUIS aan de STROOM



facetartritis L3-L4 re



spondylolyse L3 bilateraal



indeuking L4 + sekwel laminectomie

ZIEKENHUIS aan de STROOM



Man, 39j

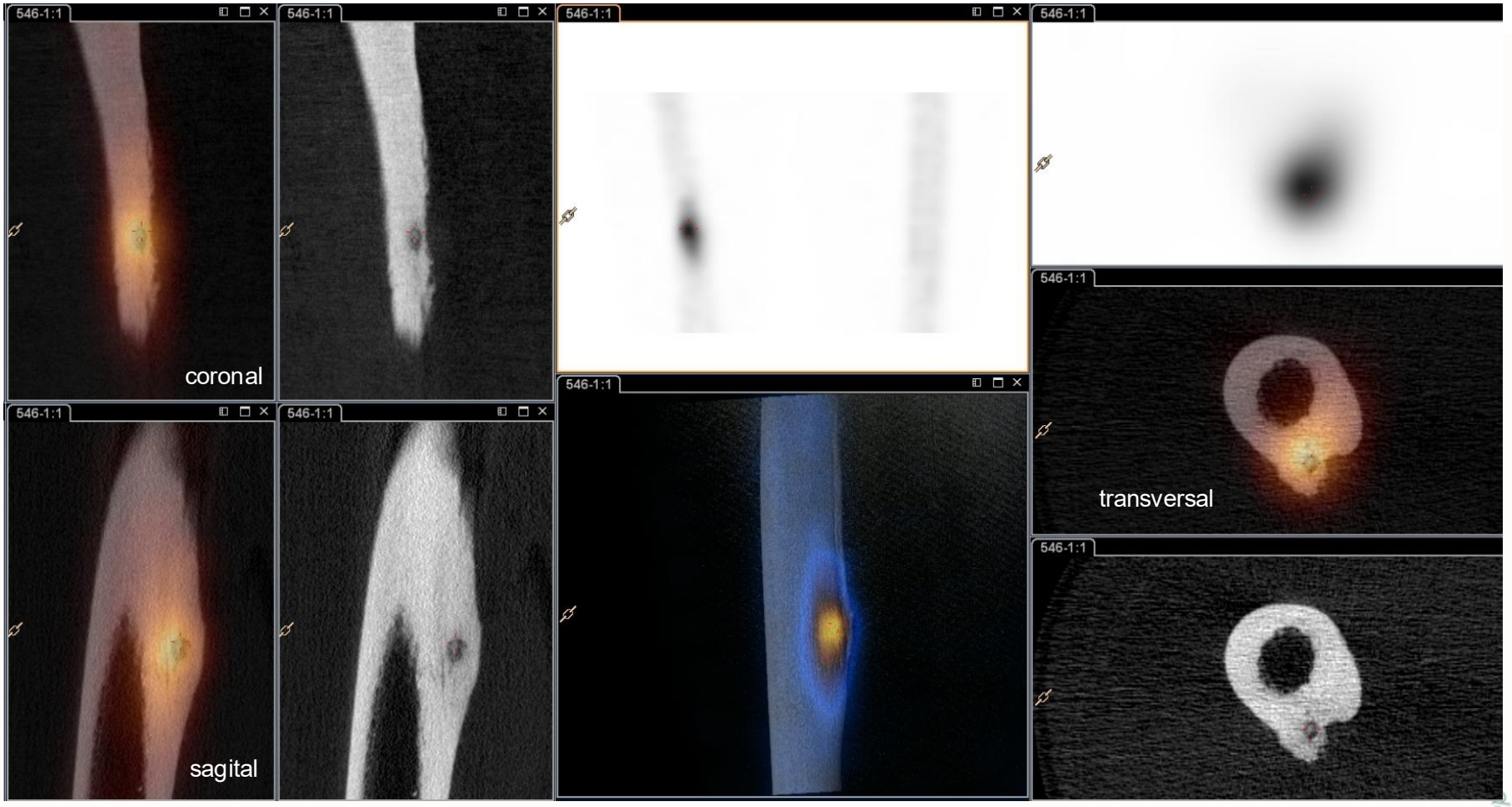
<u>Indicatie :</u> lumboischialgie rechts, vooral bij zitten of liggen, nachtelijke component

DD. lumbaal, bekken of heup?

NMR LWZ : hypertroof facet L4-L5

RX bekken en echo rechterheup : negatief

ZIEKENHUIS aan de STROOM



Diagnose: corticaal osteoïed osteoma met centrale nidus

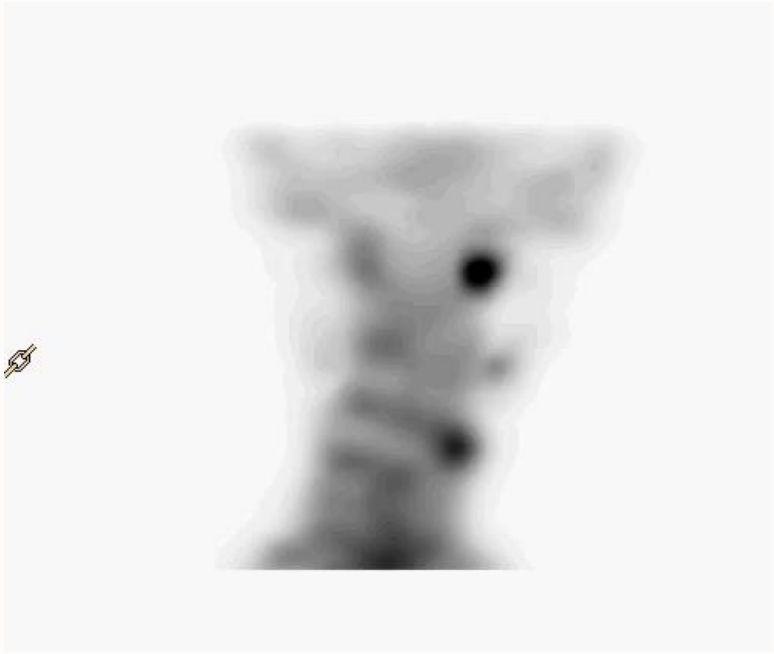
ZIEKENHUIS aan de STROOM

Vrouw, 54 jaar

Indicatie : gekende SA; aanhoudende pijn rechterkaak. Uitsluiten botpath.

