SPECT、PET
影像定量處理分析

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討論一

- 現在各醫院用在SPECT、PET定量檢查的軟體有哪些?
- 腦部
- 心臟
- 肺臟
- 腎臟
- 唾液腺
- 骨骼
- 其他

討論二

- 有無新的軟體工具提供參考，或是未來採購依據?

臺北榮民總醫院
Taipei Veterans General Hospital

Quantitative Nuclear Medicine imaging in TVGH

Bang-Hung Yang, PhD
Department of Nuclear Medicine and National PET/Cyclotron Center,
Taipei Veterans General Hospital

核醫影像品質影響因子

- 藥物
  - -吸收特性、藥物標誌比活度、注射劑量
- 儀器
  - -儀器品管、準直儀、廠牌
- 病患
  - -檢查前準備事項、移動、病兆區域大小
- 收集影像條件
  - -收集的角度、時間，Zoom，繞360、矩陣大小、COR、距離
- 影像重建法
  - - AC、SC、FBP、OSEM、Filter

What do we have now for clinical diagnosis?

- Neurology

  1. eZIS SW: ECDSPECT imaging analysis

  2. TRODAT-1 SW: TRODAT-1 SPECT imaging analysis

  3. Corex ID SW : FDG PET imaging analysis

- Cardiology

  1.EF analysis (first-pass)

  2. Heartsee for NH_3 PET

easy Z-score imaging system (eZIS)

- statistical analysis methods for automated diagnosis
- perfusion SPECT images
- regional cerebral blood flow (rCBF)

J Nuci Med 1995; 36:1238-1248

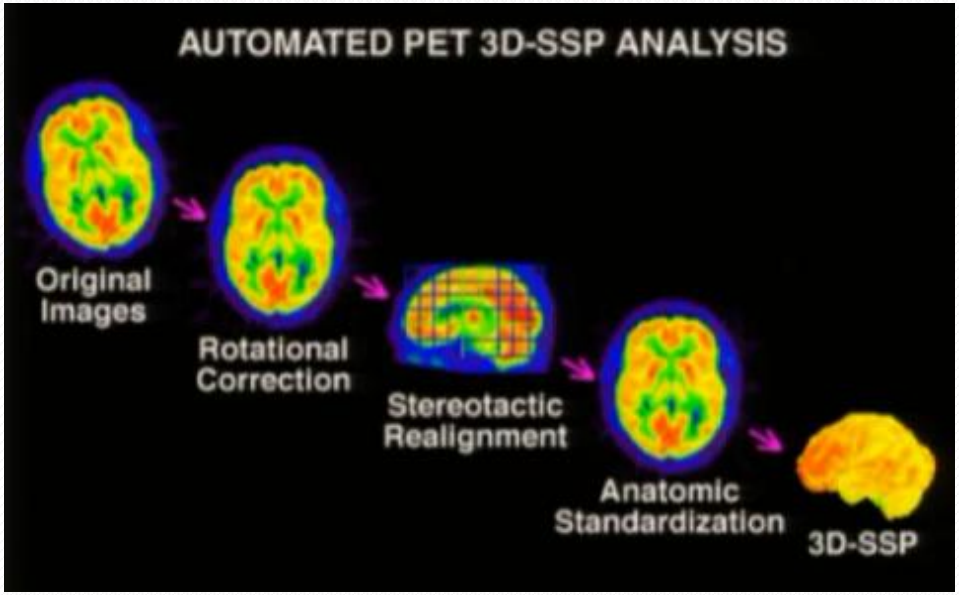
A Diagnostic Approach in Alzheimer's Disease Using Three-Dimensional Stereotactic Surface Projections of Fluorine-18-FDG PET

