Role of nuclear medicine imaging including new developments

Andor W.J.M. Glaudemans, nuclear medicine physician
Professor in Multimodality Imaging of Infections and Inflammatory Diseases
Dept of Nuclear Medicine and Molecular Imaging, UMCG, the Netherlands
President Dutch Society of Nuclear Medicine

university of groningen

University Medical Center Groningen

Disclosure slide

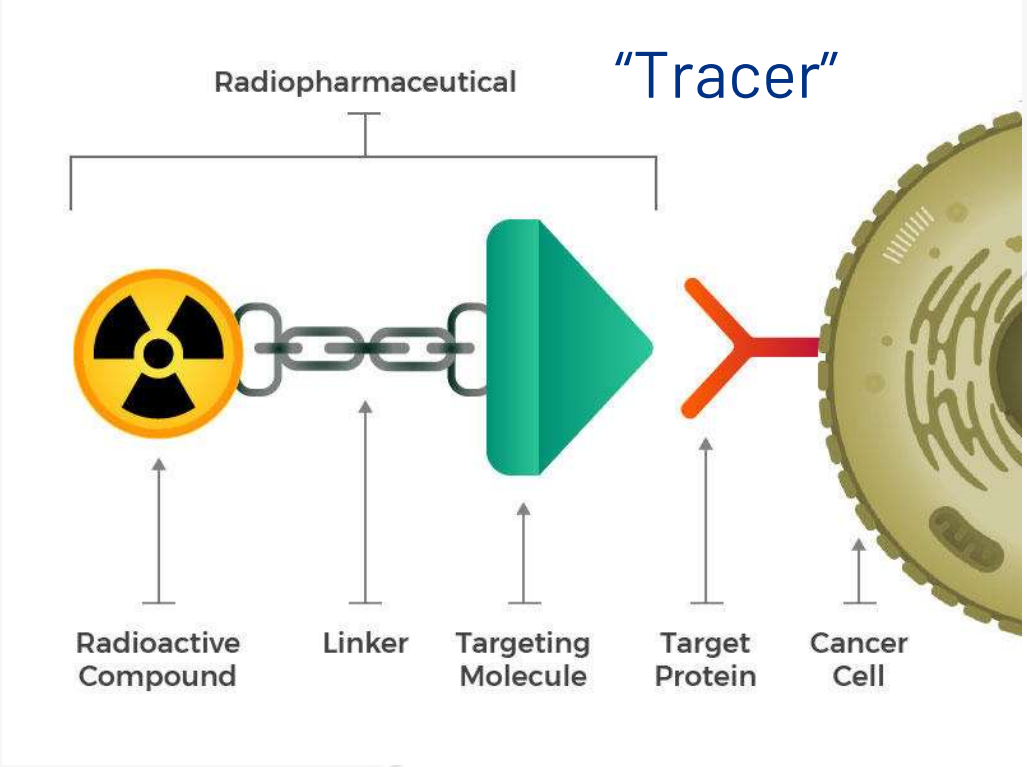
Conflict of interests	
Relevant relationship with companies	Siemens (PUSH contract Siemens/UMCG)
• Sponsoring or research money • Fee or other reimbursement • Shareholder • Other relationship, namely …	President Dutch Society of Nuclear Medicine

Content

- Nuclear medicine in general
- Department of Nuclear Medicine and Molecular Imaging
- FDG-PET/CT, overview, indications and role in current guidelines
  - FDG-PET/CT in inflammation & infection
  - Vasculitis/PMR
- New indications?
  - IgG4
  - Sjögren's disease
- New developments
  - LAFOV PET/CT systems
  - Automatic segmentation
  - Specific tracers

umcg

Nuclear medicine in a nutshell



umcg

Nuclear Medicine

Fast growing!

- Growth of 7-10% yearly in diagnostic procedures
- Expected fivefold increase in 2040 in radionuclide therapies

Why

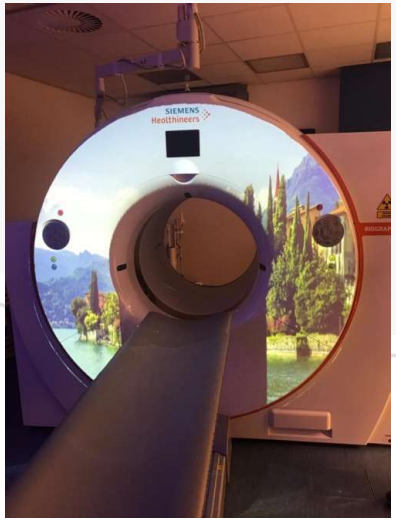
- Ageing population → higher incidence of cancer, heart diseases and infections
- Growing evidence of value and costefficacy
- Developments in camera systems and specific radiopharmaceuticals
- Treatment possibilities without severe side effects
- Biodistribution of new drugs

Three principles

- Theragnostics, Personalized care, Therapy prediction & early evaluation

umcg

Our department



Cyclotron

- CyclotrIBA Cyclone 18 TWIN, IBA 18-MeV dual beam cyclotron

Tracer production facilities

- GMP-compliant facilities for the production of tracers for human use
- Fully-equipped R&D laboratories
- Analysis laboratory

Positron Emission Tomography (PET/CT) scanners

- Siemens Biograph Vision digital PET, 128 slice CT
- Siemens Total-body PET
- Siemens Biograph mCT, 40-slice CT

SPECT scanners

- Siemens Symbia T16-slice CT
- Hologic Discovery DXA system
- Siemens Symbia T2-slice CT

Small animal imaging

- Siemens Focus 220 microPET
- Siemens INVEON microPET/CT
- MR solutions Simultaneous PET/MRI

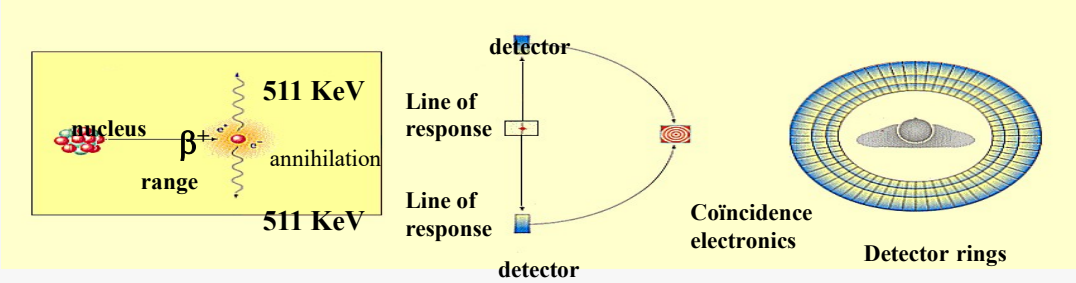
umcg

Assortment PET tracers

Regular care	Clinical research	
[^{11}C]choline	[^{11}C]DASB	[^{89}Zr]atolizumab
[^{11}C]methionine	[^{11}C]Flumazenil	[^{89}Zr]bevacizumab
[^{11}C]PIB	[^{11}C]MeDAS	[^{89}Zr]CB307
[^{11}C]raclopride	[^{11}C]methylreboxetine	[^{89}Zr]CED88004S
[^{13}N]ammonia	[^{11}C]PK11195	[^{89}Zr]pembrolizumab
[^{15}O]water	[^{11}C]telmisartan	[^{89}Zr]REGN3767
[^{18}F]FDG	[^{11}C]UCB-J	[^{89}Zr]REGN5054
[^{18}F]FDHT	[^{18}F]canagliflozin	[^{89}Zr]S095012
[^{18}F]FDOPA	[^{18}F]AlF-Resca-IL2	Other …
[^{18}F]FES	[^{18}F]FEOBV	
[^{18}F]NaF	[^{18}F]GEH200251	
[^{18}F]PSMA-1007	[^{18}F]MC225	
[^{68}Ga]DOTATOC	[^{18}F]olaparib	
[^{68}Ga]FAPI		
[^{89}Zr]trastuzumab		

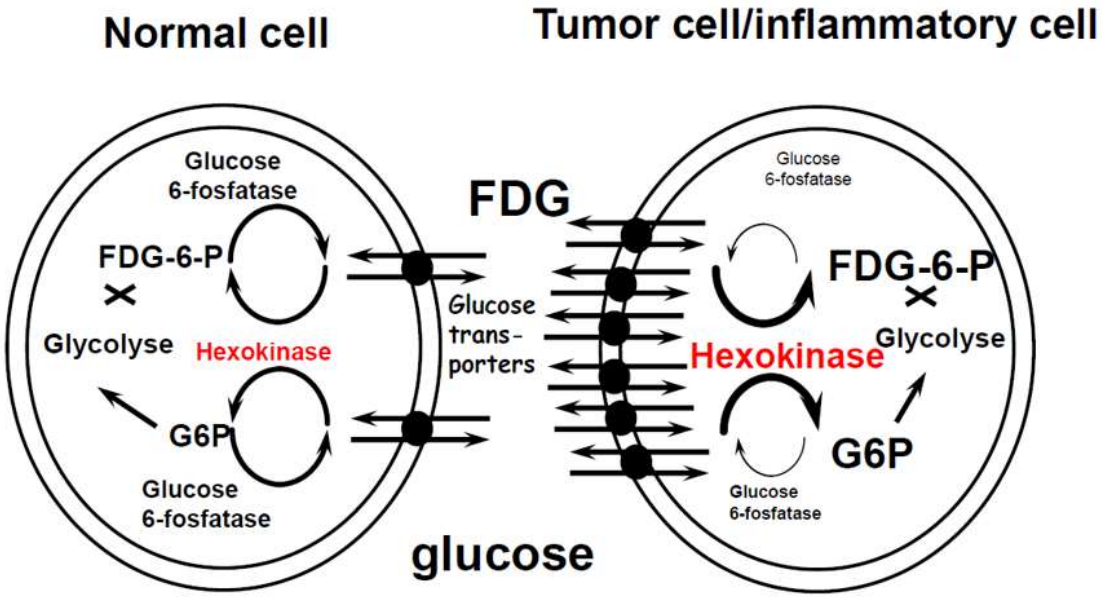
umcg

Positron emission tomography – PET/CT camera



PET/CT camera

- Positrons → 2 gamma rays in opposite direction
- Combines anatomy and physiology
- Spatial resolution: 3-4 mm
- Fast acquisition time
- One-stop-shop principle



umcg

^{18}F-FDG-PET

PROS

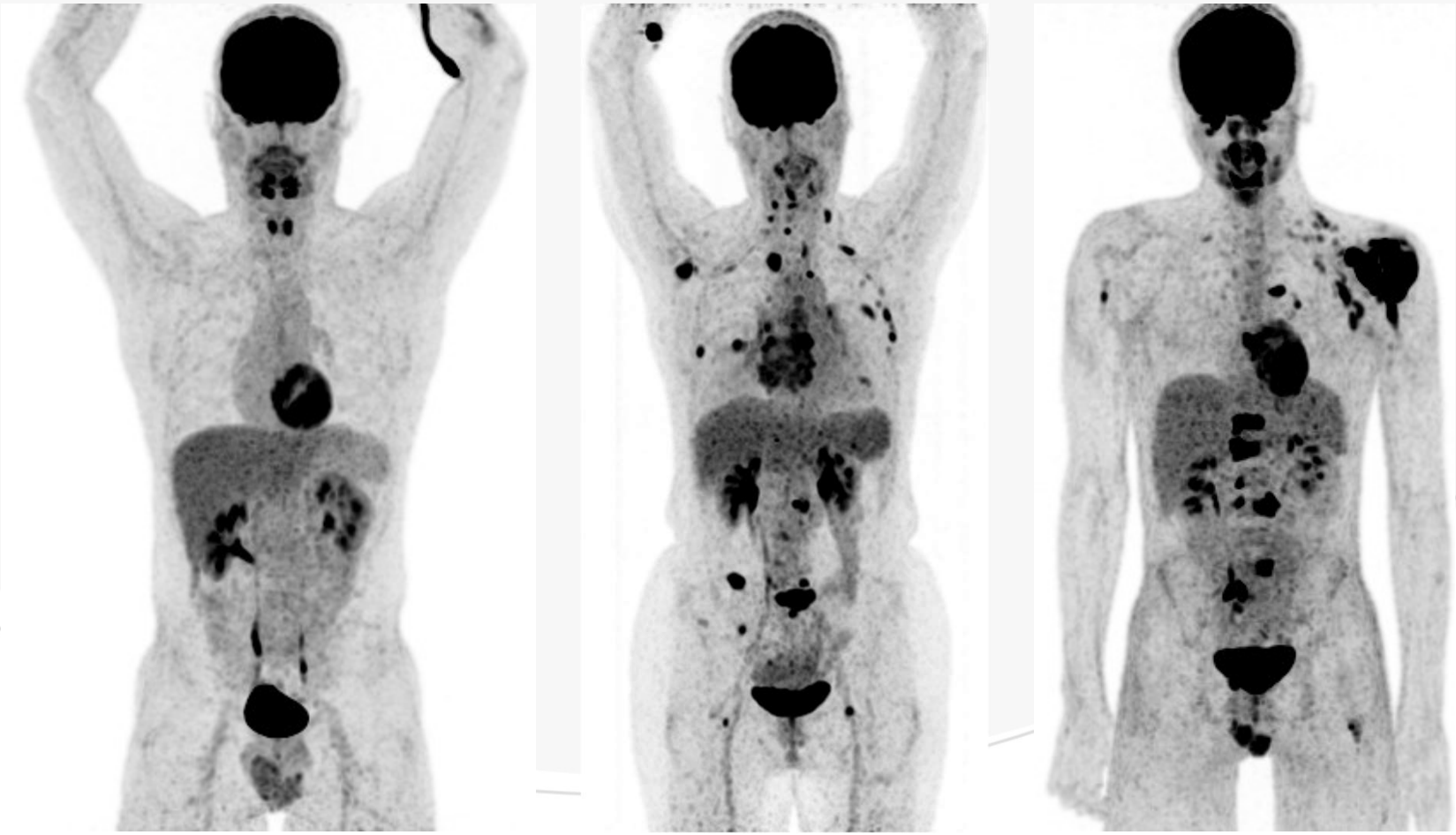
- High uptake in activated granulocytes, monocytes, macrophages and giant cells; less in bacterial and fungal cells
- Imaging 60 minutes after injection
- One-stop-shop with diagnostic CT
- High spatial resolution, possibility for quantification
- Excellent tool when searching for infection/inflammation
- Increasingly used for therapy evaluation

CONS

- Non-specific!
- Difficult to discriminate between infection, inflammation and malignancy

umcg

^{18}F-FDG-PET



Indications FDG-PET for I&I

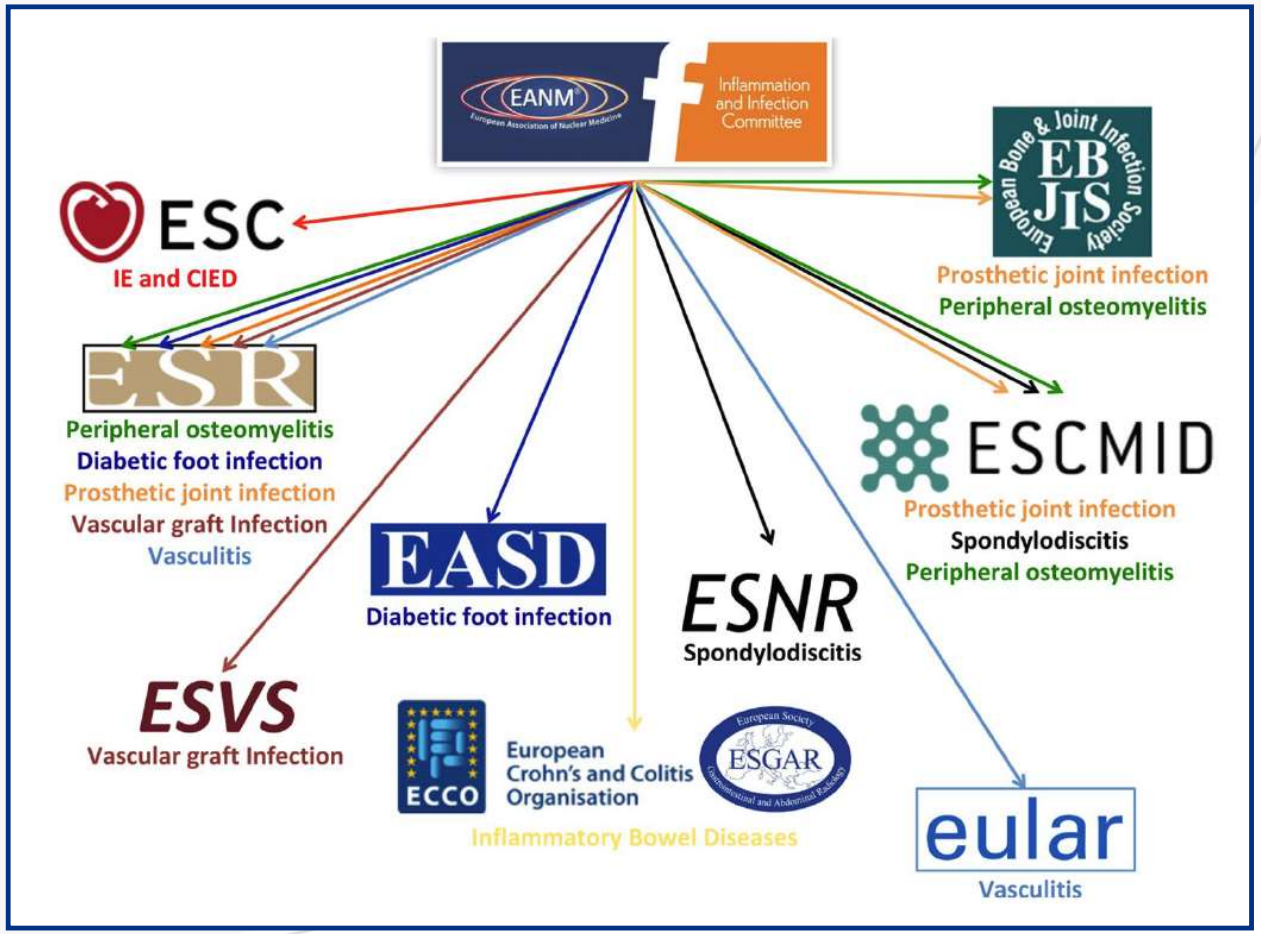
- Endocarditis + intravascular device infection
- Vasculitis and PMR
- Vascular graft infections
- Peripheral bone osteomyelitis
- Spondylodiscitis/spinal infection
- Patients with bacteremia, not only in adults but also in children
- Fungal infections
- Infected liver and kidney cysts
- Therapy evaluation & evaluation of side effects in patients with immunotherapy
- (Cardiac) sarcoidosis/tuberculosis/AIDS associated infections
- Inflammatory Bowel Disorders?
- Prosthetic joint infection, diabetic foot infection → WBC first choice