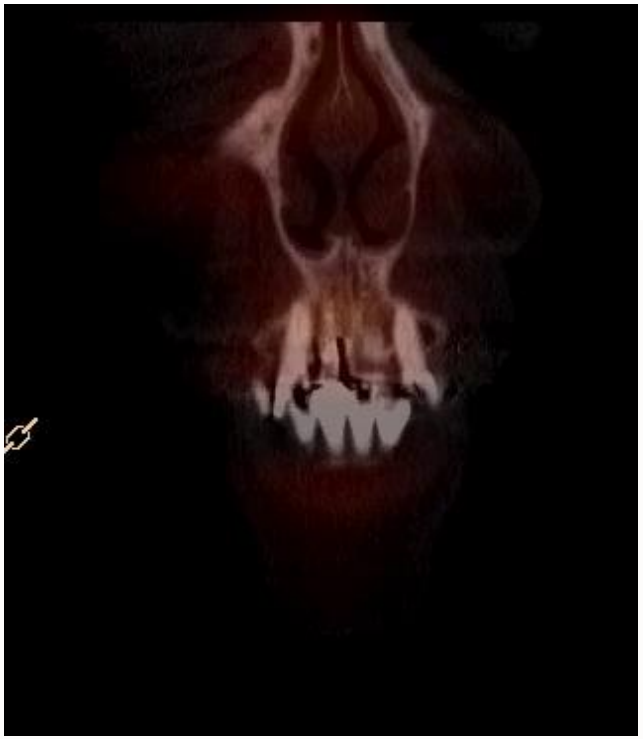
MRI trigeminus normaal

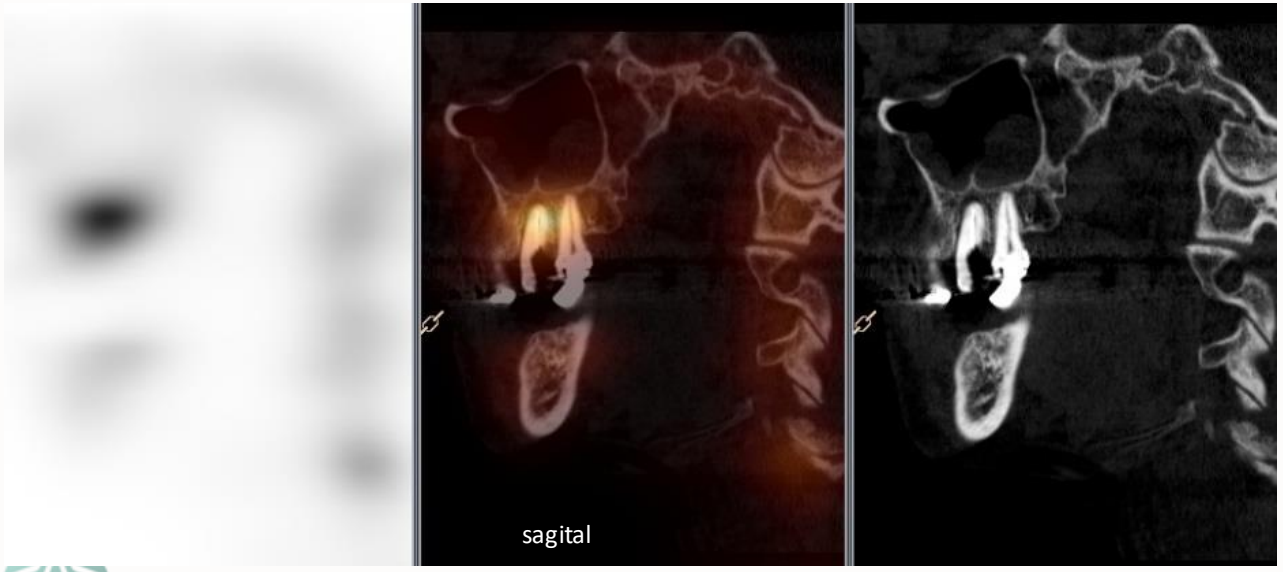




ZIEKENHUIS aan de STROOM



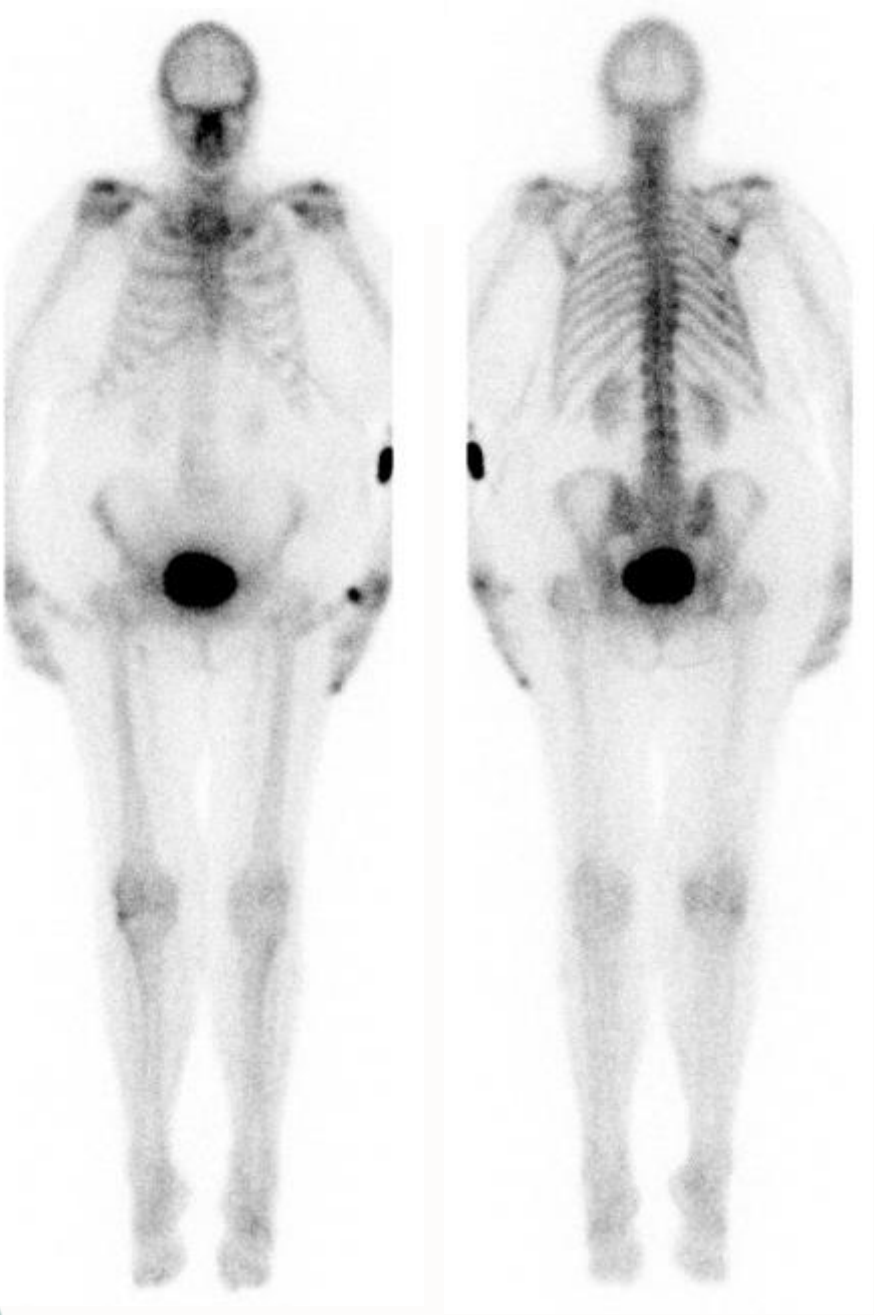




Diagnose: tandabces

NB. facetartrose C4-C5 re

ZIEKENHUIS aan de STROOM