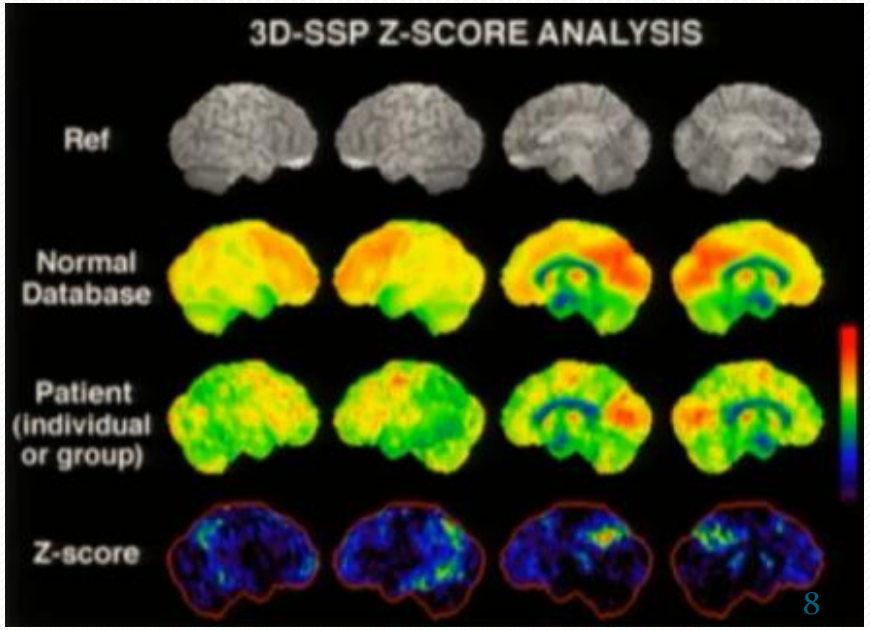
Satoshi Minoshima, Kirk A. Frey, Robert A. Koeppe, Norman L. Foster and David E. Kuhl

Division of Nuclear Medicine, Department of Internal Medicine, and Departments of Neurology and Radiology, University of Michigan, Ann Arbor, Michigan

To improve the diagnostic performance of PET as an aid in evaluating patients suspected of having Alzheimer's disease, we developed a fully automated method which generates compre-