In UMCG: FDG-PET/CT <72 h in patients with suspected endocarditis, suspected VGI, and in patients with S. aureus bacteremia

umcg

INFLAMMATION & INFECTION Committee

- To develop guidelines and recommendations for nuclear medicine imaging in I&I
- To develop diagnostic flowcharts for the optimum use of nuclear medicine imaging for I&I
- To bridge with clinical societies involved in diagnosis and treatment of I&I
- To provide education and training for nuclear medicine physicians
- To organize scientific and educational sessions at international meetings



umcg

Joint EANM/SNMMI guideline/procedure standard for hybrid [^{18}F]FDG-PET/CT use in infection and inflammation

Expected May 2024

umcg

General protocol recommendations

- Myocardial suppression protocol
  - Recommended for cardiac sarcoidosis, infective endocarditis/cardiac device infections, bacteremia and selected FUO indications (when cardiac infection is suspected)
- Glucocorticoids
  - Vasculitis: Delay steroid therapy until after PET (unless risk of ischemic complications) or perform study within 3 days after start of oral steroids
  - High dose IV steroids may reduce sensitivity (even after 1 day)
- Antibiotics
  - Perform study as soon as possible to minimize impact sensitivity
  - Unlikely to have a significant impact on diagnostic accuracy when performed in the work-up phase of infection or in patients with severe disease and lack of response to therapy
- Hyperglycemia
  - Neither hyperglycemia nor diabetes significantly affects false negative rate in a retrospective series (Rabkin et al. J Nucl Med 2010)
  - Not an absolute contra-indication, however efforts should be made to have glycemia < 140 mg/dL (Pijl et al. J Nucl Med 2023)

umcg

EANM/SNMMI Guideline for ^{18}F-FDG Use in Inflammation and Infection*

Version 2.0 - May2024

Inflammation

Major indications	Well described applications without sufficient evidence	Unclear advantage
- Primary evaluation of vasculitides - Primary evaluation of suspected c-GCA - Confirm/exclude suspected flare/recurrence LVV - (Suspected) PMR to confirm/exclude GCA - Atypical PMR (e.g. pt non responding to steroids) **-Sarcoidosis** (+ cardiac involvement) - Treatment monitoring in cardiac sarcoidosis - IgG4-related disease and retroperitoneal fibrosis	- Treatment response LVV - Inflammatory bowel disease	- Inflammatory arthropathies/myopathies - Interstitial lung diseases (SSc-ILD)

umcg

Vasculitis and PMR

FDG-PET/CT(A) imaging in large vessel vasculitis and polymyalgia rheumatica: joint procedural recommendation of the EANM, SNMMI, and the PET Interest Group (PIG), and endorsed by the ASNC

European Journal of Nuclear Medicine and Molecular Imaging (2018) 45:1250–1269

Writing group*:
Riemer H.J.A. Slart[1a,d], Andor W.J.M. Glaudemans[b,d], Panithaya Chareonthaitawee[c,e], Giorgio Treglia[b,d], Florent L. Besson[d], Thorsten A. Bley[d], Daniel Blockmans[d], Ronald Boellaard[d], Jan Bucerius[a], José Manuel Carril[d], Wengen Chen[c], Maria C Cid[d], Bhaskar Dagupta[d], Sharmila Dorbala[c,e], Olivier Gheysens[b,d], Fabien Hyafil[a], Shaifali Jain[d], Thorsten Klink[d], Conny J. van der Laken[d], Francisco Lomeña[d], Michela Massollo[d], Sergio Prieto-González[d], Raashid Luqmani[d], Anne Roivainen[d], Carlo Salvarani[d], Antti Saraste[d], Michael Schirmer[d], Hein J. Verberne[a], Annibale Versari[b,d], Alexandre E. Voskuyl[d], Martin A. Walter[d], Dario Camellino[d], Elisabeth Brouwer[d], Marco A. Cimmino[d]

PET Interest Group (PIG)

EANM European Association of Nuclear Medicine — BIOMEDICAL IMAGING AND THERAPY FOR PERSONALIZED HEALTHCARE

Cardiovascular Committee
Infection and Inflammation Committee

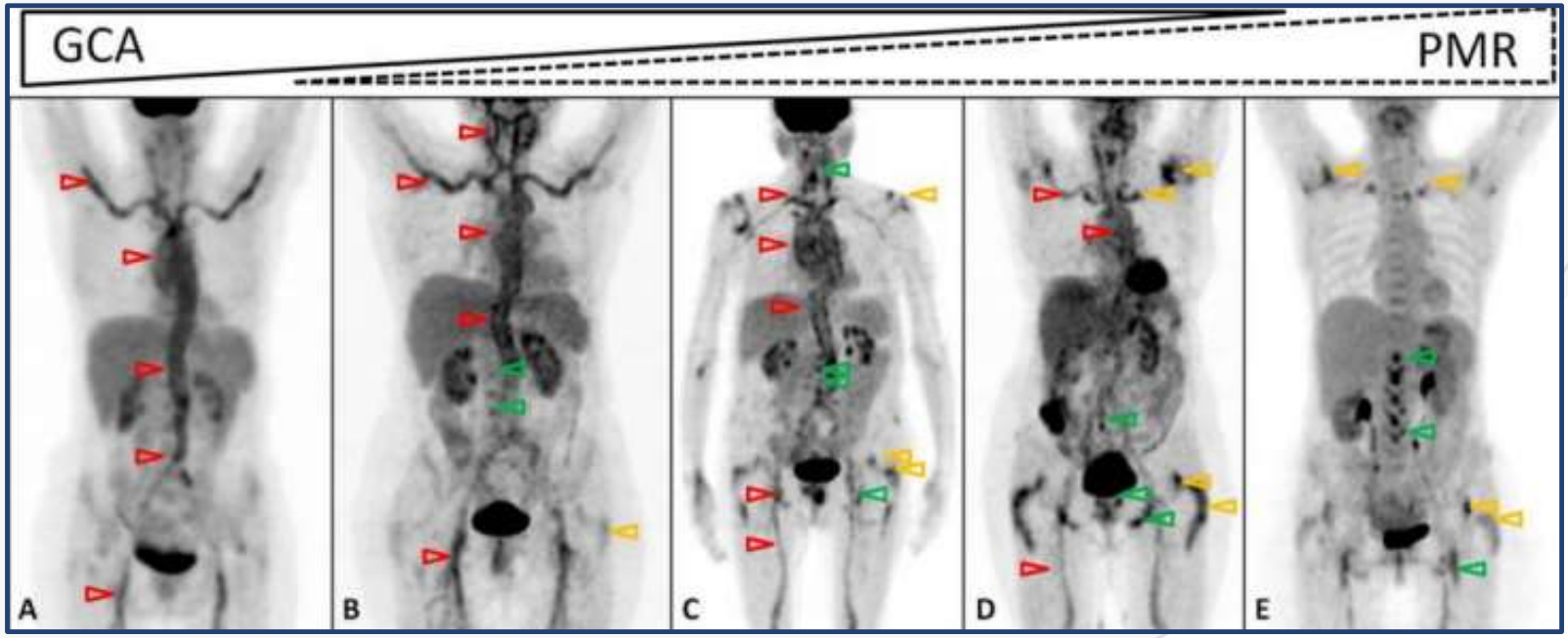
SNMMI SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

Cardiovascular Council ASNC

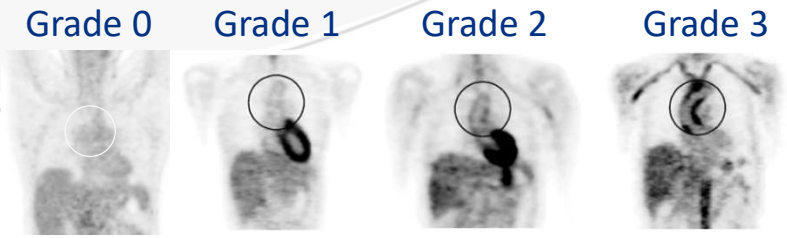
umcg

Vasculitis and PMR

A disease continuum



Grade 0 = no uptake
Grade 1 = minimal uptake (< liver)
Grade 2 = moderate uptake (= liver)
Grade 3 = marked uptake (> liver)



umcg

Vasculitis and PMR

Patient preparation and scan acquisition

Consensus recommendations (see supplement 1)

- Recommend patient fasting for at least 6 h prior to FDG administration, although intake of non-caloric beverages is allowed during that period (evidence level II, grade B).
- Normal blood glucose levels are desirable, but glucose levels below 7 mmol/L (126 mg/dL) are preferable (evidence level II, grade B).
- Withdraw or delay GC therapy until after PET, unless there is risk of ischemic complications, as in the case of GCA with temporal artery involvement. FDG-PET within 3 days after start of GC is optional as a possible alternative (evidence level III, grade B).
- A minimum interval of 60 min is recommended between FDG administration and acquisition for adequate biodistribution (evidence level III, grade B).

Scan interpretation

Consensus recommendations

- We propose the use of a standardized grading system: 0 = no uptake (≤ mediastinum); 1 = low-grade uptake (< liver); 2 = intermediate-grade uptake (= liver), 3 = high-grade uptake (> liver), with grade 2 considered possibly positive and grade 3 positive for active LVV (evidence level II, grade B).
- Typical FDG joint uptake patterns including scapular and pelvic girdles, interspinous regions of the cervical and lumbar vertebrae, or the knees should be evaluated and reported if present (evidence level II, grade B).
- Normalization of the arterial wall uptake to the background activity of venous blood pool provides a good reference for assessing vascular inflammation (evidence level II, grade B).
- Grading of arterial inflammation against the liver background is an established method (evidence level II, grade B).

In general

Consensus statement

- Based on the available evidence, FDG-PET imaging exhibits high diagnostic performance for the detection of LVV and PMR (evidence level II, grade B).
- FDG-PET/CT(A) may be of value for evaluating response to treatment by monitoring functional metabolic information and detecting structural vascular changes (evidence level III, grade C), but additional prospective FDG-PET/CT(A) studies are warranted.

umcg

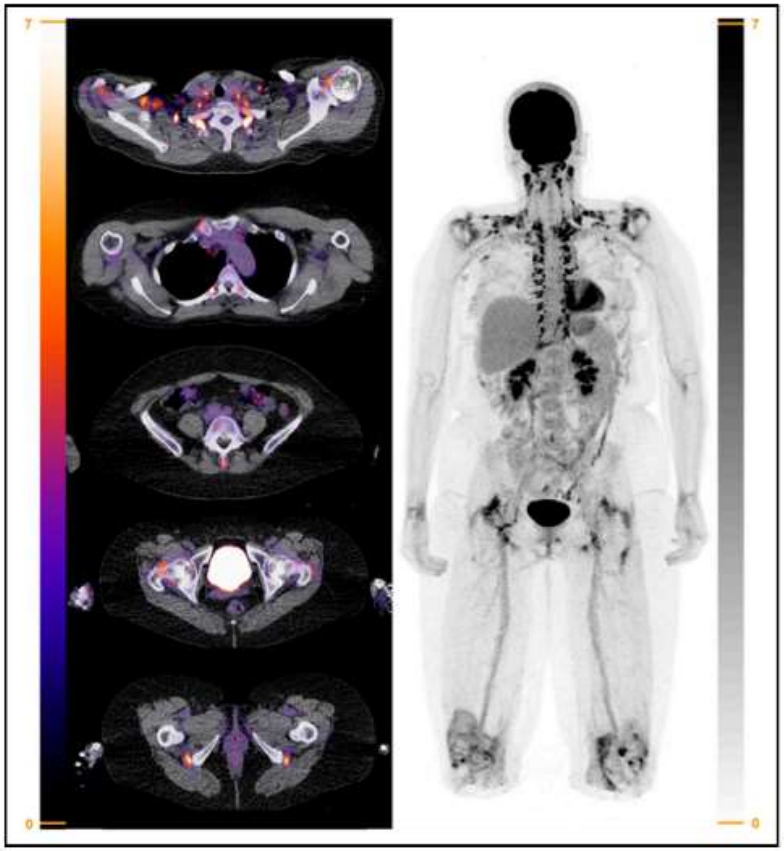
FDG-PET/CT findings and PMR

Diagnostic value of [18F]FDG-PET/CT in polymyalgia rheumatica: a systematic review and meta-analysis

K. S. M. van der Geest[1] · G. Treglia[2,3,4,5] · A. W. J. M. Glaudemans[6] · E. Brouwer[1] · F. Jamar[7] · R. H. J. A. Slart[6,8] · O. Gheysens[7]

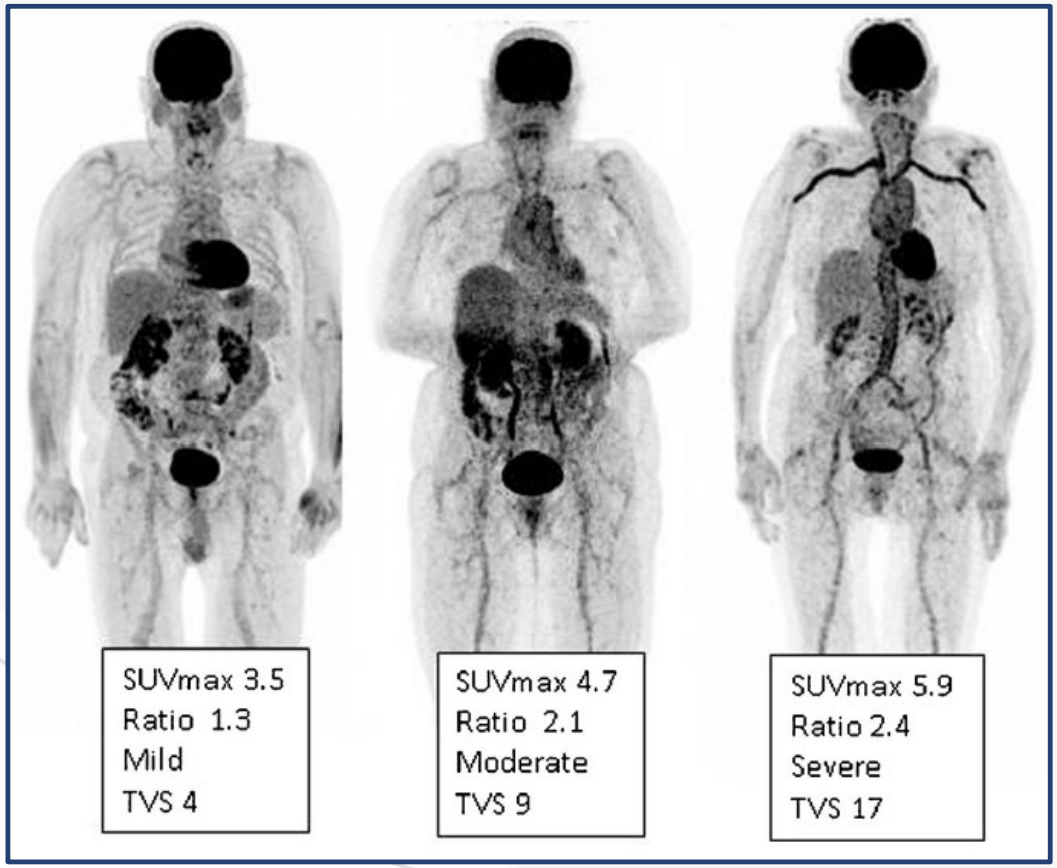
Table 3 Diagnostic accuracy of [18F]FDG-PET/CT findings

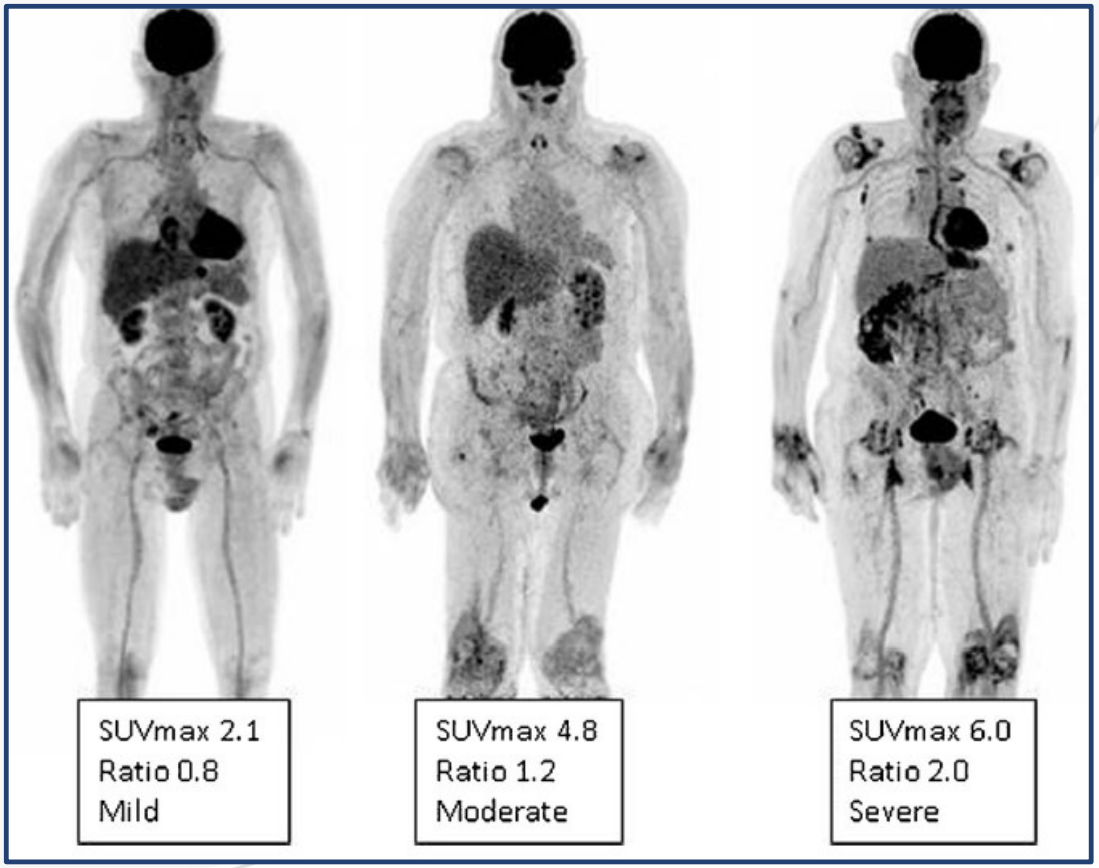
Site positive on [18F]FDG-PET/CT	No. of patients (no. of cohorts[b])	Sensitivity (95% CI)	Specificity (95% CI)	Diagnostic OR (95% CI)
Hip	346 (5)	63.7 (46.3–78.1)	78.1 (69.1–85.1)	6.25 (3.32–11.79)
Greater trochanter	428 (6)	83.3 (59.0–94.5)	56.7 (38.3–73.5)	6.54 (2.87–14.90)
Interspinous bursa	546 (6)	74.5 (59.3–85.4)	81.4 (59.6–92.8)	12.76 (5.64–28.89)
Ischial tuberosity	428 (6)	85.4 (62.3–95.4)	70.1 (53.5–82.7)	13.72 (5.20–36.18)
Shoulder[a]	406 (6)	78.4 (65.4–87.5)	69.5 (42.5–87.5)	8.30 (3.05–22.58)
Sternoclavicular joint	375 (5)	64.4 (39.1–83.6)	72.1 (48.3–87.8)	4.68 (2.06–10.63)



umcg

Vasculitis and PMR

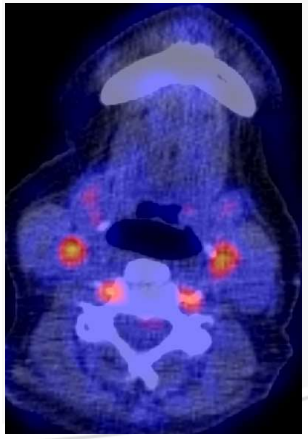




umcg

Vasculitis

GCA



GCA
+
PMR

Polyarteritis
nodosa

Polychon-
dritis

umcg

FDG PET in LVV

EULAR recommendations for the use of imaging in large vessel vasculitis in clinical practice: 2023 update