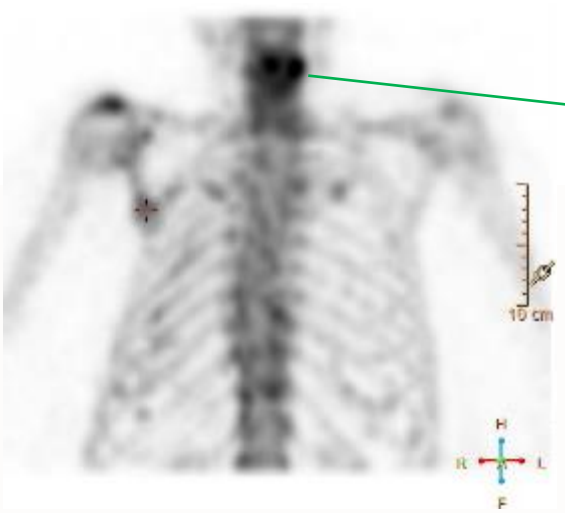
Vrouw, 88j

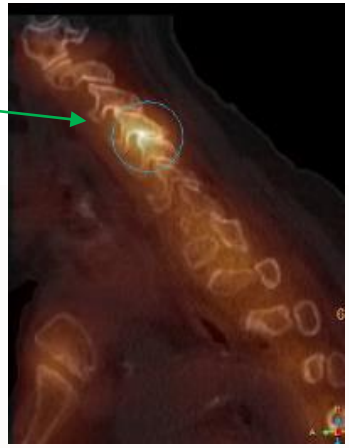
<u>Indicatie :</u> val, pijn rechter flank en schouder

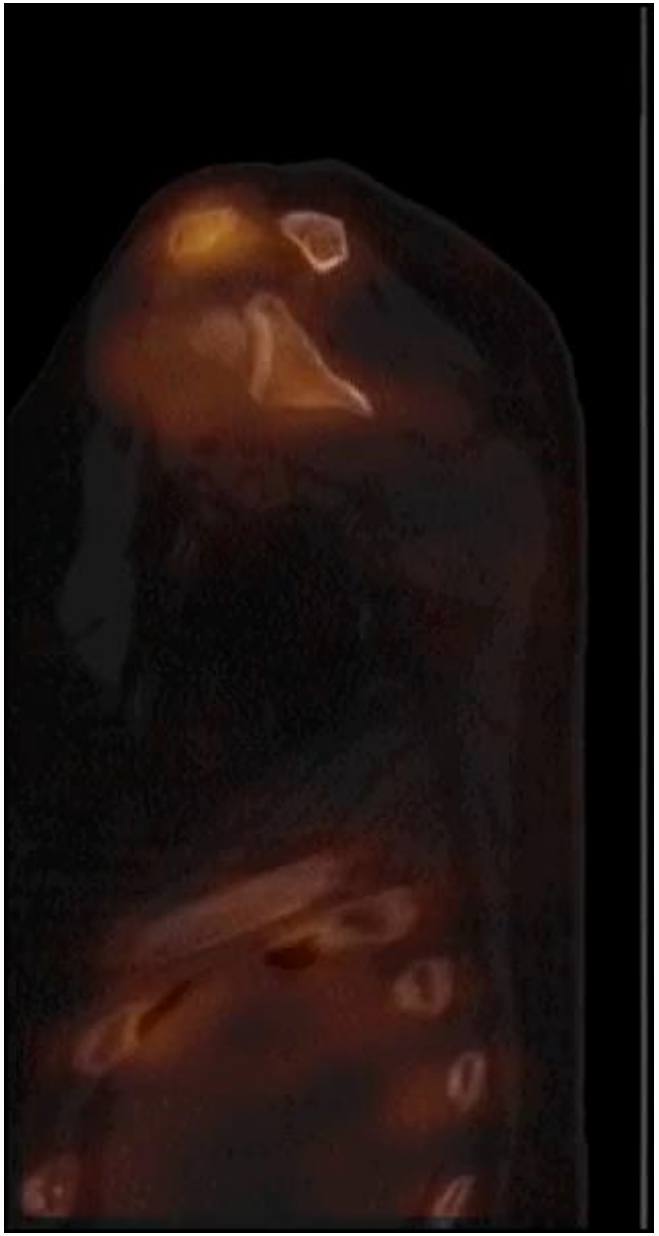
Op RX geen fractuur van humerus of schouder, vermoeden fractuur 6^{e} rib rechts