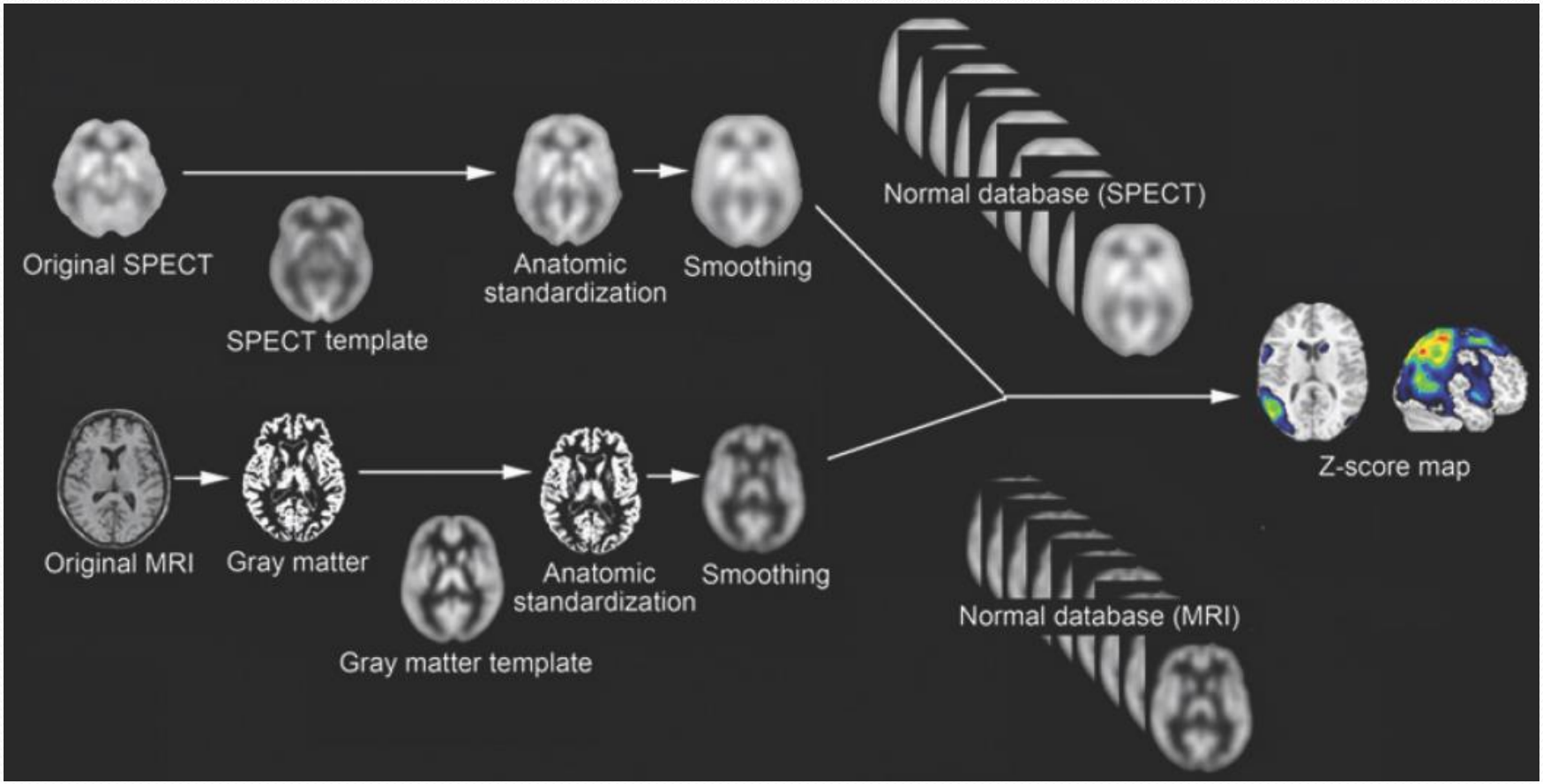
For more than a decade, PET has been used to investigate functional alteration of the brain in patients with Alzheimer's disease (*1–5*). Various researchers have demonstrated metabolic and blood flow reductions in the pari-





easy Z-score imaging system (eZIS)

- developed by Prof. Hiroshi Matsuda, National Center of Neurology and Psychiatry, Japan (NCNP; 日本國立精神神經研究中心)



Z-score

- Voxel normalization : global mean or cerebellar values
- Z-score = ([control mean] - [individual value])/ (control SD)

easy Z-score imaging system (eZIS)

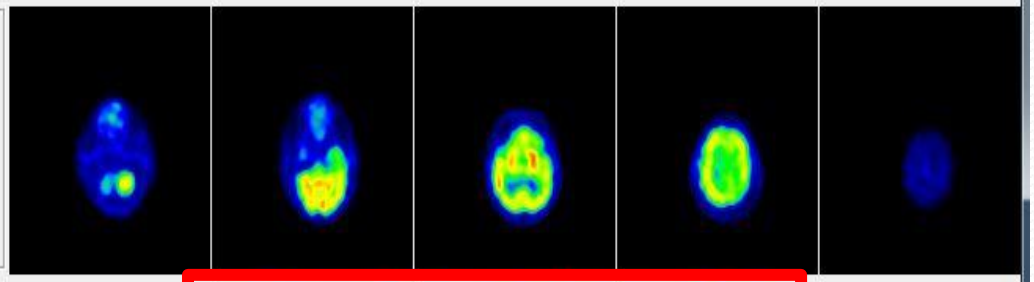
^{99m}Tc-ECD データベース名	年齢階層	性別	例数	SPECT 収集中心時刻(MST)*1	減弱補正(AC)の有無(+/-)
ECD1-3yDB *2	1-3 歳 *1	男女混合	21 例		AC+
ECD3-5yDB *2	3-5 歳 *1		18 例		
ECD6-10yDB *2	6-10 歳		17 例		
ECD10-15yDB *2	10-15 歳		9 例		
ECD20-39yDB	20-39 歳		28 例		
ECD40-59yDB	40-59 歳		30 例		
ECD60-69yDB	60-69 歳		40 例		
ECD70y-DB	70 歳以上		40 例		
ECD60-69y の男 DB	60-69 歳	男性のみ	18 例		
ECD60-69y の女 DB	60-69 歳	女性のみ	22 例		
ECD70y-の男 DB	70 歳以上	男性のみ	20 例		
ECD70y-の女 DB	70 歳以上	女性のみ	20 例		