3. FDG-PET*, alternatively MRI or CT, can be used for the detection of mural inflammation or luminal changes of extracranial arteries in patients with suspected GCA.	1 (PET), 3 (CT), 5 (MRI)
2. High-resolution MRI or FDG-PET* can be used as alternatives to ultrasound for the assessment of cranial arteries† in patients with suspected GCA.	1

Diagnostic yield of combined cranial and large vessel PET/CT, ultrasound and MRI in giant cell arteritis: A systematic review and meta-analysis

Authors	Patients included	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR- (95% CI)	DOR (95% CI)
Moreel et al.	149	58% (45-71)	97% (91-99)	18.7 (6.0-58.3)	0.43 (0.31-0.59)	NR

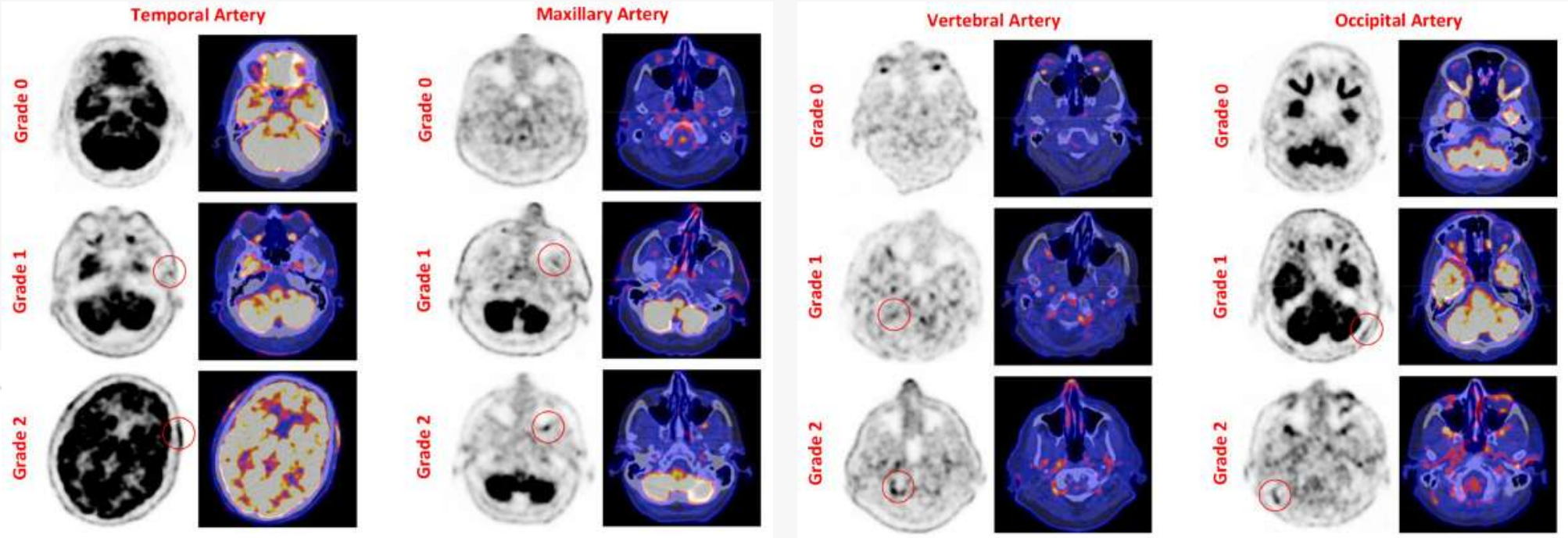
umcg

Dejaco C et al, Ann Rheum Dis 2023, Moreel et al, Autoimmun Rev 2023

FDG PET in cranial giant cell arteritis

Visual and semiquantitative assessment of cranial artery inflammation with FDG-PET/CT in giant cell arteritis

Pieter H Nienhuis[a,*], Maria Sandovici[b], Andor WJM Glaudemans[a], Riemer HJA Slart[a,c], Elisabeth Brouwer[b]



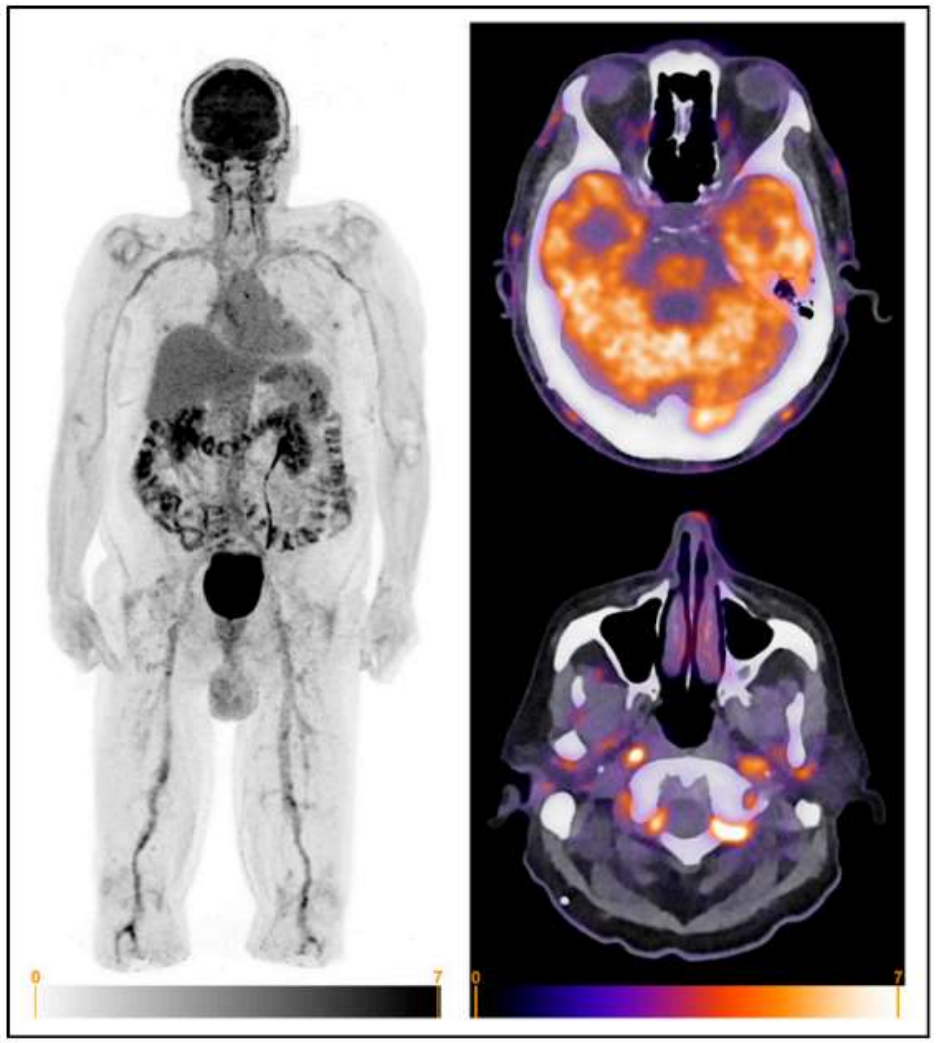
- Grade 0 : no uptake above surrounding tissue
- Grade 1 : uptake just above surrounding tissue
- Grade 2 : uptake significantly above surrounding tissue

→

- Sensitivity 79%
- Specificity 92%

umcg

FDG PET in cranial giant cell arteritis



Role of ^{18}F-FDG PET/CT in Large Vessel Vasculitis and Polymyalgia Rheumatica

Riemer H.J.A. Slart[1,2], Pieter H. Nienhuis[1,3], Andor W.J.M. Glaudemans[1], Elisabeth Brouwer[3], Olivier Gheysens[4], and Kornelis S.M. van der Geest[3]

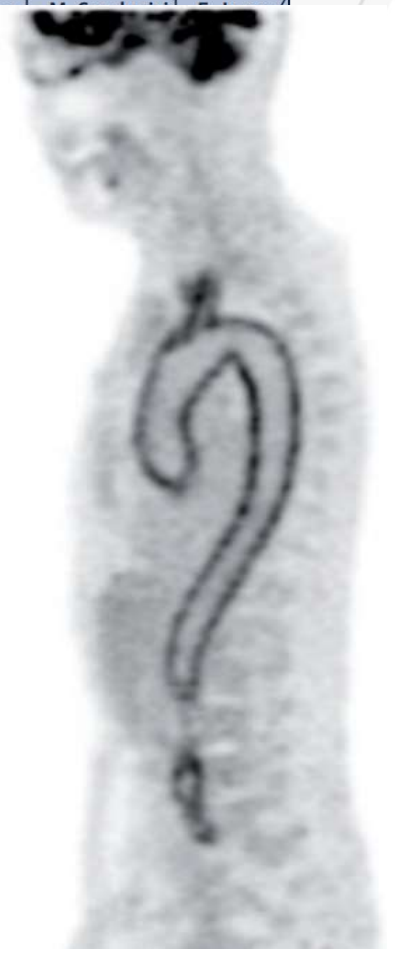
umcg

FDG PET in LVV : treatment monitoring

Diagnostic value of [18F]FDG-PET/CT for treatment monitoring in large vessel vasculitis: a systematic review and meta-analysis

K. S. M. van der Geest[1] · G. Treglia[2,3,4,5] · A. W. J. M. Glaudemans[6] · E. Brouw
O. Gheysens[7] · R. H. J. A. Slart[6,8]

Patients included	Sensitivity (95% CI)	Specificity (95% CI)	LR+ (95% CI)	LR- (95% CI)
111	77% (57-90)	71% (47-87)	2.65 (1.16-6.08)	0.32 (0.13-0.8

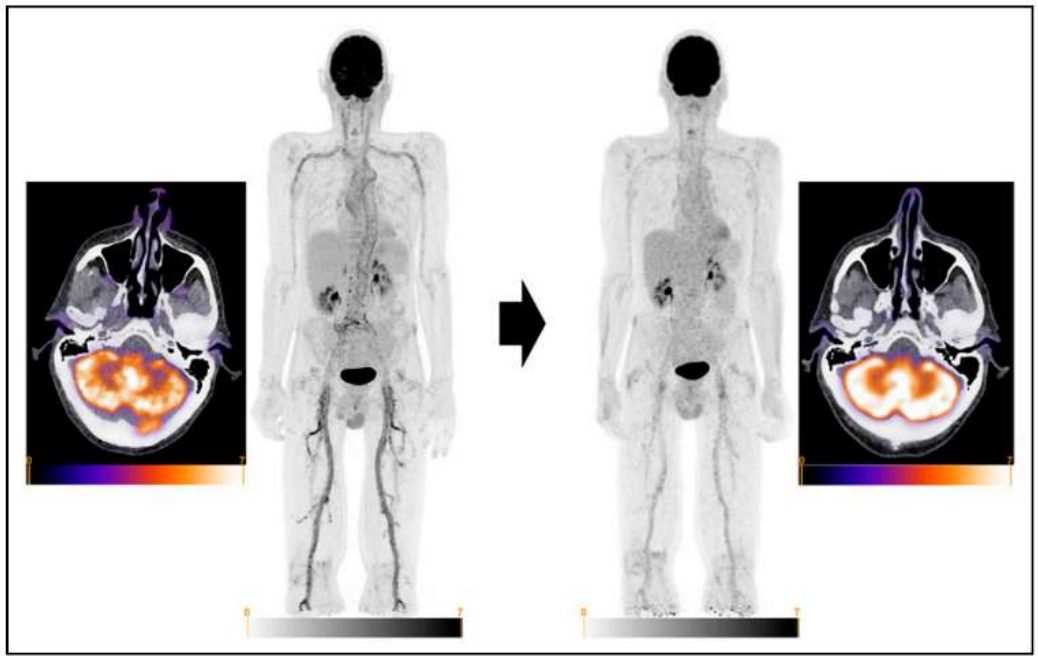


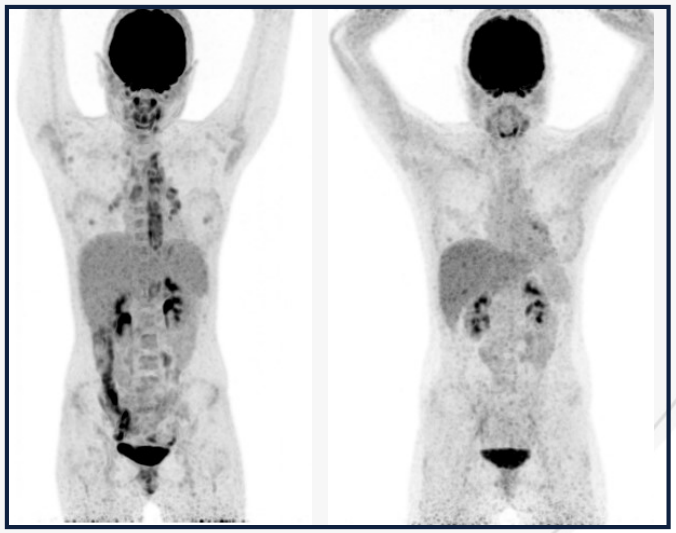
- FDG uptake decreases during treatment, but does not normalize
- Pooled proportion of pts with a positive follow-up PET during clinical remission ~ 25%

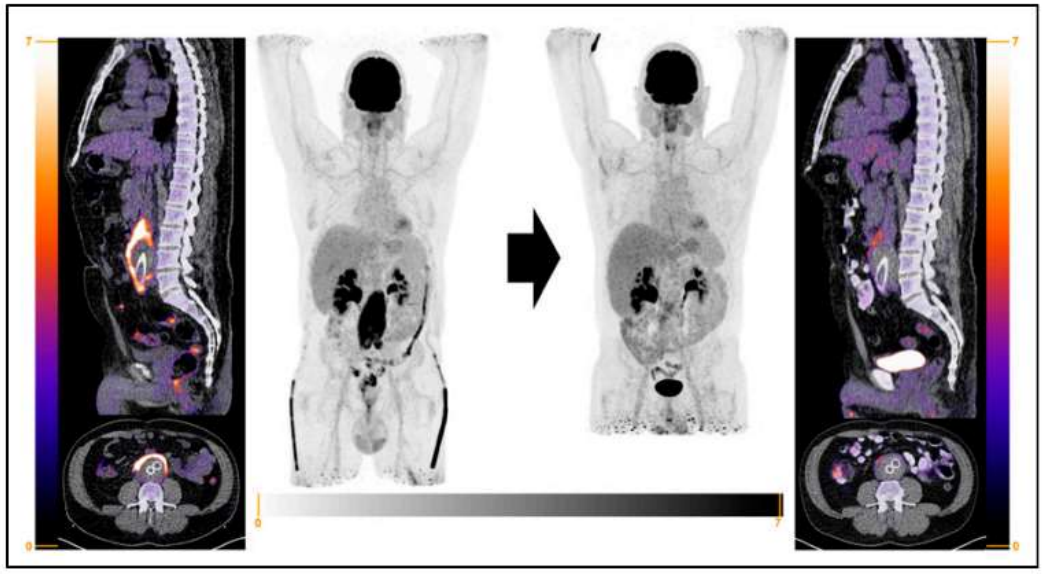
FDG PET has moderate diagnostic accuracy to discriminate patients with active disease from clinical remission

umcg

FDG PET in LVV : treatment monitoring







Van der Geest et al, J Nucl Med 2023

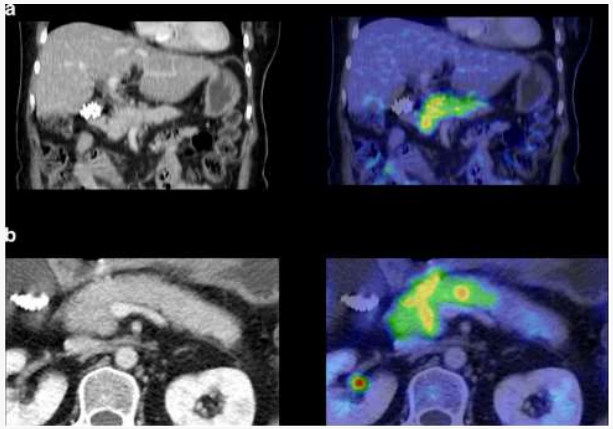
umcg

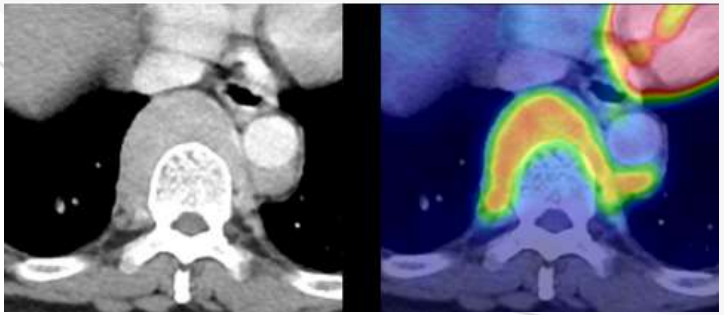
FDG PET in IgG4-related disease and retroperitoneal fibrosis