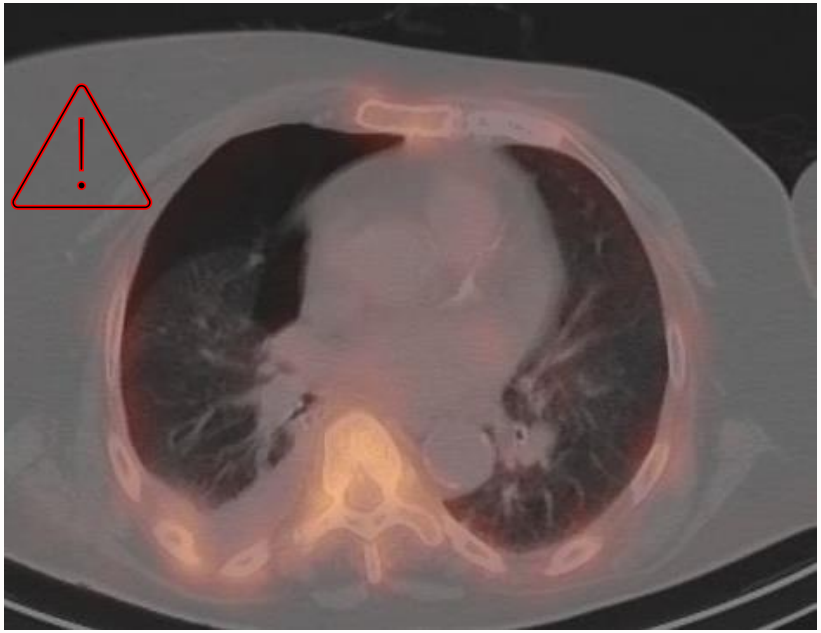


ZIEKENHUIS aan de STROOM

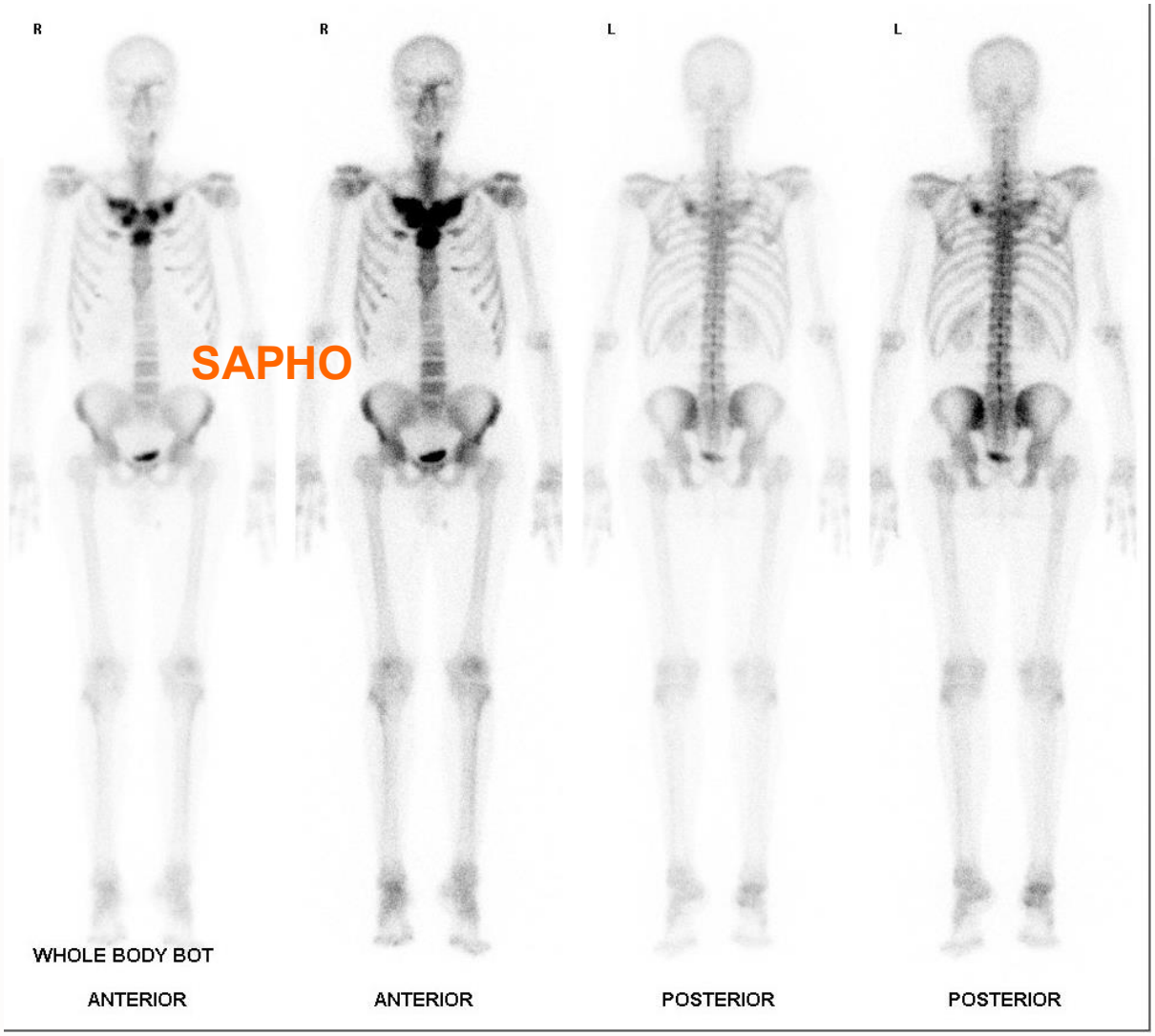








ZIEKENHUIS aan de STROOM



Bullhead-sign" : sternocostoclavicular hyperostosis

ZIEKENHUIS aan de STROOM

Botscan samenvatting

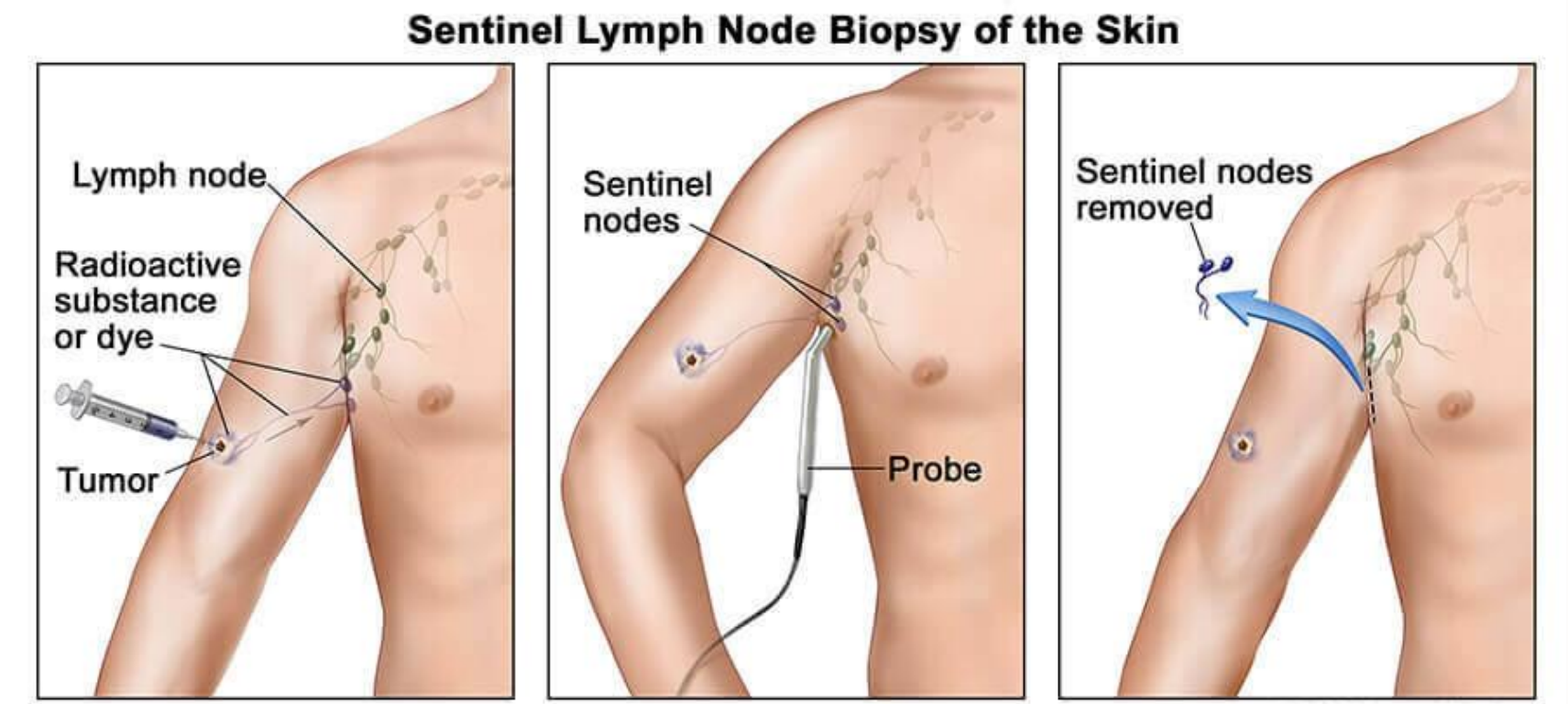
- vasculaire fase (hand/voet/knie): synovitis
- whole body evaluatie
- additionele diagnostische waarde van SPECT/CT
  - ☑ verwijsbrief: + evt. SPECT/CT van specifieke regio
  - → *lage dosis lokalisatie CT (cone beam)*
  - → *klassieke diagnostische CT (incl. weke delen: discus,…)*
- actieve osteoarticulaire letsels
- culprit-lesie → gerichte therapie
- specifiek patroon: DD reuma, orthopedisch, onco