tes\ECD2_SPM2.img
Original of patient:C:\Users\cbdoctor\Desktop\20160630\-EARLY_IRACSC001_DS_Result\t_-EARLY_IRACSC001_DS.img
Patient:C:\Users\cbdoctor\Desktop\20160630\-EARLY_IRACSC001_DS_Result\nt_-EARLY_IRACSC001_DS.img
Result:C:\Users\cbdoctor\Desktop\20160630\-EARLY_IRACSC001_DS_Result\chg_snt_-EARLY_IRACSC001_DS_Z-GLOB.img
MRI:C:\eZISv3\surface mri.img

Original SPECT

Start,End
Step Mode

Start 10/53
End 50/53



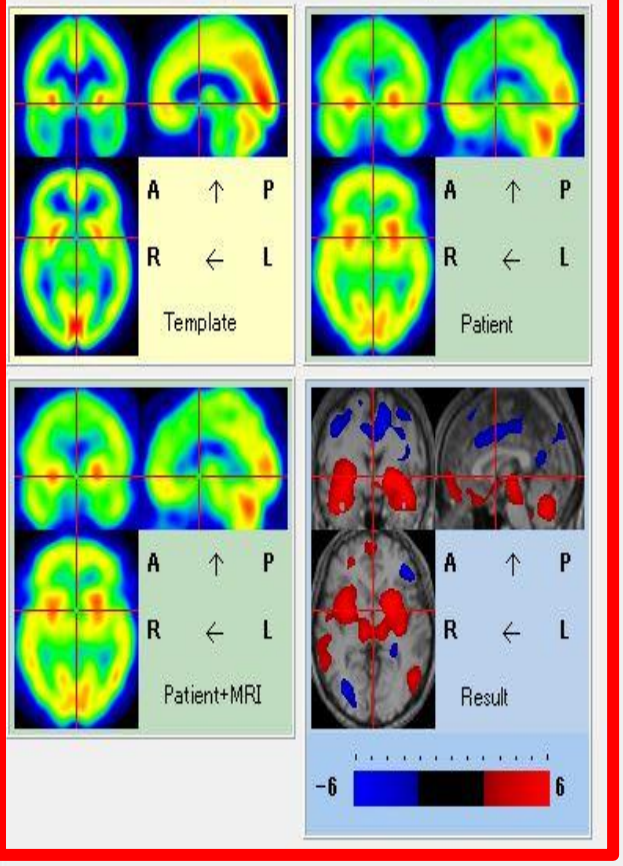
CONTROL

ColorMap: Scintipac-7000 Zoom: x 1.0

100
0

MRI 100
0

Fusion: 100



POSITION

X 40
Y 57
Z 26

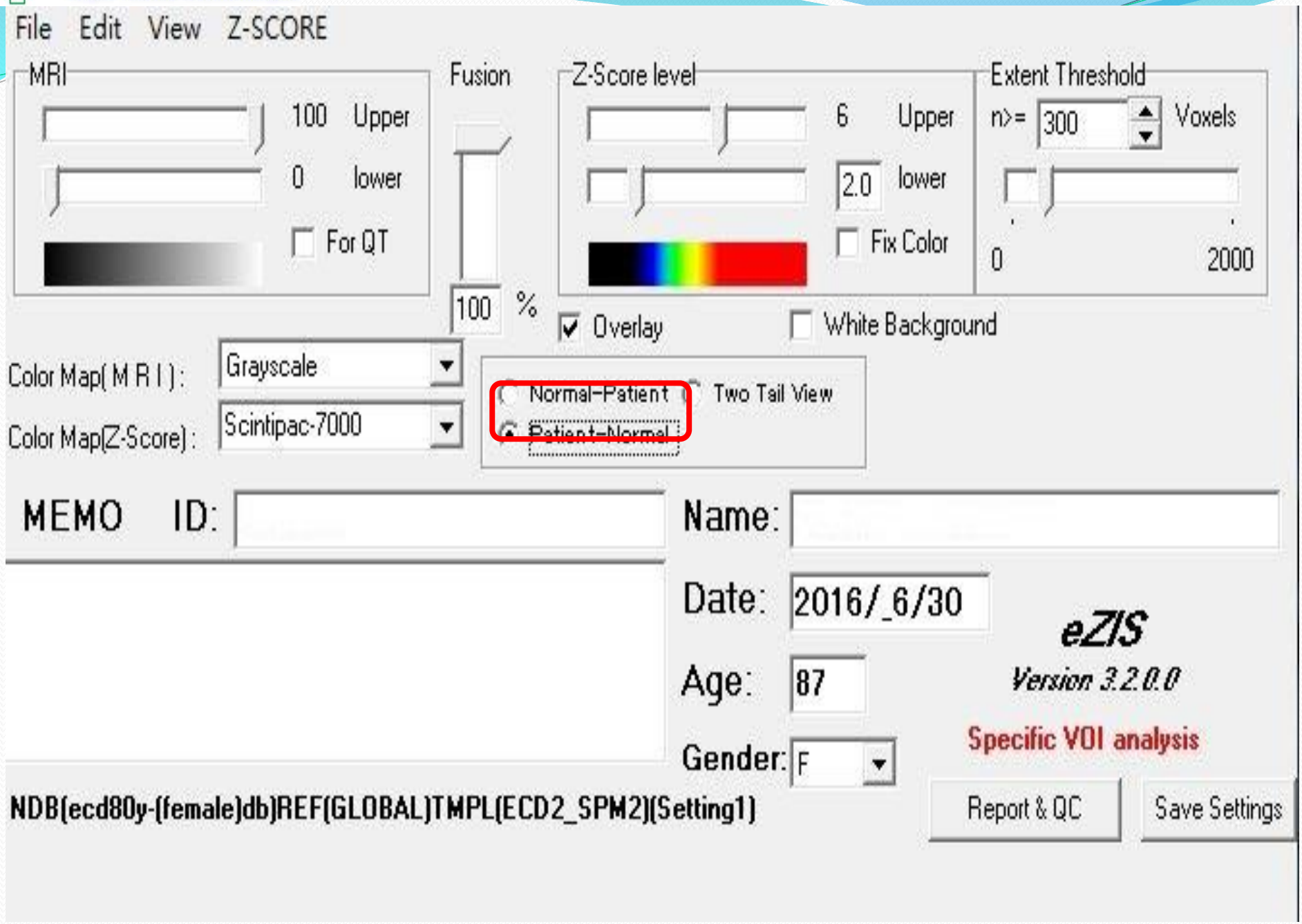
Xbars crosshair spacing

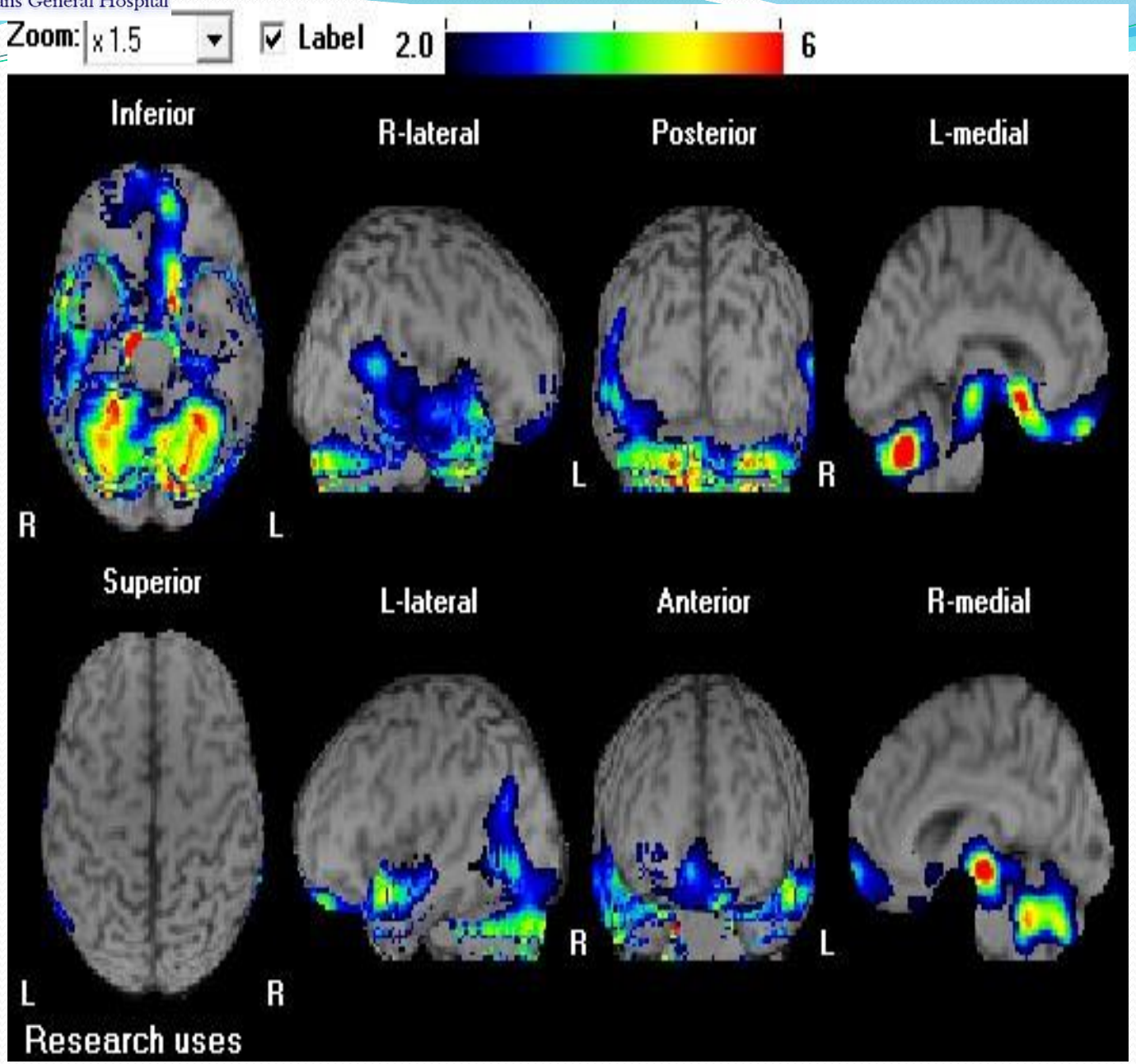