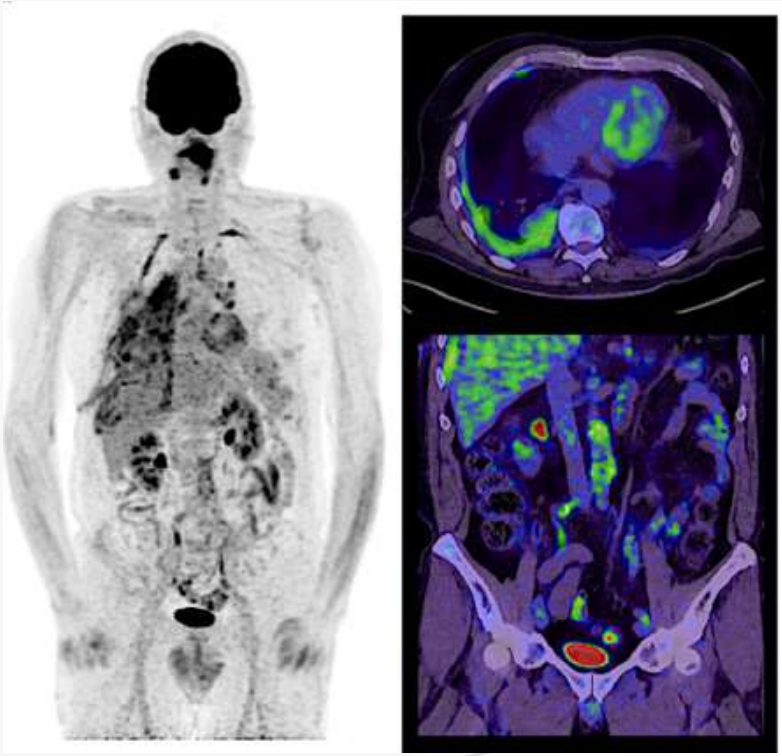
- No data available from meta-analyses
- Evaluation of disease activity in retroperitoneal fibrosis, particulary in asymptomatic patients with elevated CRP
- Assessment of disease extent and organ involvement in patients with IgG4-RD

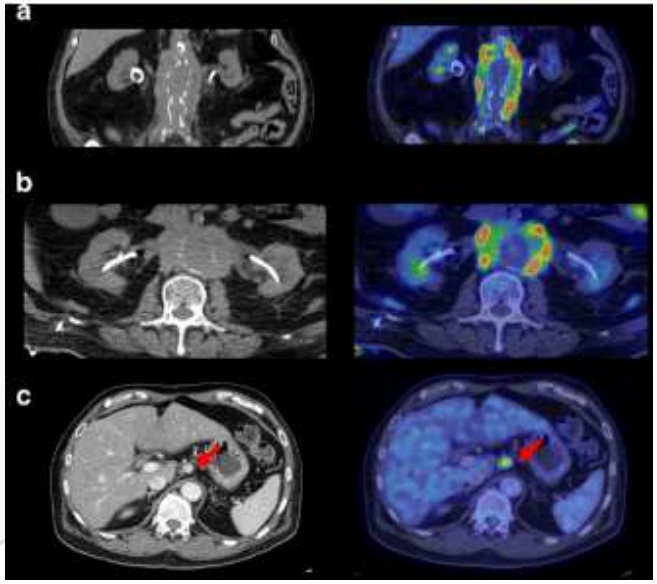
umcg

FDG PET in IgG4-related disease and retroperitoneal fibrosis









Lin Tang et al, BJR 2021
Besson et al, Sem Nucl Med 2023

umcg

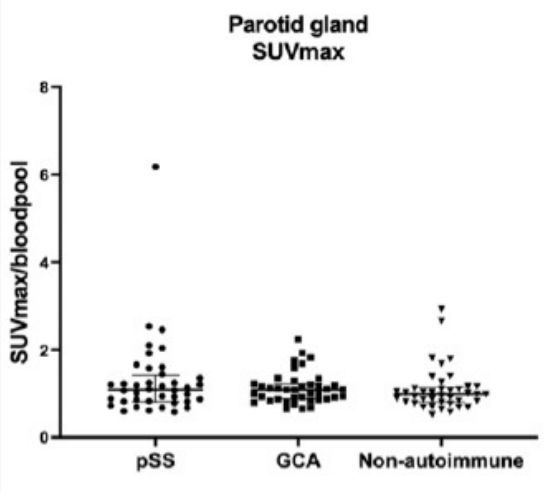
Sjögren's syndrome

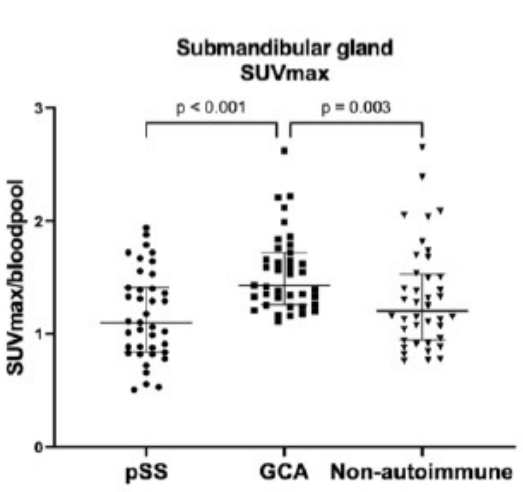
Salivary gland ^{18}F-FDG-PET/CT uptake patterns in Sjögren's syndrome and giant cell arteritis patients

R.G.J. Grootelaar[1], M.S. van Ginkel[2], P.H. Nienhuis[1], S. Arends[2], R.M. Pieterman[3], E. Brouwer[2], H. Bootsma[2], A.W.J.M. Glaudemans[1], R.H.J.A. Slart[1]

EXPERTISE CENTER Sjögren's Syndrome

	Sjögren N=40	GCA N=40	Non-autoimmune N=40
Patient characteristics			
Female (%)	30 (75%)	24 (60%)	22 (55%)
Age at time of ^{18}F-FDG-PET	66.3 ± 8.9	67.13 ± 8.1	66.6 ± 7.8
Medication use at time of ^{18}F-FDG-PET:			
Methylprednisone (1000mg i.v.)	2 (5%)	2 (5%)	0 (0%)
Oral prednisone	6 (15%)	2 (5%)	0 (0%)
Dosage (mg)	5.0 (5.0-10.0)	2.5-60.0	
Other DMARDs	9 (22.5%)	0 (0%)	0 (0%)
^{18}F-FDG-PET/CT parameters			
Parotid gland			
Visual uptake (0-3)	0 (0-2)	0 (0-1)	0 (0-1)
Visual uptake≥2	10 (25%)	8 (20%)	5 (12.5%)
SUV_{max}/bloodpool	1.09 (0.83-1.43)	1.09 (0.88-1.22)	0.99 (0.81-1.15)
Diameter transversal (highest)	2.86 (2.16-3.19)	2.99 (2.62-3.25)	3.43 (2.91-3.67)
Diameter frontal (highest)	3.67 (3.19-4.33)	3.97 (3.55-4.32)	4.24 (3.82-4.72)
Submandibular gland			
Visual uptake (0-3)	0 (0-1)	2 (1-3)	1 (0-2)
Visual uptake≥2	6 (15.4%)	27 (69.2%)	15 (37.5%)
SUV_{max}/bloodpool	1.10 (0.84-1.41)	1.43 (1.26-1.72)	1.20 (0.94-1.54)
Diameter transversal (highest)	1.39 (1.05-1.83)	2.19 (1.77-2.40)	2.05 (1.75-2.28)





On a patient level, FDG uptake in salivary glands cannot differentiate between SS and GCA

umcg

Sjögren's syndrome

FDG-PET/CT discriminates between patients with and without lymphomas in primary Sjögren's syndrome

Martha S. van Ginkel [1,*], Suzanne Arends[1], Bert van der Vegt[2], Marcel Nijland[3], Fred K. L. Spijkervet[4], Arjan Vissink[4], Frans G. M. Kroese[1], Andor W. J. M. Glaudemans[5,†], Hendrika Bootsma[1,†]

EXPERTISE CENTER Sjögren's Syndrome

	pSS patients with pSS-associated lymphoma ($N=26$)	pSS patients without lymphoma ($N=44$)	*P*-value
Age at time of FDG-PET	58.6 (14.9)	57.3 (17.7)	0.758
Female	22 (84.6)	33 (75.0)	0.386
Disease duration at time of FDG-PET (years)	4.5 (0.0–9.5)	5.0 (1.0–11.8)	0.531
ACR-EULAR items			
Ocular item[a] (OSS ≥ 5 and/or Schirmer ≤ 5)	23 (95.8)	28 (77.8)	0.072
Oral item[a] (UWS ≤ 0.1 ml/min)	16 (84.2)	27 (75.0)	0.511
Serology item[b] (anti-SSA positivity)	22 (88.0)	37 (86.0)	1.000
Biopsy item[b] (positive labial and/or parotid gland biopsy)	26 (100)	40 (93.0)	0.285
ESSDAI scores[b]			
ESSDAI total score ≥ 5	26 (100)	29 (65.9)	0.004
ESSDAI score without lymphoma item	10.5 (5.5–14.3)	8.0 (4.0–16.0)	0.563
ESSDAI total score (with lymphoma item)	20.0 (16.0–23.3)	8.0 (4.0–16.0)	<0.001
Serology			
Haemoglobin levels (mmol/l)	7.7 (7.2–8.5)	7.5 (6.2–8.0)	0.085
Lymphocyte count (10^9/l)	1.23 (0.92–1.60)	1.42 (0.99–3.79)	0.055
ESR(mm/h)	27.5 (20.5–84.5)	69.0 (21.3–119.0)	0.065
IgG levels (g/l)	13.1 (10.2–18.1)	14.8 (12.3–24.1)	0.236
RF levels (IU/ml)	31.5 (9.6–164.0)	12.5 (2.5–42.3)	0.029
Complement C3 levels (g/l)	0.98 (0.92–1.21)	1.13 (0.97–1.34)	0.153
Complement C4 levels (g/l)	0.12 (0.04–0.17)	0.20 (0.14–0.25)	0.005
Presence of cryoglobulins[c]	11 (57.9)	12 (40.0)	0.221
Medication use at time of FDG-PET/CT			
Methylprednisone (1000 mg/day)[d]	0 (0)	2 (4.5)	0.526
Prednisone	1 (3.8)	6 (13.6)	0.246
Dosage of oral prednisone (mg/day)	5.0	10.0 (5.0–21.3)	
HCQ	6 (23.1)	5 (11.4)	0.193
Other immunosuppressant agents[e]	2 (7.7)	5 (11.4)	1.000

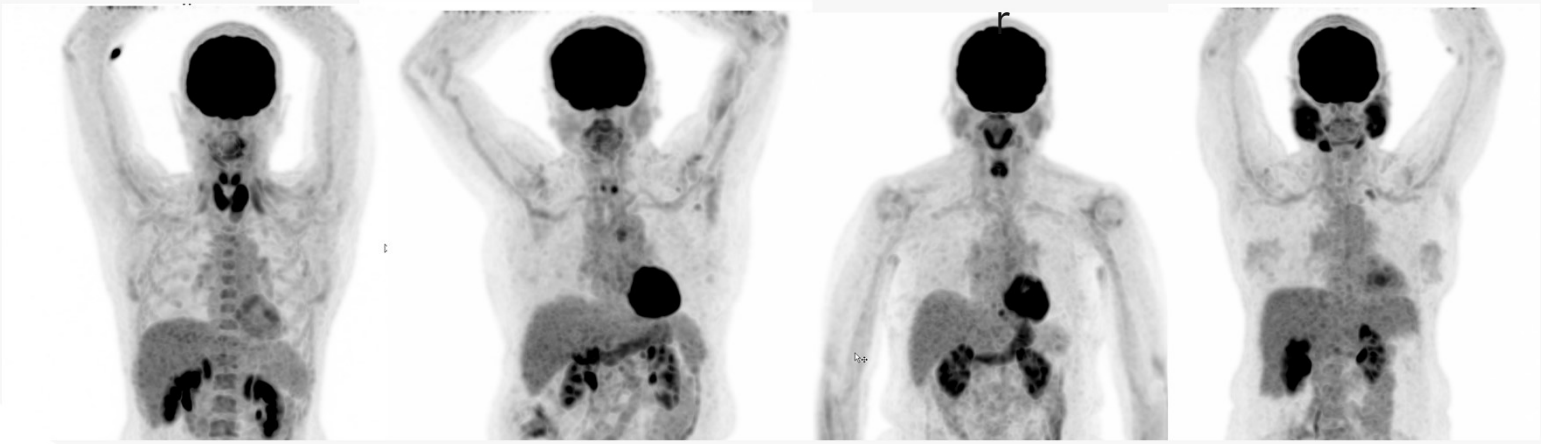
Type and biopsy location	
MALT	
- Parotid	17
- Lacrimal/orbita	2
- Lymph node	2
- Lungs	2
M Hodgkin	1
DLBCL cavum nasi	1
B-cell lymphoma	1

umcg

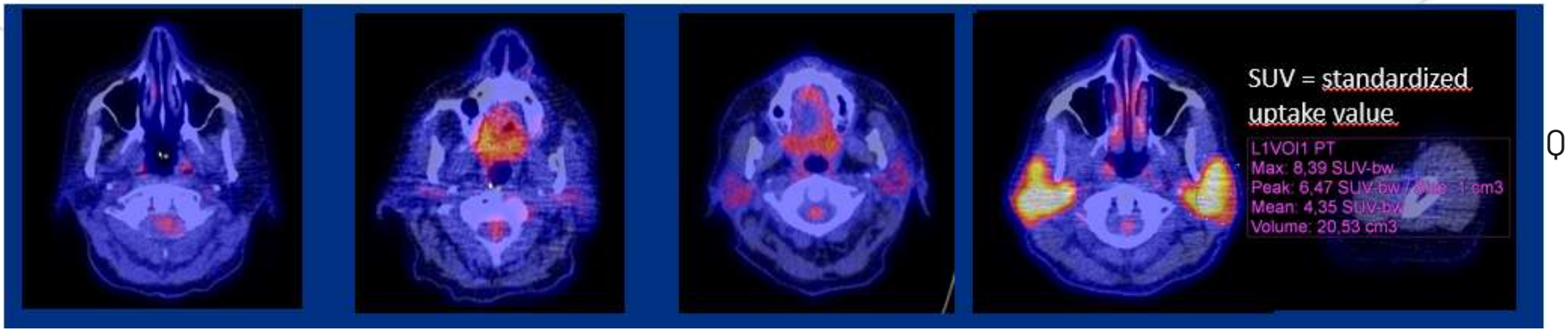
Sjögren's syndrome

EXPERTISE CENTER
Sjögren's Syndrome

0	1	2	3
no uptake	uptake=mediastinum	mediast<uptake<liver	uptake>liver



And scoring systemic manifestations



Quantitative analysis

umcg

	With lymphoma N=26	No lymphoma N=44	P-value
Parotid glands			
Visual uptake≥2	88.0%	45.5%	**<0.001**
SUVmax	4.86 (3.01-8.71)	2.29 (1.69-2.86)	**<0.001**
Diameter, cm	4.49 (3.91-5.25)	3.32 (2.86-4.19)	**<0.001**
Submandibular glands			
Visual uptake≥2	66.7%	34.9%	**0.012**
SUVmax	3.32 (2.60-6.52)	2.42 (1.66-2.83)	**<0.001**
Diameter, cm	1.60 (1.40-2.33)	1.70 (1.23-1.86)	0.471
Lacrimal glands			
Visual uptake≥2	8.0%	2.3%	0.296
SUVmax	1.84 (1.43-2.63)	1.63 (1.37-2.00)	0.162
Abnormal uptake in lymph nodes	80.8%	70.5%	NS
Arthritis	0%	9.1%	NS
Myositis	3.8%	2.3%	NS
Enthesopathy	34.6%	29.5%	NS
Interstitial lung disease	3.8%	9.1%	NS
Nodular lung lesion(s)	**30.8%**	**6.8%**	**0.015**

EXPERTISE CENTER
Sjögren's Syndrome

umcg

Sjögren's syndrome

EXPERTISE CENTER
Sjögren's Syndrome

	Sensitivity	Specificity
Separate items:		
Par SUVmax ≥ 3.08	76%	82%
Subm SUVmax ≥ 2.92	67%	84%
Presence of nodular lung lesions	31%	93%
Combinations:		
≥1 out of 3 present	92% (24/26)	68%
≥2 out of 3 present	71%	93% (41/44)

Rheumatology key messages

- [^{18}F]-fluorodeoxyglucose (FDG)-PET/CT is useful in primary SS (pSS) patients suspected of high disease activity and/or a lymphoma.
- In pSS patients without PET abnormalities, FDG-PET/CT assists in excluding a pSS-associated lymphoma.
- FDG-PET/CT visualizes systemic manifestations in pSS and can guide to the best biopsy location.