ZIEKENHUIS aan de STROOM

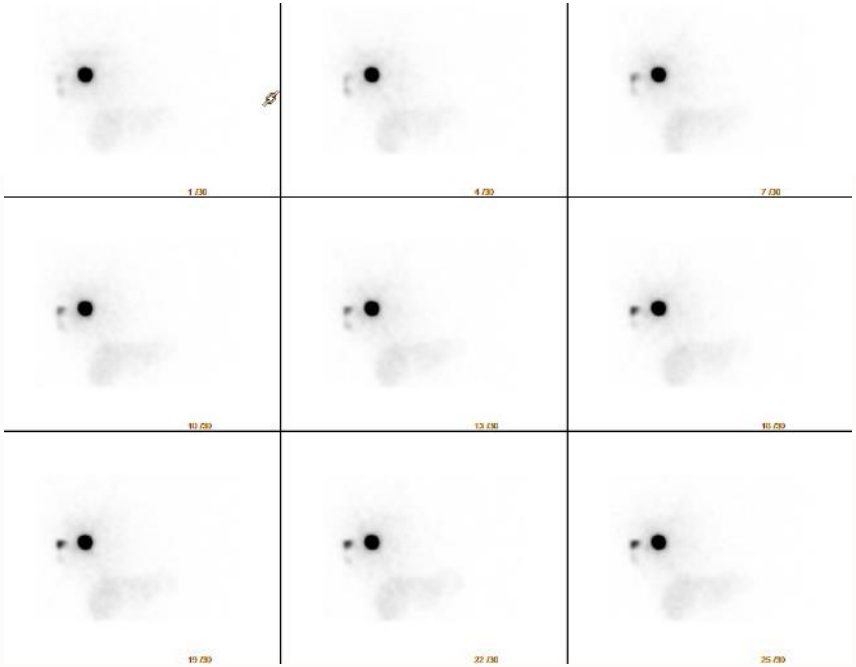


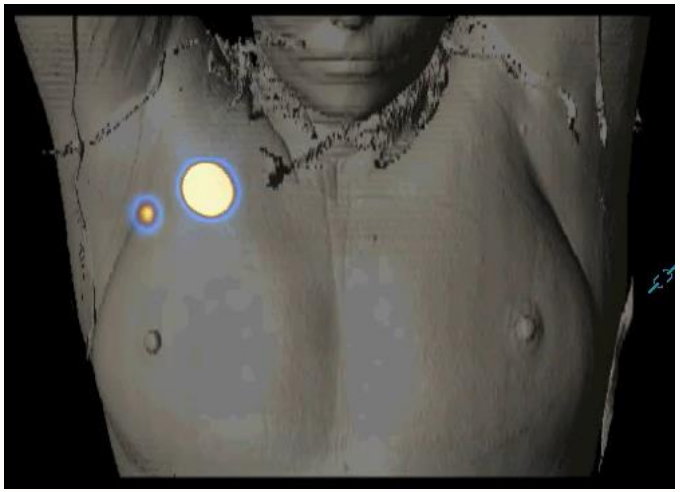
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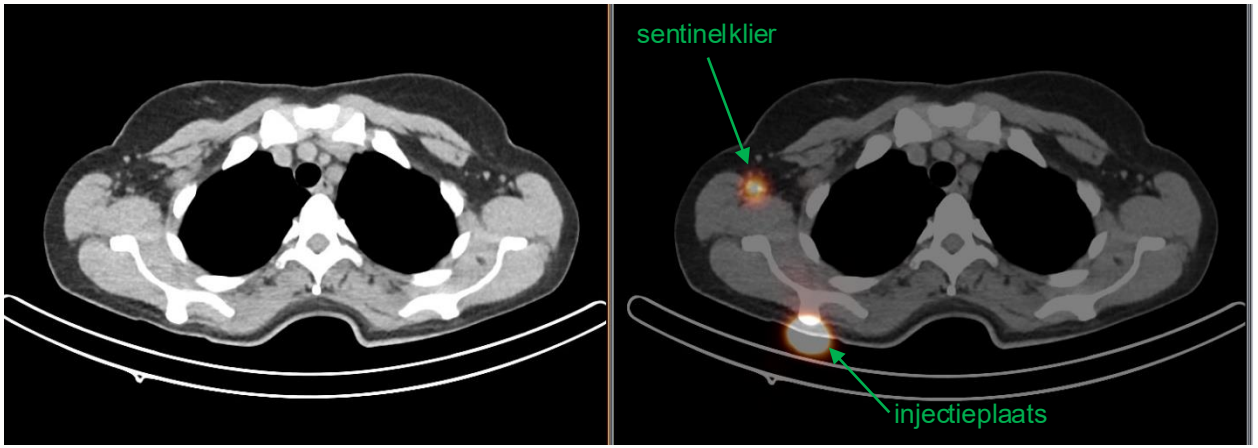
Sentinel-scintigrafie



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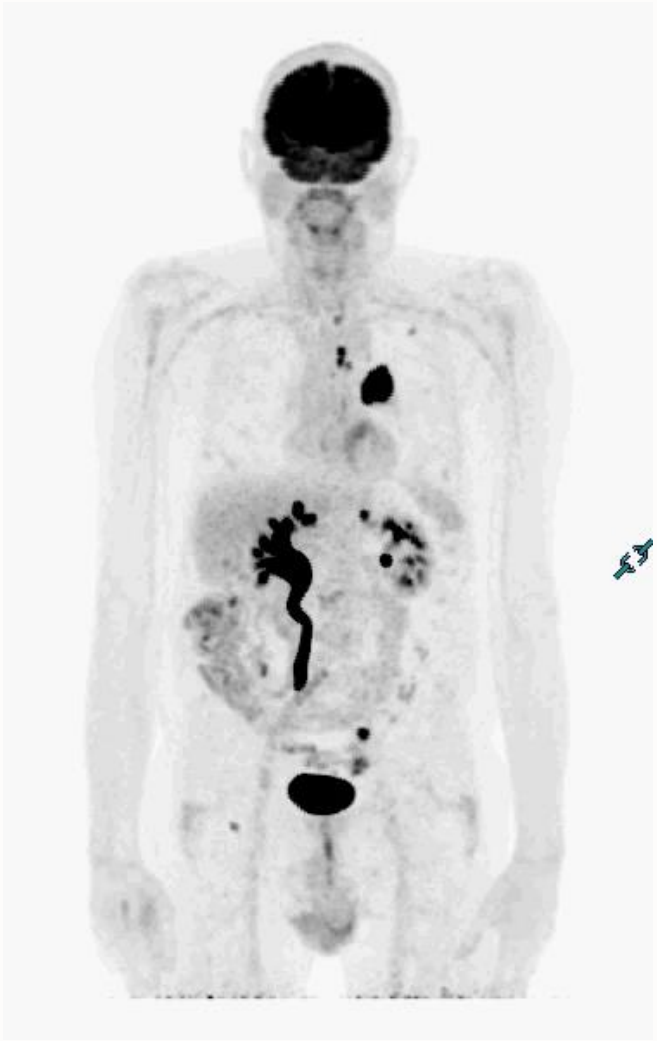