+ −

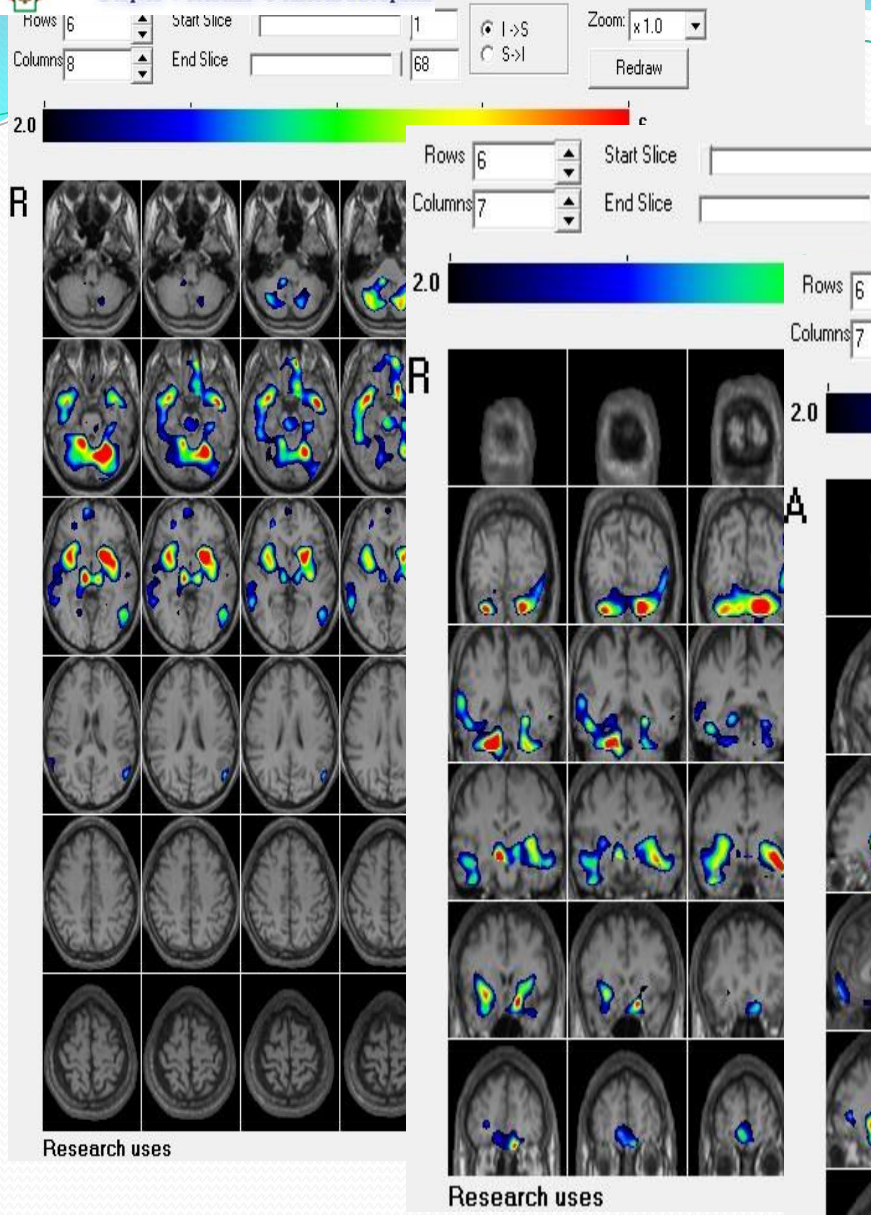
MNI: X=0, Y=0, Z=0
(Result=1.46, Spect=302.00, Template=27.40)
Talairach: X=0.0000, Y=0.0000, Z=0.0000

MNI:
Talairach:

For Hyperperfusion


File Edit View Z-SCORE
MRI
100 Upper
0 lower
For QT
Fusion
100 %
Z-Score level
6 Upper
2.0 lower
Fix Color
Extent Threshold
n>= 300 Voxels
0 2000
Overlay
White Background
Color Map(M R I):
Grayscale
Color Map(Z-Score):
Scintipac-7000
Normal-Patient
Two Tail View
Patient-Normal
MEMO
ID:
Name:
Date: 2016/_6/30
Age: 87
Gender: F
eZIS
Version 3.2.0.0
Specific VOI analysis
NDB(ecd80y-(female)db)REF(GLOBAL)TMPL(ECD2_SPM2)(Setting1)
Report & QC
Save Settings