New developments

- LAFOV PET/CT systems
- Automatic segmentation
- Specific tracers

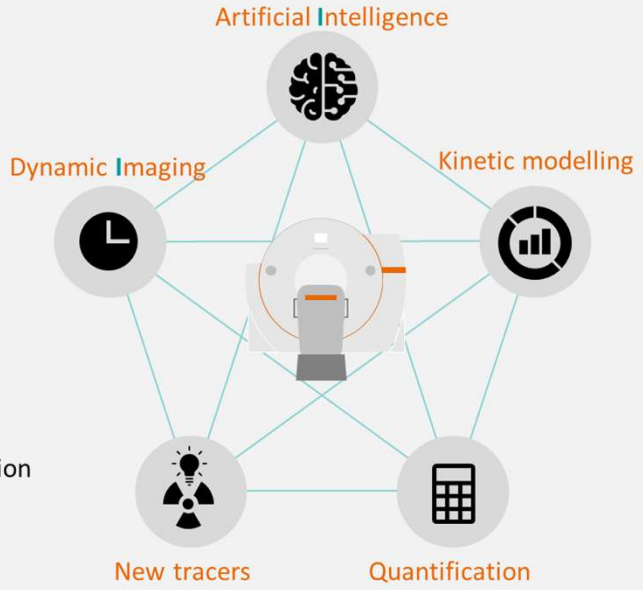
I7 Nuclear medicine Imaging and artificial Intelligence of Infection, Inflammation, and Immunology, including Infants and ICU patients

Infection and Inflammation

Speed up time to diagnosis and treatment
Differentiate infection vs inflammation
Low-grade chronic
Biofilms on prosthetic material
Small structures

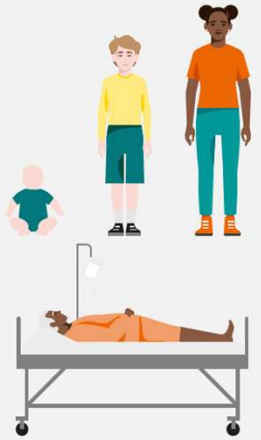
Immunology

Visualisation immune cell - disease interaction
Therapy prediction and evaluation
Early detection side effects



ICU and Infants

Ultra-fast imaging



Aim – Finding the 'holy grail' in infection/inflammation imaging:

- Differentiation between infection, inflammation and tumor
- Towards more specific tracers
- Towards higher sensitivity

umcg

Total-Body PET in Groningen

- Our road to implementation: business & financial plan
- Installation and validation: Sept/Oct 2021

umcg

New PET/CT camera

UMCG neemt Biograph Vision Quadra PET/CT-scanner in gebruik

"De beloften op klinisch en onderzoeksgebied zijn enorm"

UMCG in Groningen neemt nieuwe scanner in gebruik. Patiënten kunnen sneller gescand worden, met minder nucleaire speurstof

RTV NOORD

Nederlandse primeur voor UMCG met nieuwe scanner

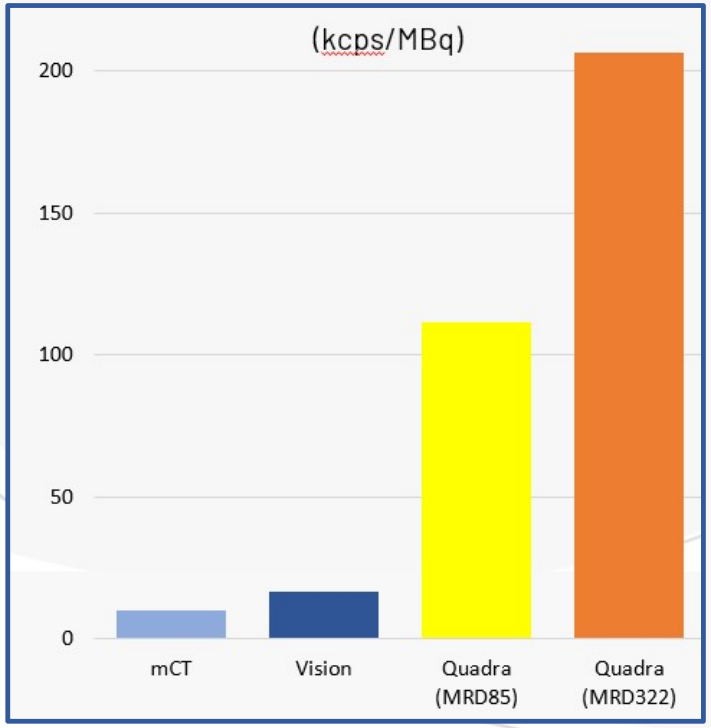
SIEMENS Healthineers

DAGBLAD VAN HET NOORDEN

umcg

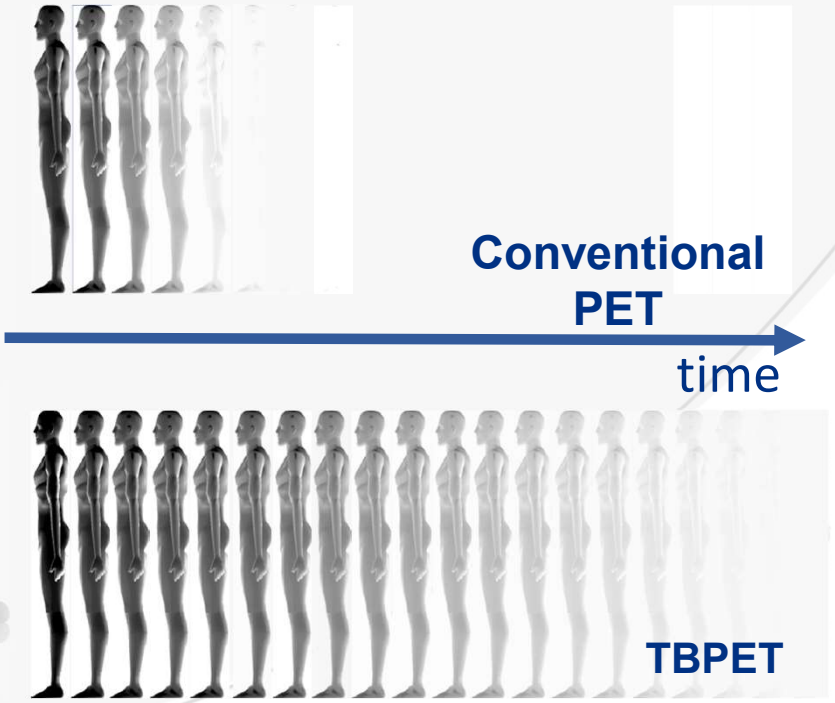
Ronald Borra (links) en Andor Glaudemans: "Met deze Whole-Body PET/CT-scanner komt de heilige graal binnen de geneeskunde in zicht."

Performance and opportunities



Sensitivity increase

Dose reduction

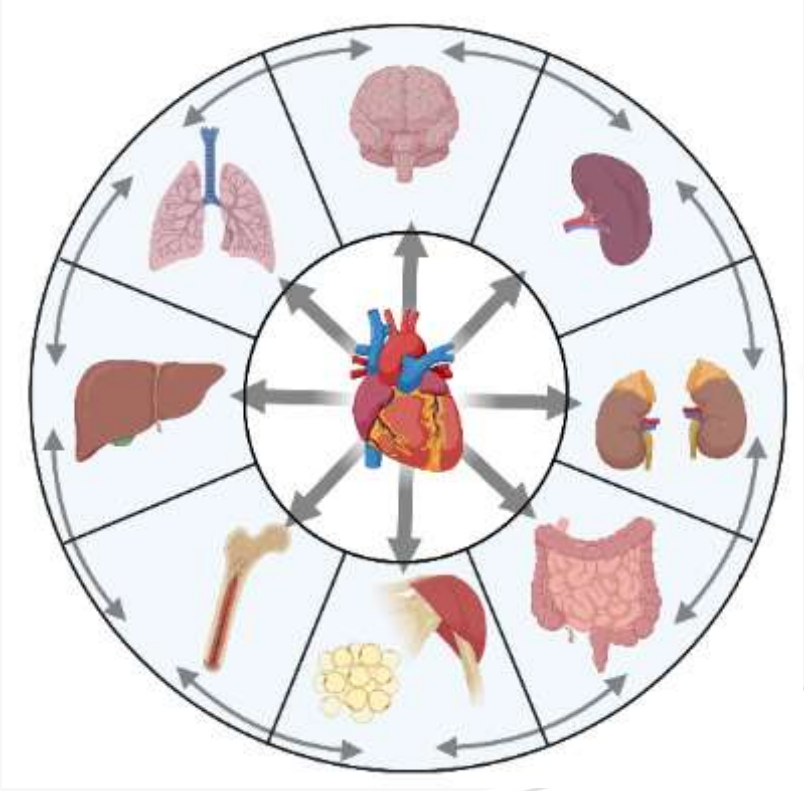


Delayed imaging: > 5 half lives

umcg

Performance and opportunities

Dynamic imaging



Organ axes

More detail

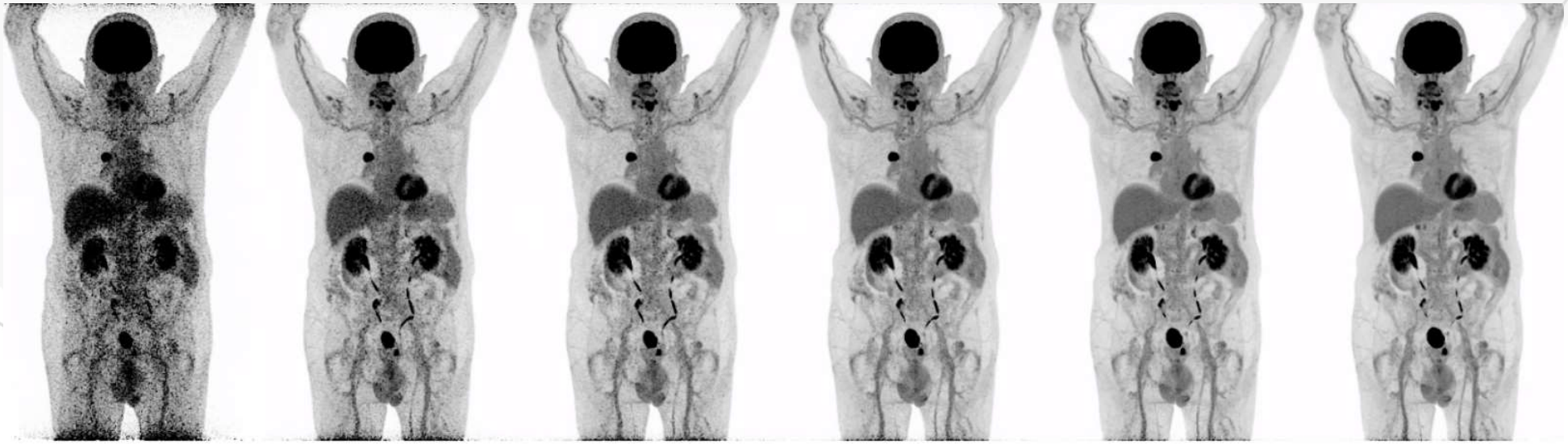
TBP: possibilities

European Journal of Nuclear Medicine and Molecular Imaging (2021) 48:4236–4245
https://doi.org/10.1007/s00259-021-05461-6

REVIEW ARTICLE

Long axial field of view PET scanners: a road map to implementation and new possibilities

Riemer H. J. A. Slart[1,2] · Charalampos Tsoumpas[1,3] · Andor W. J. M. Glaudemans[1] · Walter Noordzij[1] · Antoon T. M. Willemsen[1] · Ronald J. H. Borra[1] · Rudi A. J. O. Dierckx[1] · Adriaan A. Lammertsma[1]



umcg

Total body/LAFOV PET opportunities

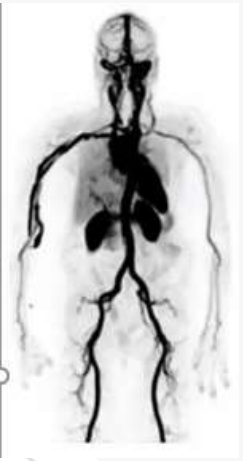
High sensitivity

Fast acquisition: ICU/pediatrics

Late imaging
(antibodies)

Equivalent to 3-4 (dig.) PET scanners

Increased rate of patient through-put



High temporal resolution

Organ interaction:

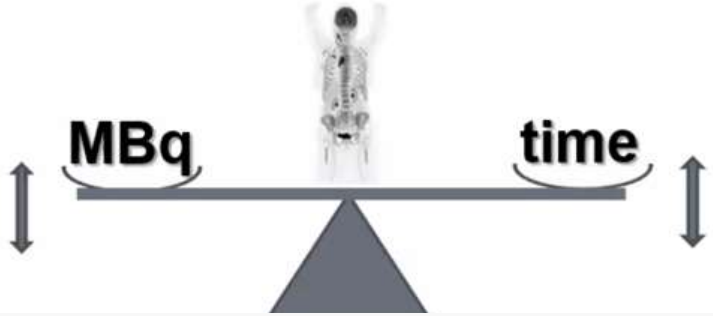
- Brain-heart,
- brain gut,
- heart-kidneys
- ..

Multitracer studies
Long-living isotopes

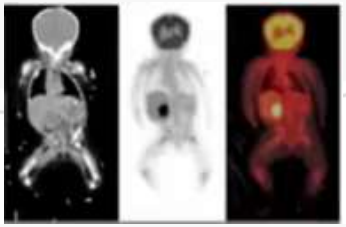
Med.drug response evaluation

Quantification accuracy

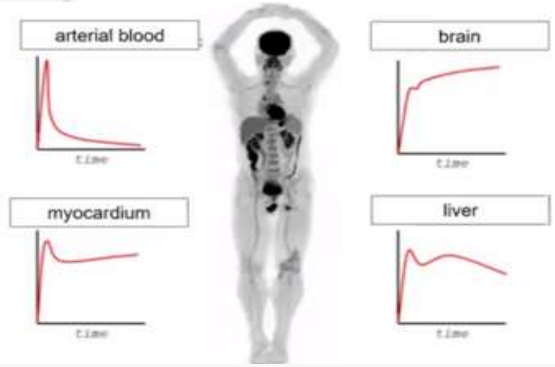
Dynamic & whole-body parametric imaging



Low radiation burden

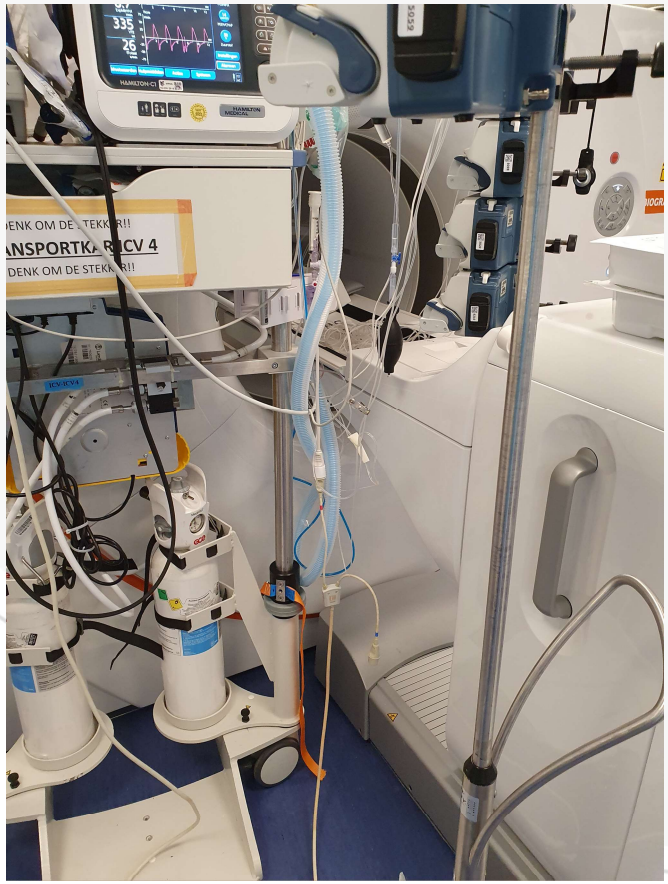


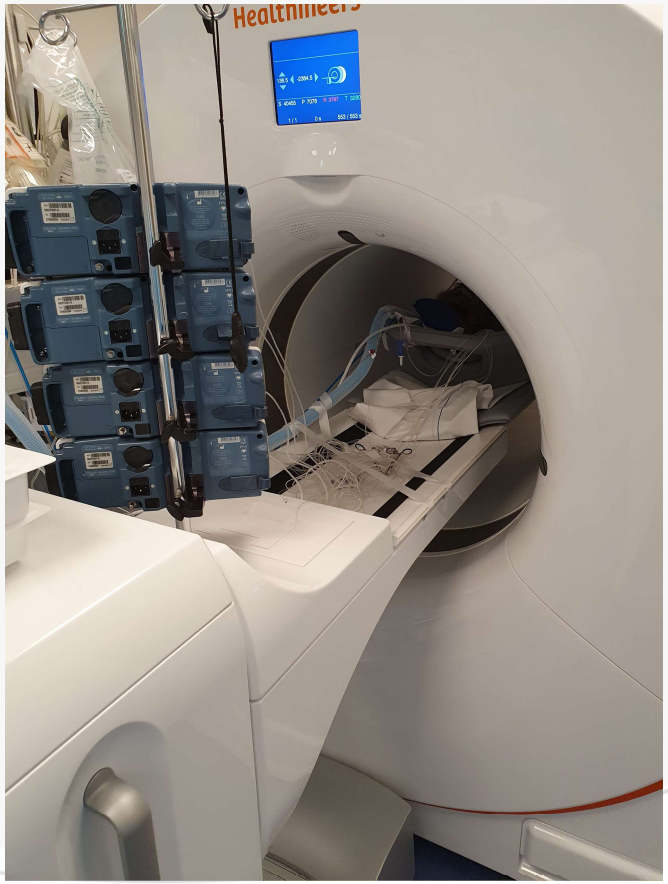
Waiting room



Slart *et al* (2021) Long axial field of view PET scanners: a road map to implementation and new possibilities *EJNMMI*