ZIEKENHUIS aan de STROOM



ZIEKENHUIS aan de STROOM

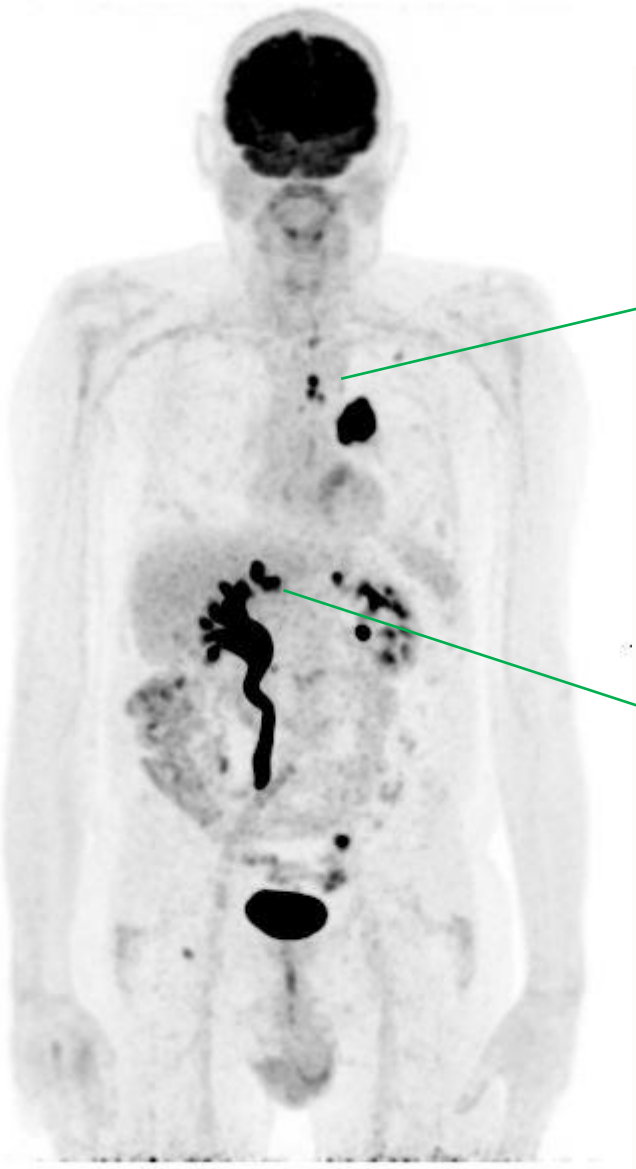
F^{18}DG en F^{18}PSMA PET/CT-scan

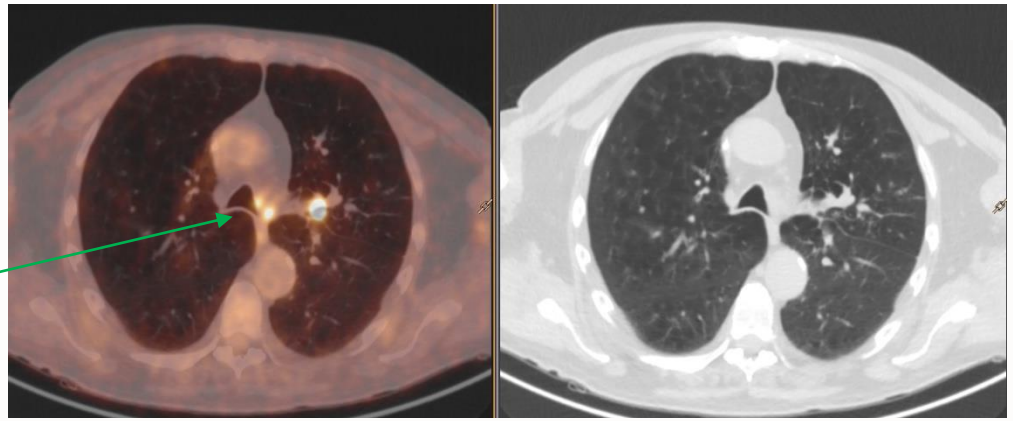


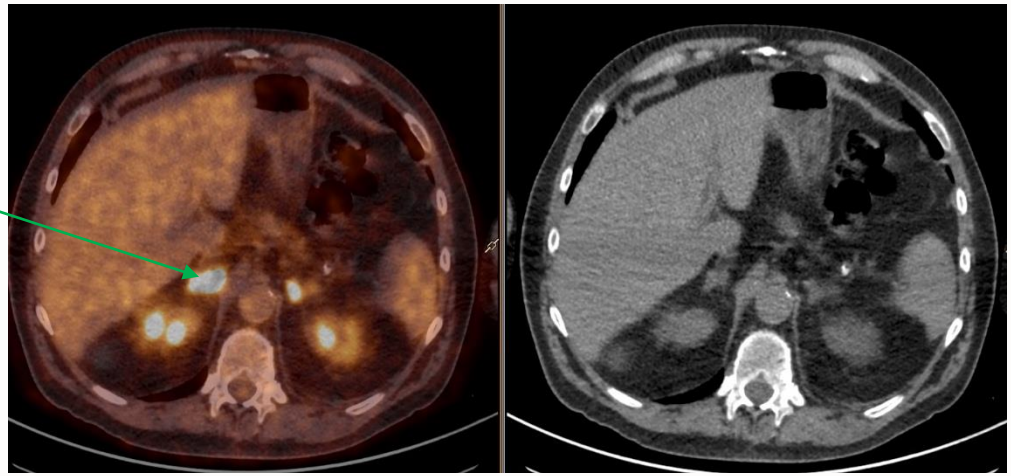


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Fluor^{18} Deoxy Glucose



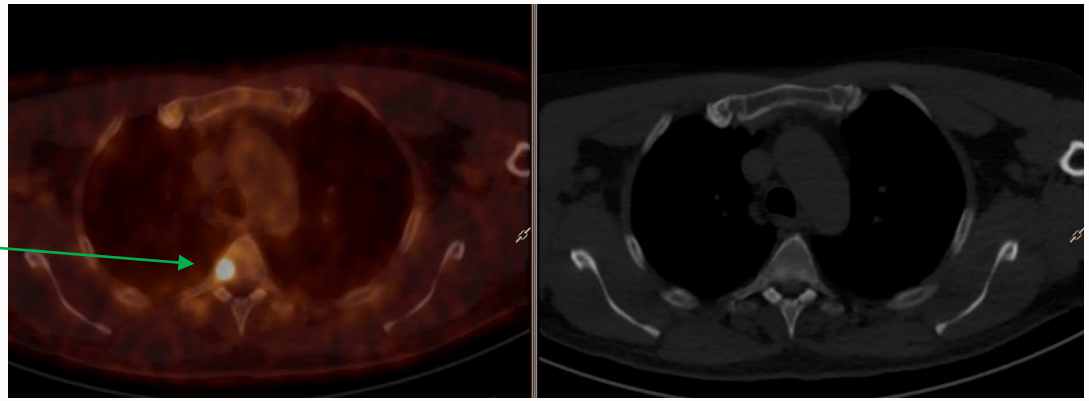


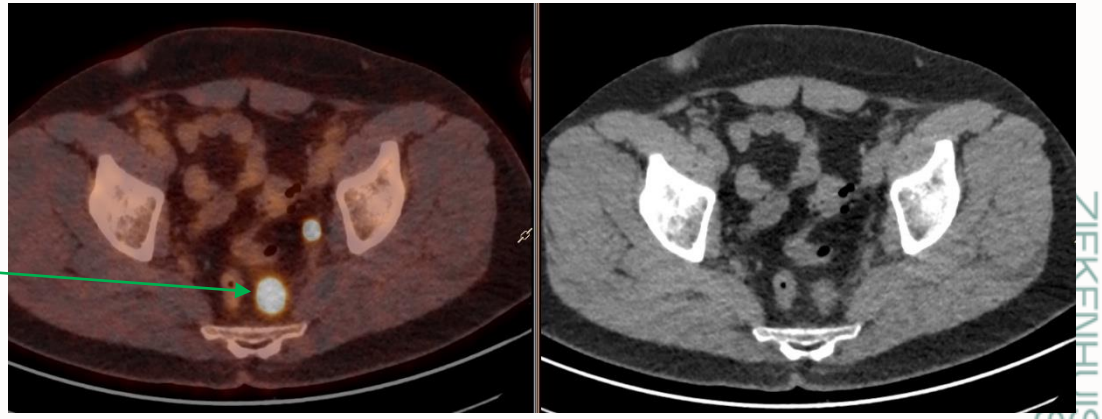


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Fluor^{18} Prostate Specific Membrane Antigen