ICU patient on the Quadra





MIC
MEDICAL IMAGING CENTRE
GRONINGEN

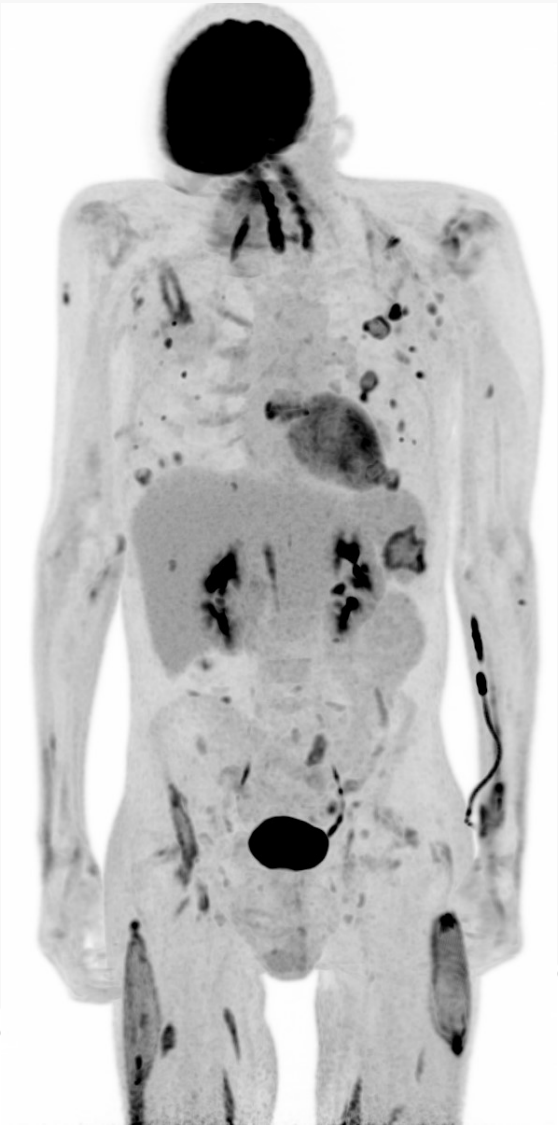
umcg

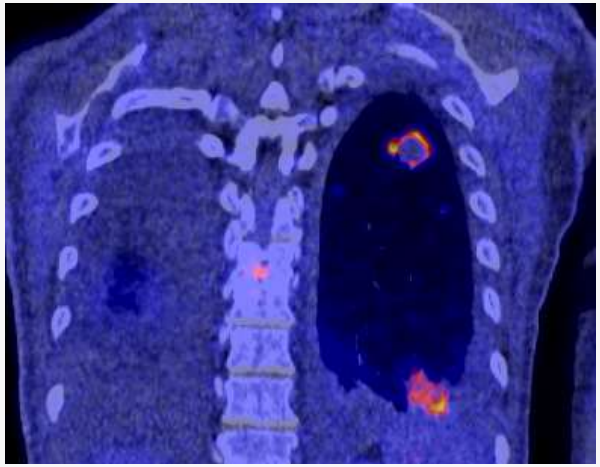
Example

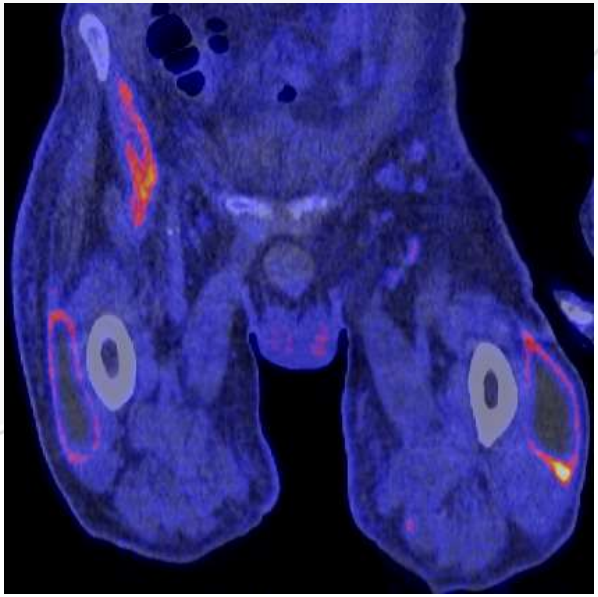
- Male, 46 years old
- MRSA bacteremia
- Port of entry unclear
- Probably pneumonia
- Other signs of infection?

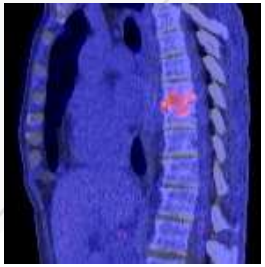
Quadra FDG PET/CT
3 MINUTES SCAN TIME

- → lung infections, abscesses, spondylodiscitis









umcg

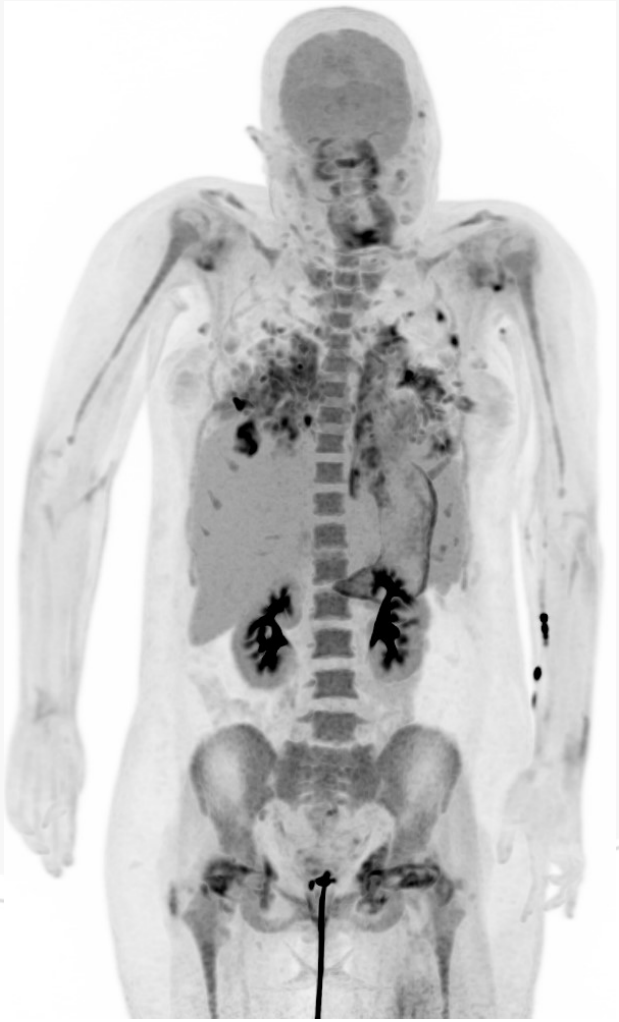
COVID-ICU-FDG

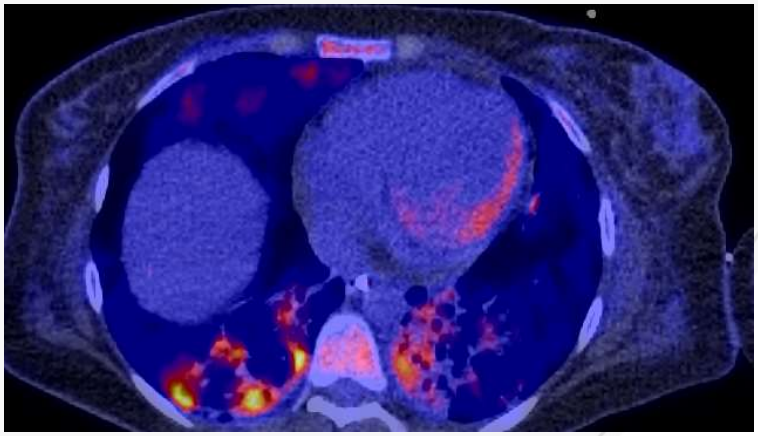
- Female, 26 years old
- 3 weeks ago: section caesaria
- 2 weeks ago: COVID
- Respiratory problems
- ICU, intubation
- Infection beside COVID?

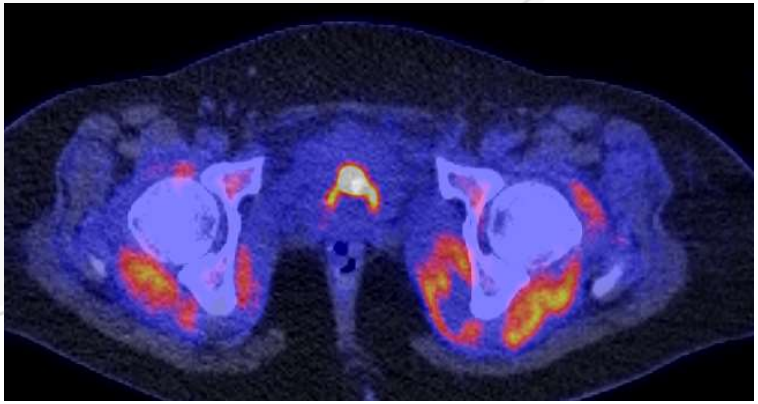
Quadra FDG PET/CT

3 MINUTES SCAN TIME

- → COVID & superinfection (Aspergillus) & peri-articular ossification





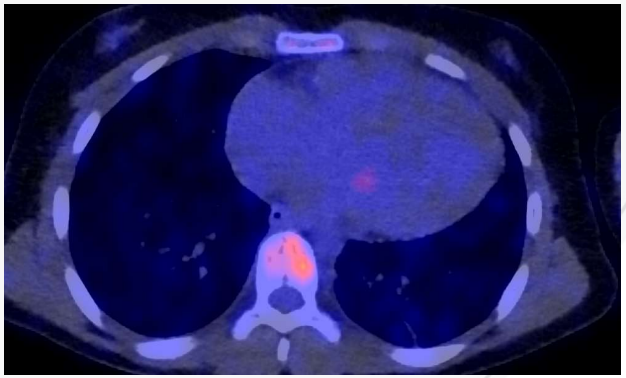


MIC
MEDICAL IMAGING CENTRE GRONINGEN

umcg

Example

- Girl, 11 years old
- Incomplete AVSD
- Fever
- Positive blood cultures (S. Aureus)
- CRP 31
- Possible endocarditis (Duke criteria)



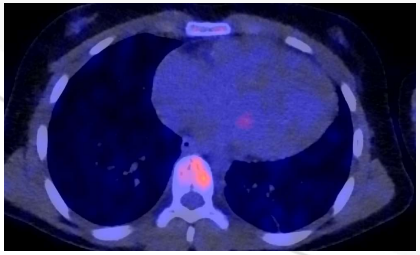
SCANNED ON THE mCT 40

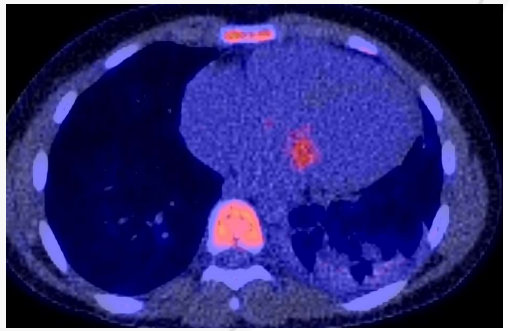
18 MINUTES SCAN TIME

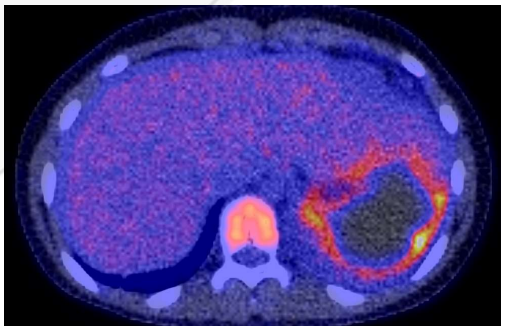
umcg

Example

- Girl, 11 years old
- 5 days later
- Sepsis
- CRP 289
- Admitted to the ICU







mCT; 18 MINUTES SCAN TIME

Quadra; 3 MINUTES SCAN TIME

umcg

Example

- 10-week-old newborn
- Tetralogy of Fallot
- S. aureus sepsis

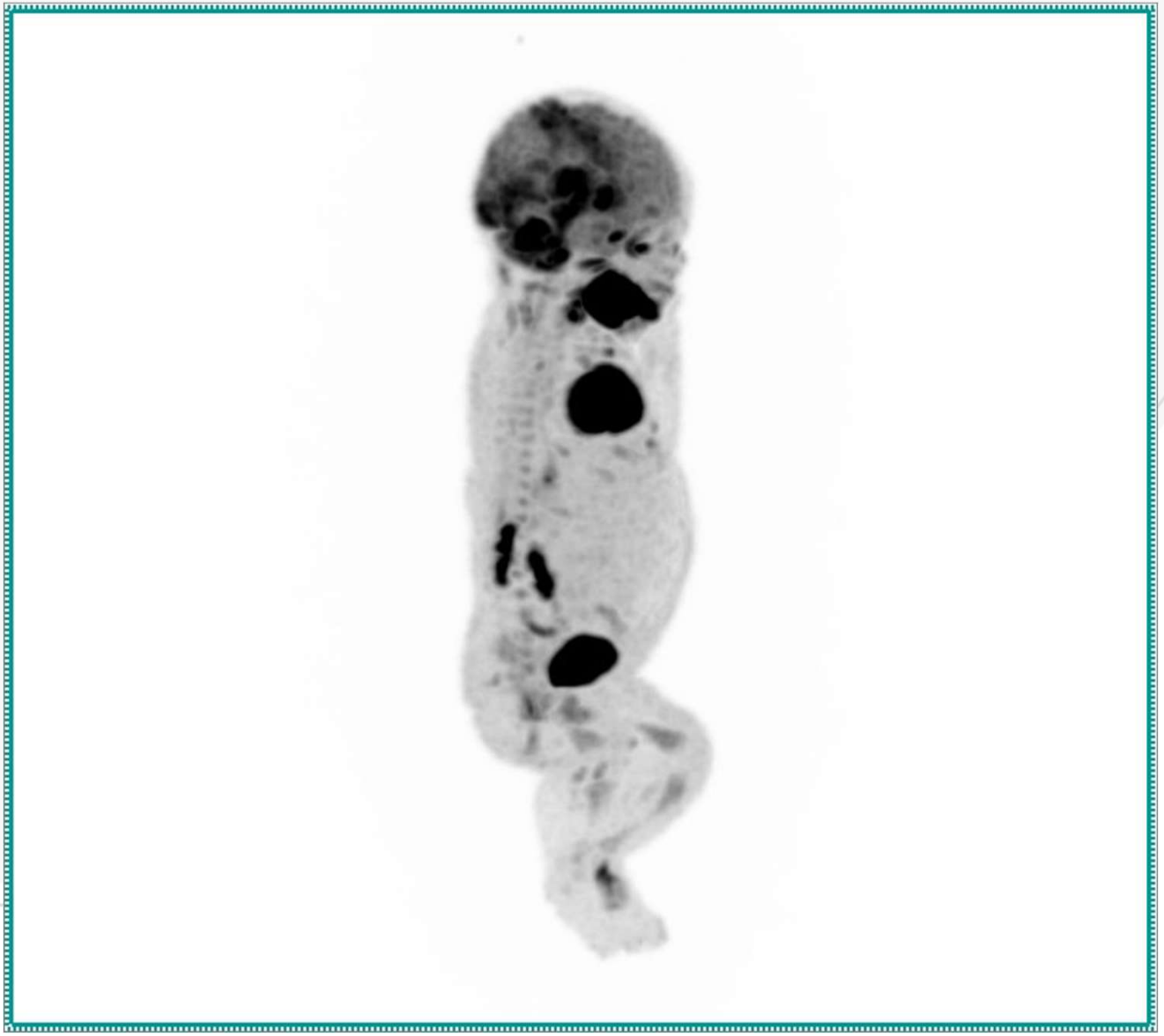
Quadra

12 MBq ^{18}F-FDG

3 MINUTES SCAN TIME

NO SEDATION

- Effective patient dose 1.3mSv
- <<< international recommendations



Example

- Endocarditis, location Eustachian valve

  (Fetal valve inferior vena cava -> right atrium)

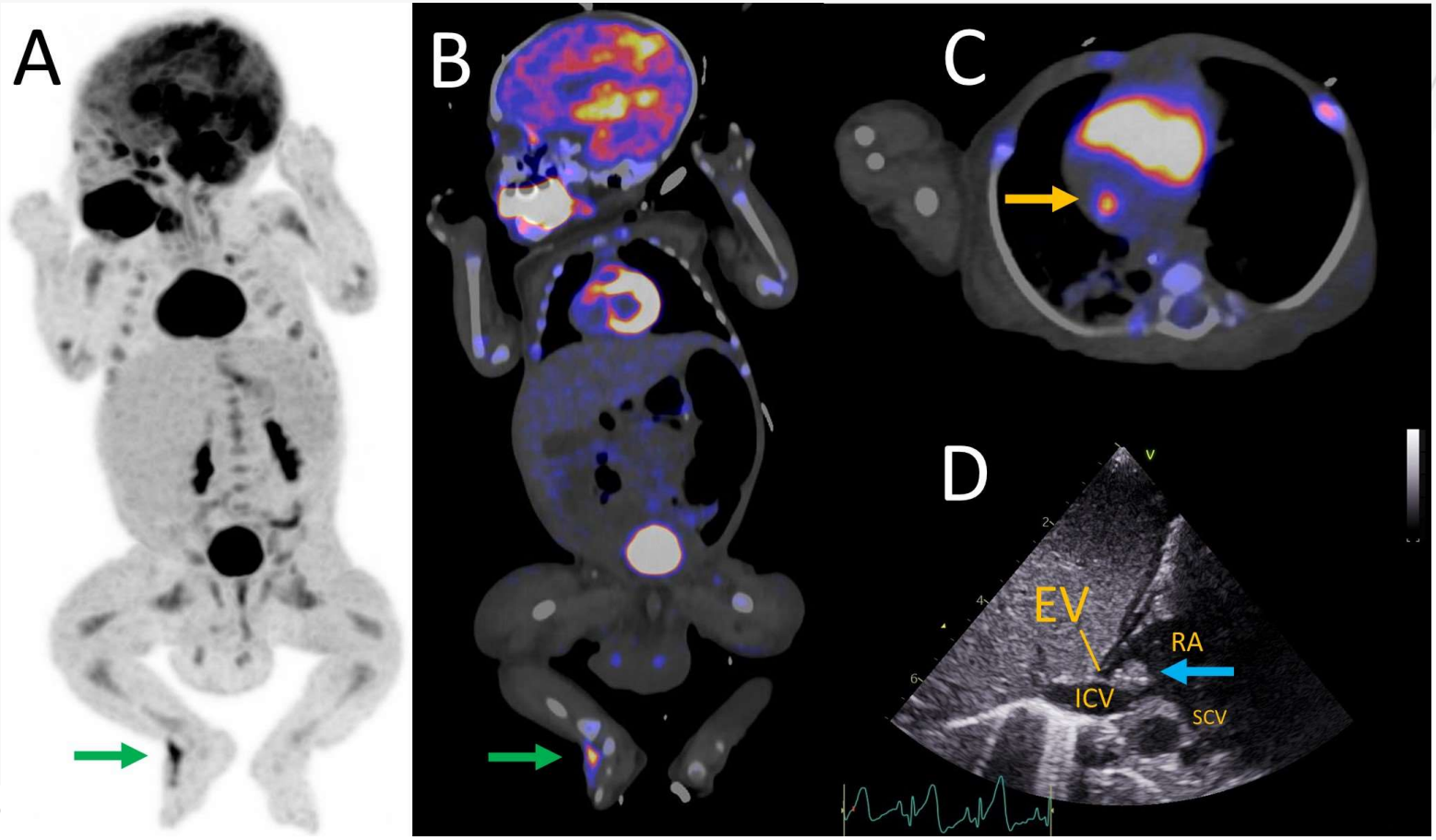
- Infection & abscess right foot around i.v. access line

Quadra

12 MBq ^{18}F-FDG

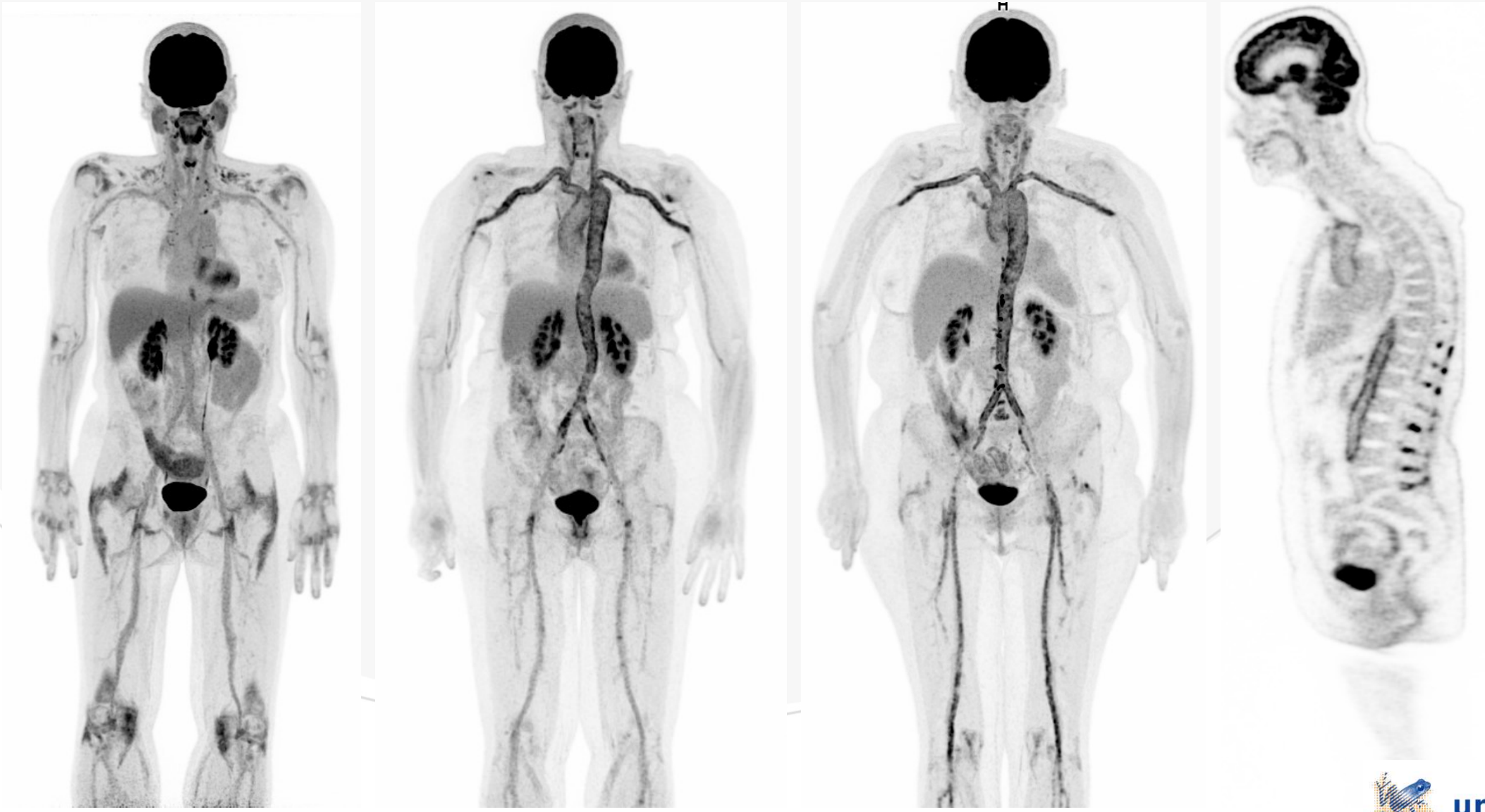
3 MINUTES SCAN TIME

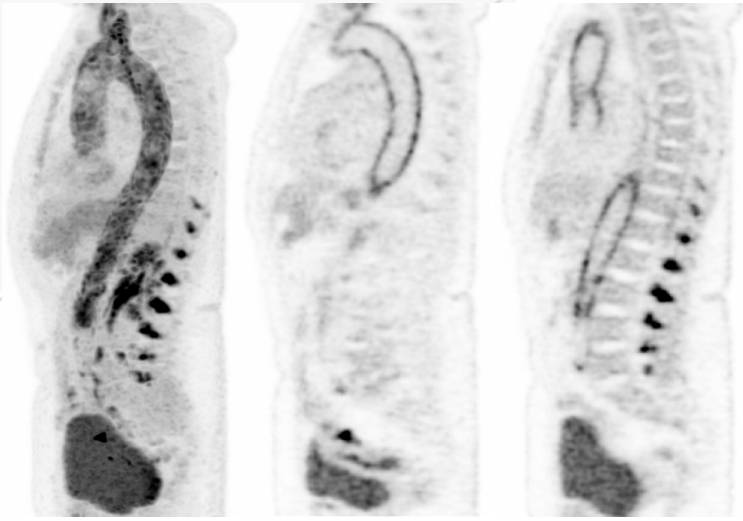
NO SEDATION



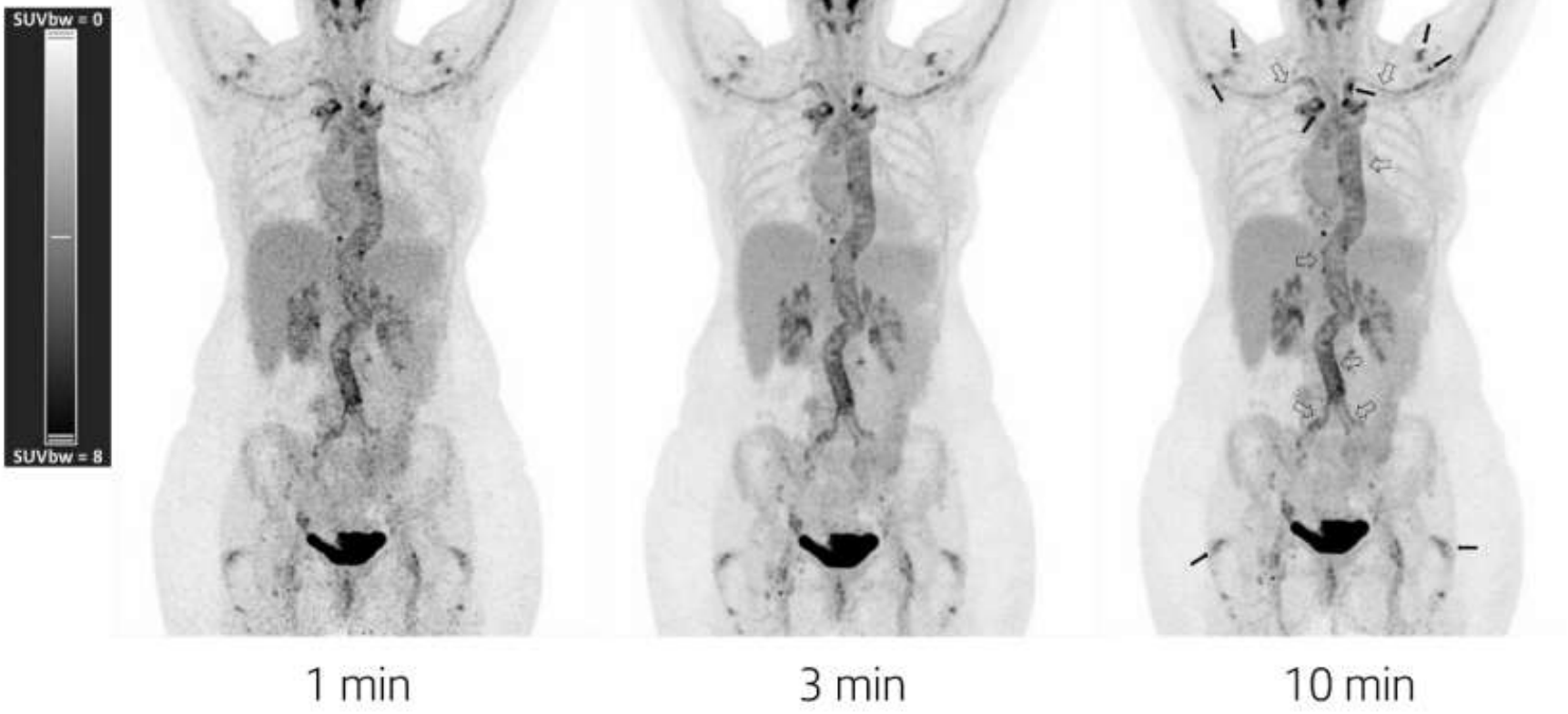
Van Rijsewijk et al, EJNMMI 2022

umcg





umcg

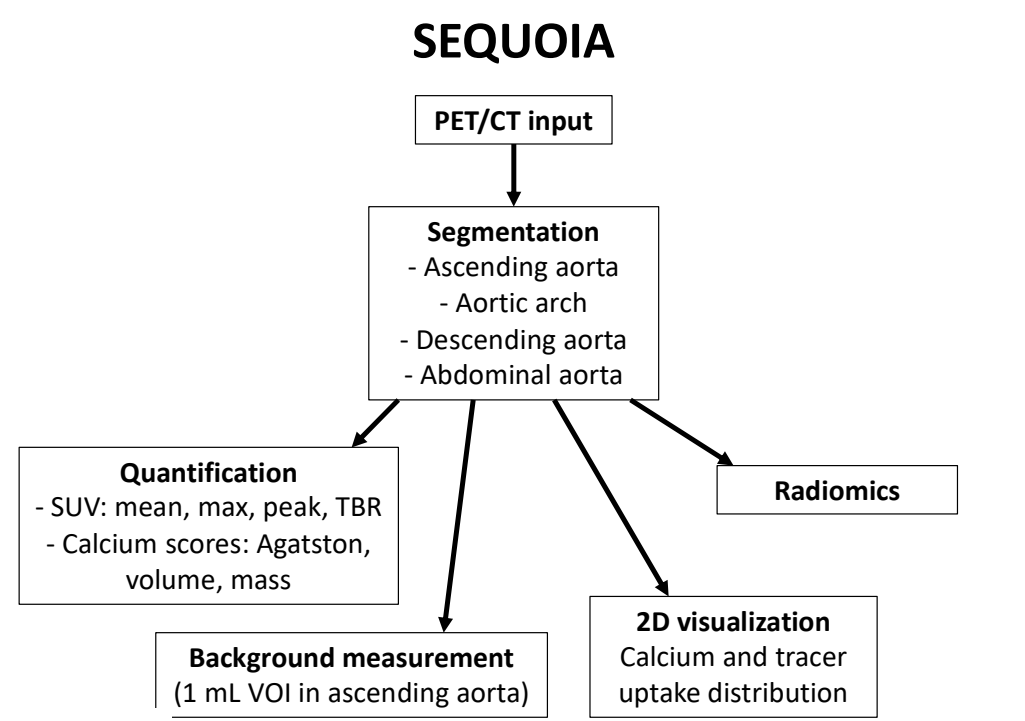


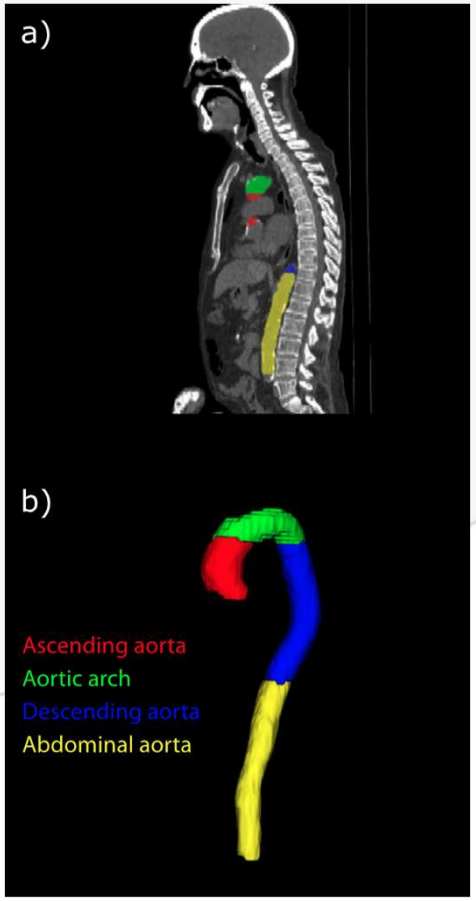
Nienhuis et al, Diagnostics 2023

umcg

SEQUOIA

- Automatic quantification software program/algorithm in vascular diseases for PET/CT
- SEQUOIA – SEgmentation, QUantification, and visualisatiOn of the dIseased Aorta in PET/CT