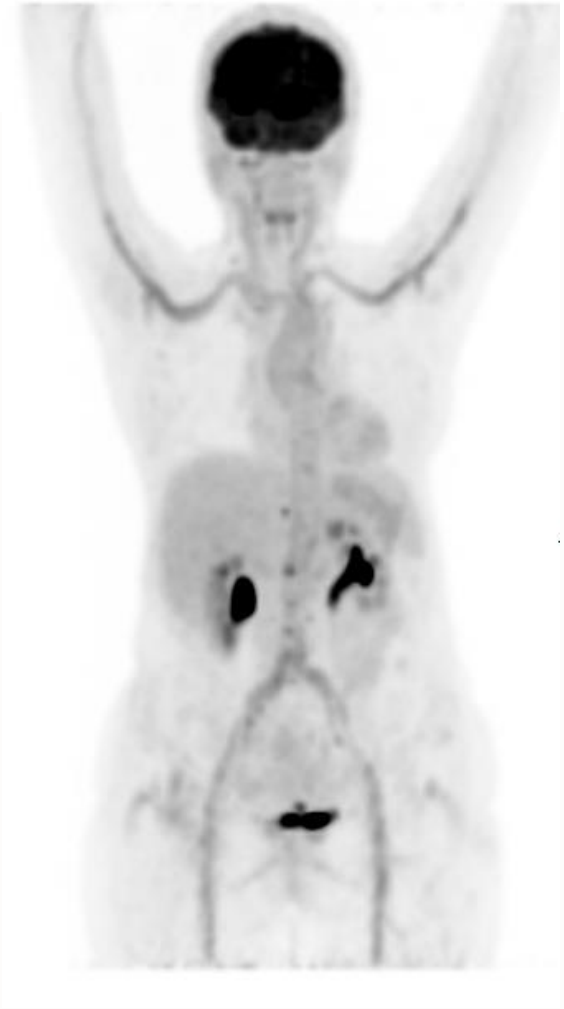
ZIEKENHUIS aan STROOM

Praktische uitvoering F^{18}DG PET/CT-scan

- 4-6 uur nuchter, enkel water
- geen excessieve spierinspanningen
- **glycemie** meten voor IV FDG-injectie
- '**incubatieduur**': 1 uur rust met hydratatie en warmte
- PET/CT whole body-scan: duur +/-15 min
- zo nodig +/- handen en voeten