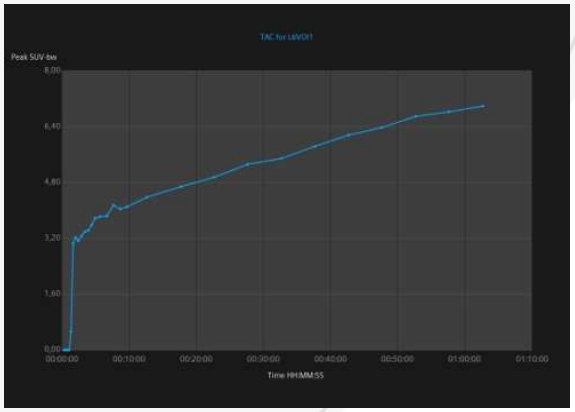


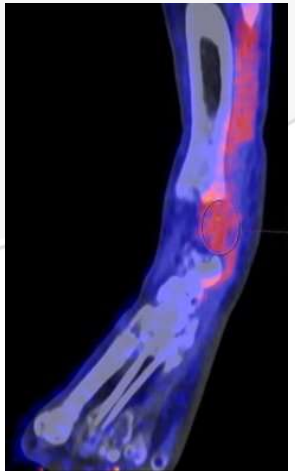
Gijs van Praagh, PhD student

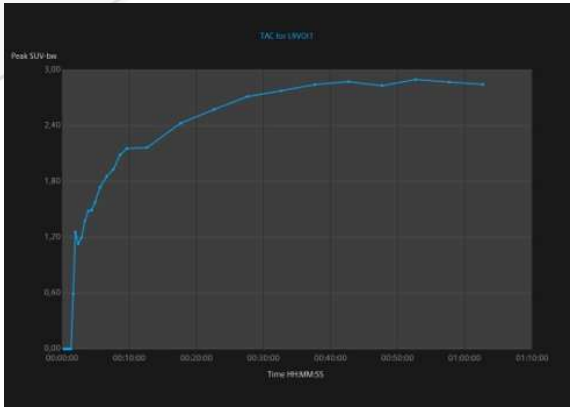
Prof. Riemer Slart

umcg

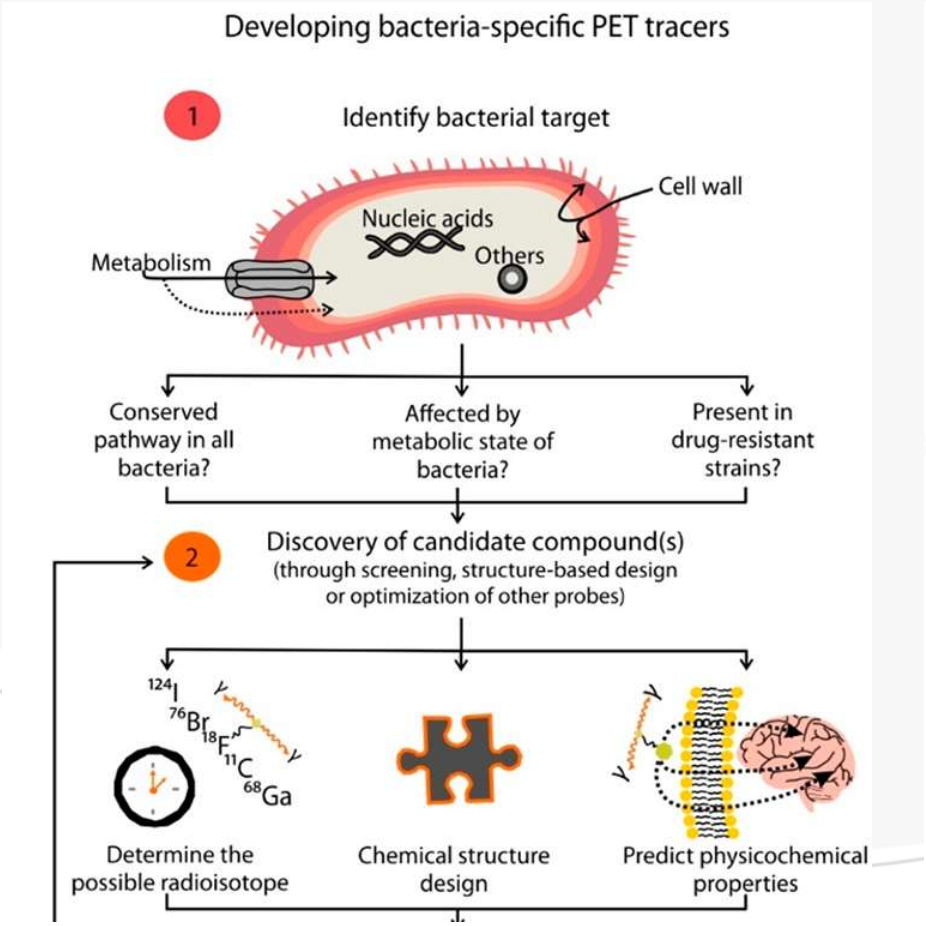
Infection – Dynamic imaging

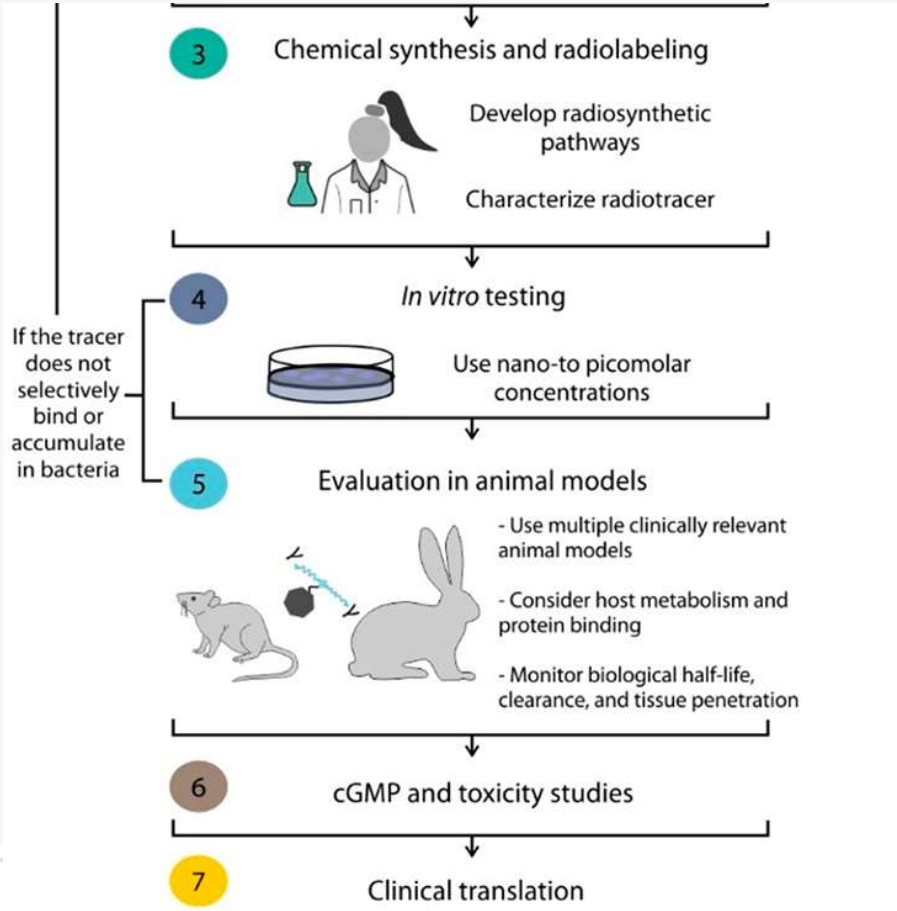






New tracers - general



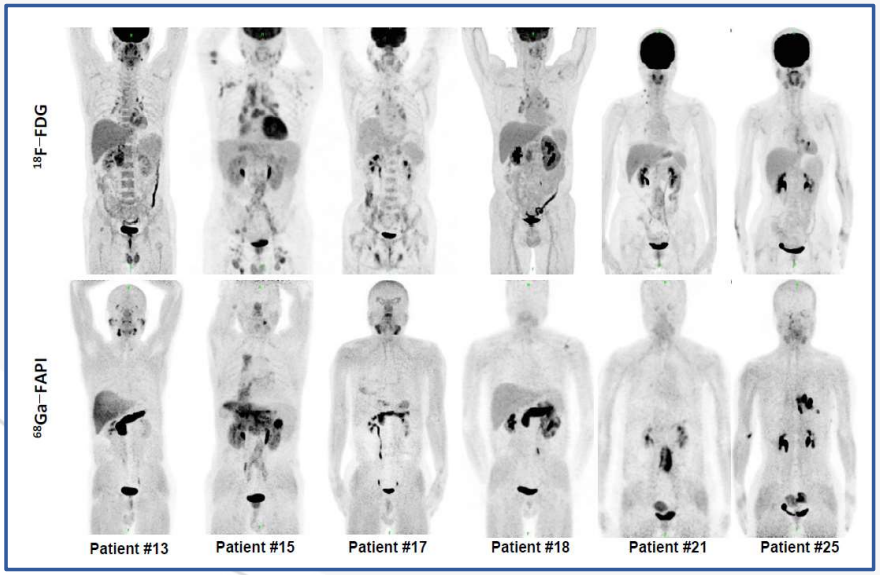


Timeline: > 2 years

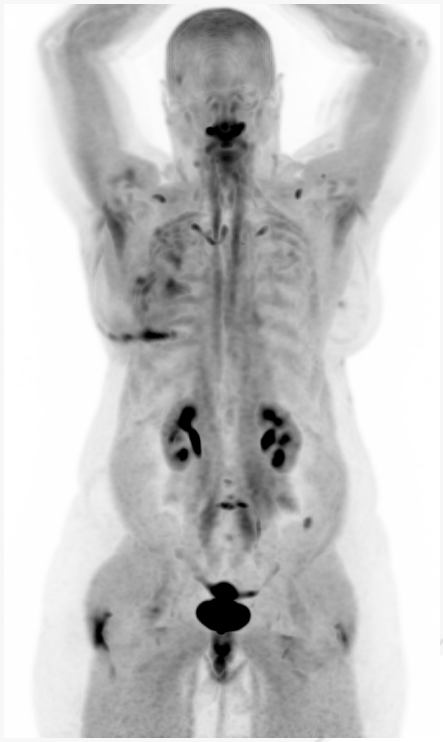
umcg

New tracers - FAPI

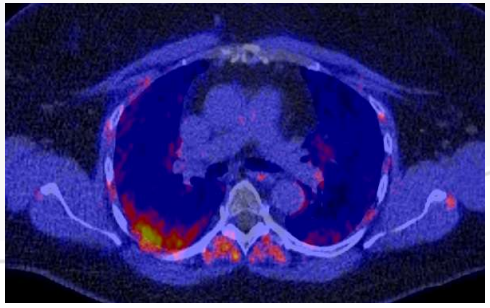
- $^{68}Ga/^{18}F$ – FAPI = Fibroblast Activation Protein Inhibitor → Marker for fibrosis?

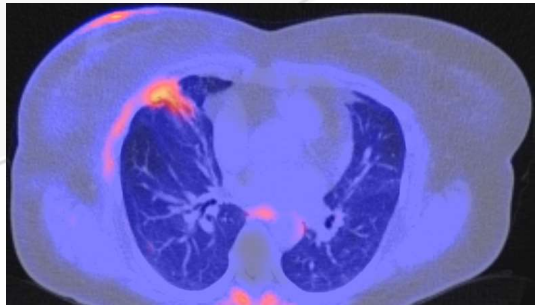


IgG4-mediated diseases



Courtesy: Riemer Slart/ Bram van Leer

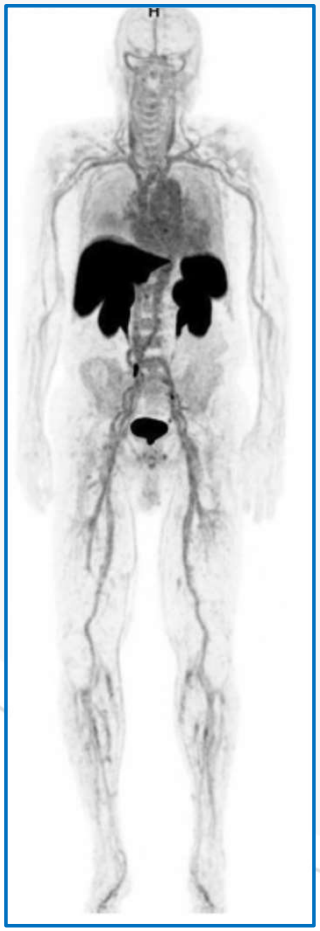




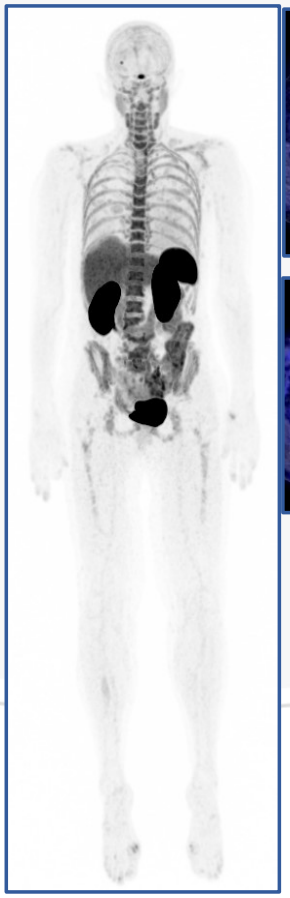
Long COVID

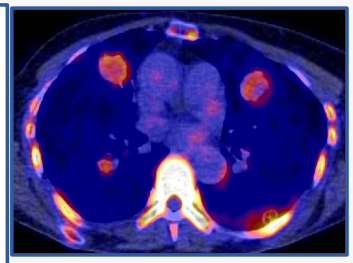
umcg

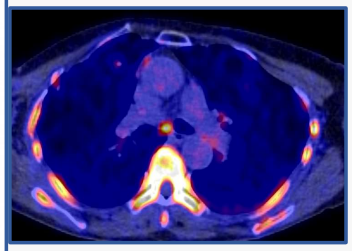
New tracers - Immune cells

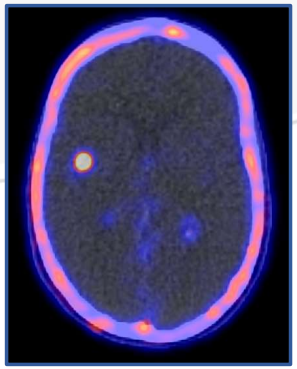


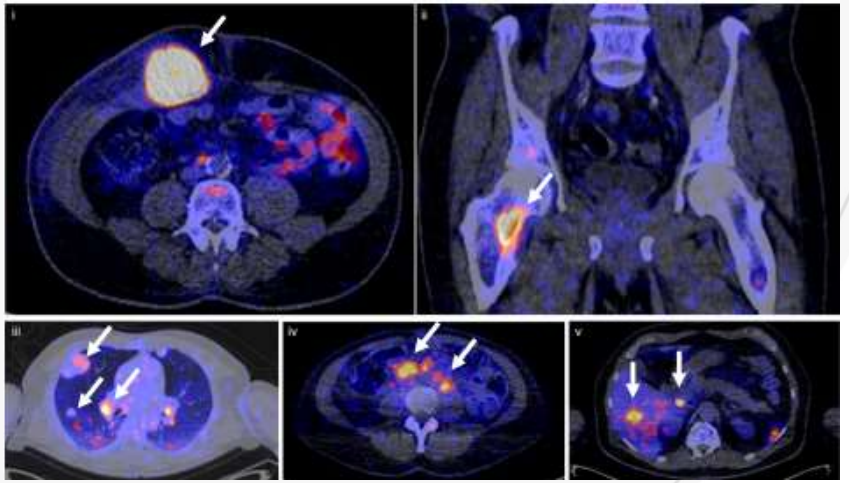
- ^{18}F-Interleukin-2
- ^{18}F/^{89}Zr-PD-1/PDL-1
- ^{89}Zr-CD8
- ^{18}F-folate

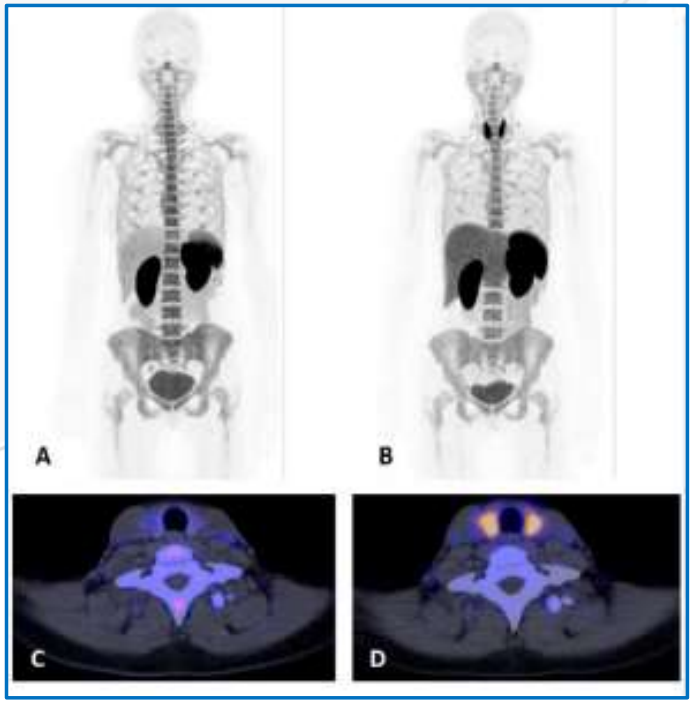












New tracers – ImmunoPET with ^{89}Zr

mCT – 45 min

Quadra – 30 min

30 min

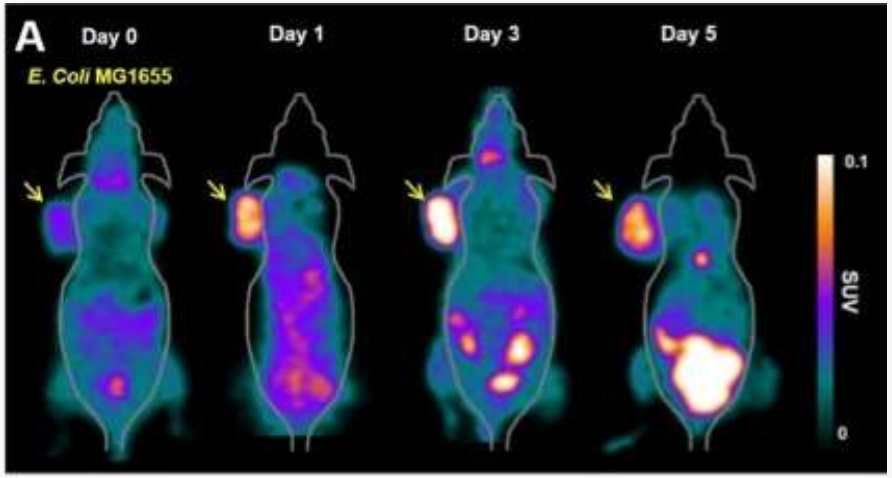
20 min

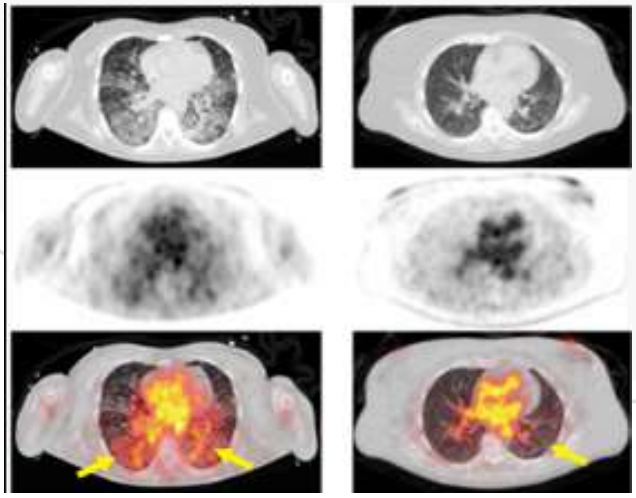
10 min

3 min

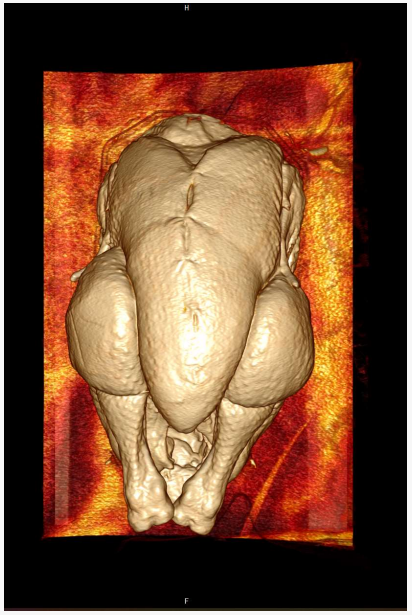
New tracer - Bacterial

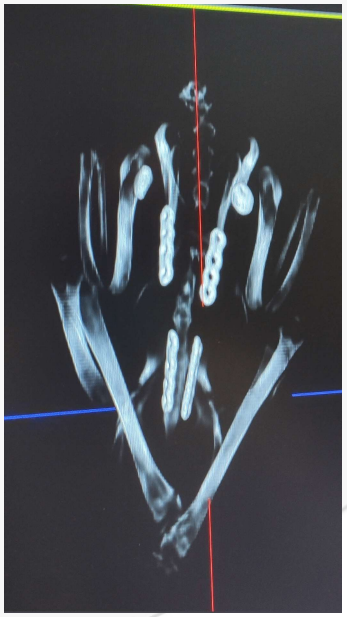
- ^{18}F-vancomycine
- ^{18}F-sorbitol





Ordonez et al





Elsinga, Spoelstra et al

umcg

Conclusions

- Nuclear medicine imaging widely used for infections and inflammatory diseases
- Prominent role for NM imaging in guidelines, especially in LVV/PMR
- Fast growing area with huge developments in camera systems and tracers
- Research aims for the future are:
  - Development of more specific tracers
  - To guide treatment
  - To evaluate therapy in an early phase
  - For better personalized care

umcg

E-mail: a.w.j.m.glaudemans@umcg.nl

NVNG
NEDERLANDSE VERENIGING VOOR NUCLEAIRE GENEESKUNDE

EANM®
European Association of Nuclear Medicine

umcg