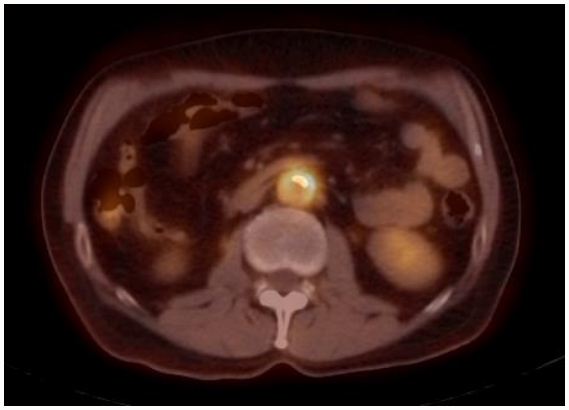
ZIEKENHUIS aan de STROOM

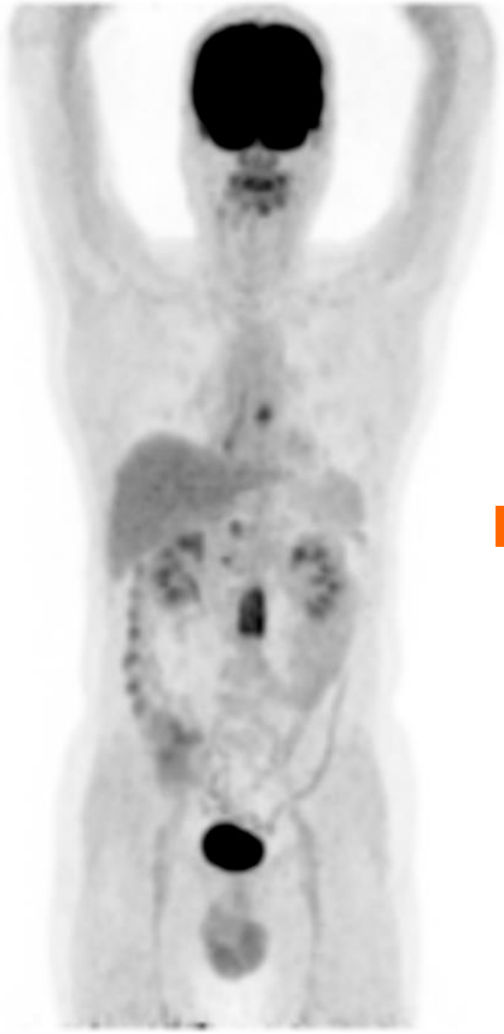


Vrouw 69 j**, Large vessel vasculitis (GCA)**

+ thoracolumbar interspinous bursitis and coxartritis

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6 wk



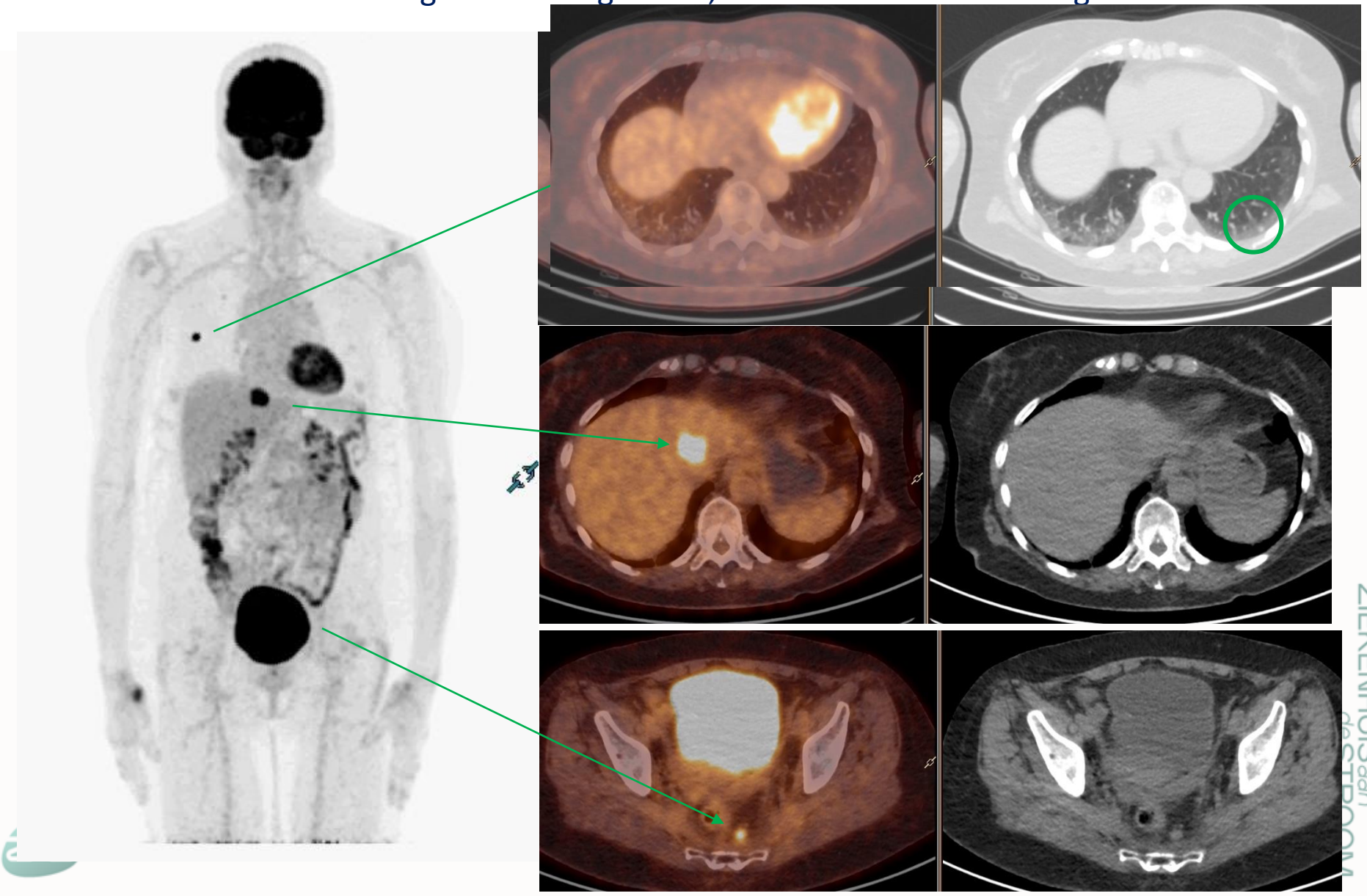
Infrarenale aortitis (segmentele Takayasu/sarcoidose) R/ steroiden

ZIEKENHUIS aan TROOM

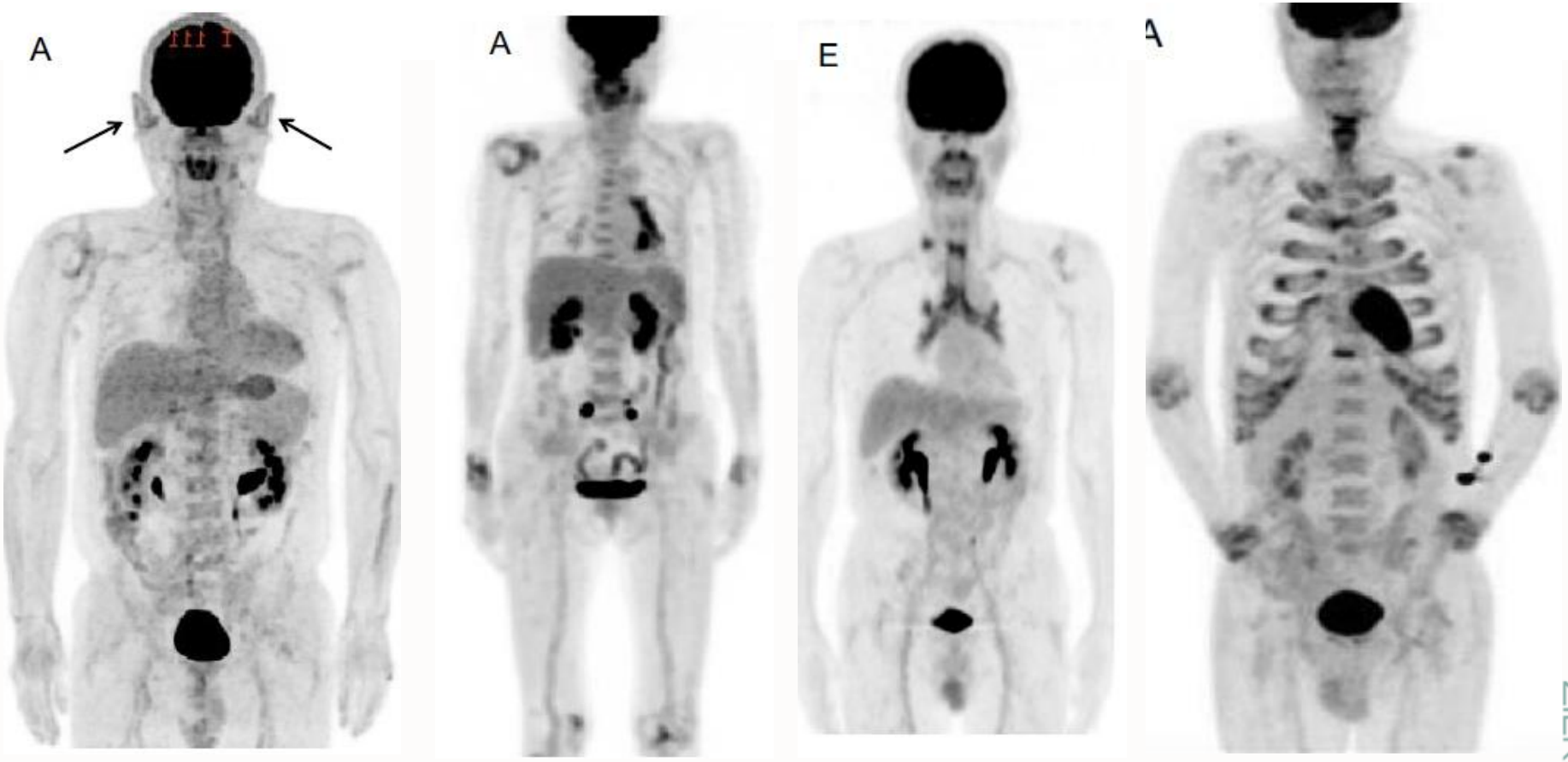
Vrouw, 81j

Indicatie : follow-up na rectumcarc R/radiochemo en ESD

CT thor-abd 2 maanden geleden: longmeta's, residuele wandverdikking rectum



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Relapsing polychondritis : auricular, nasal, tracheal, bronchial, costosternal cartilage, peripheral joints,…

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Final nuclear artistic view

- **tijd** en **aandacht** maken voor individuele patiënt, met voorzichtige keuze van juiste technieken
- ophelderen van diagnose door puzzel van **kliniek**, **hybride beeldvorming**, creativiteit en innovatie
- ode aan de **verwondering**



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