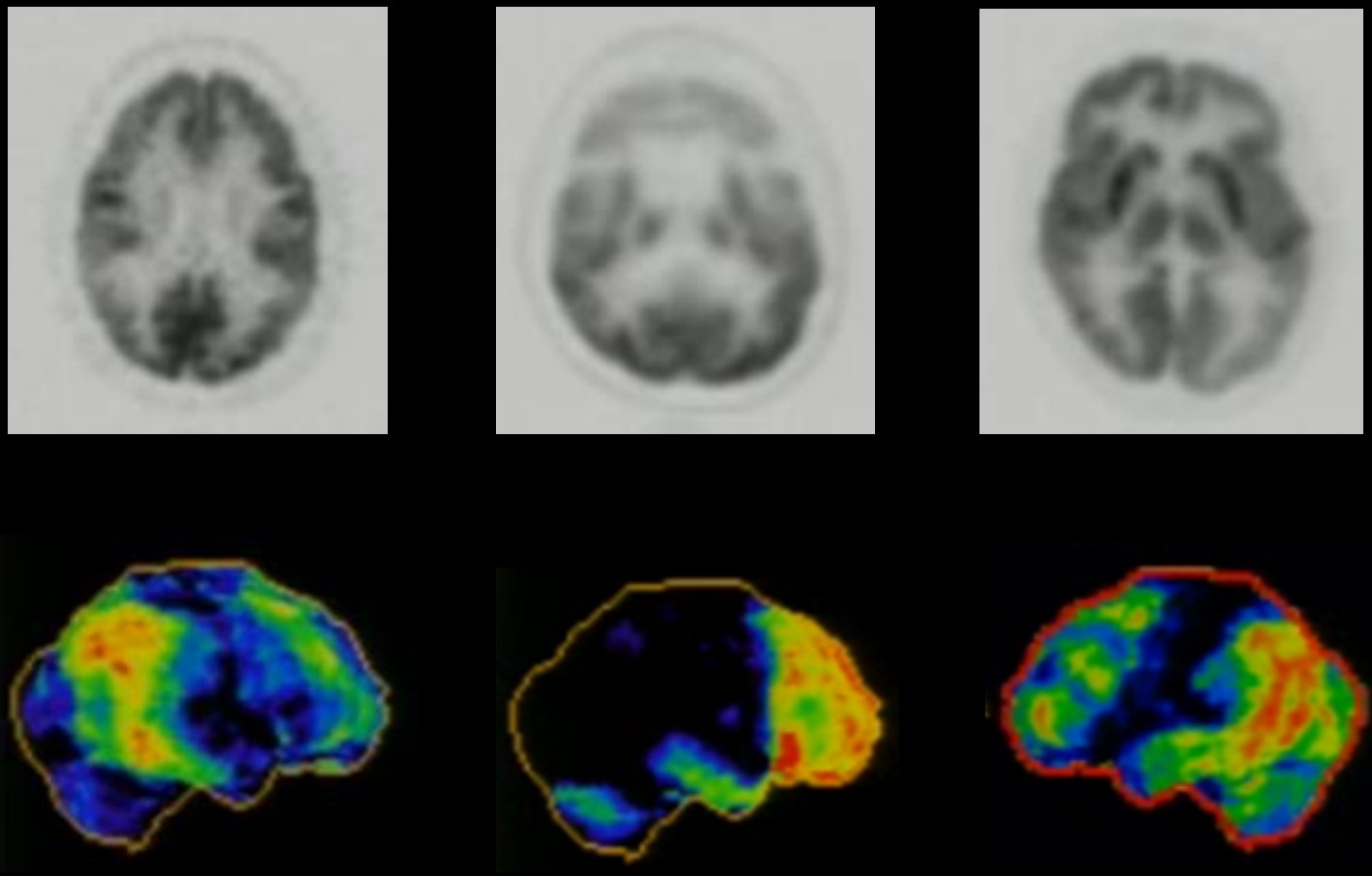

Zoom: x1.5
Label
2.0
6
Inferior
R-lateral
Posterior
L-medial
R
L
L
R
Superior
L-lateral
Anterior
R-medial
L
R
R
L
Research uses

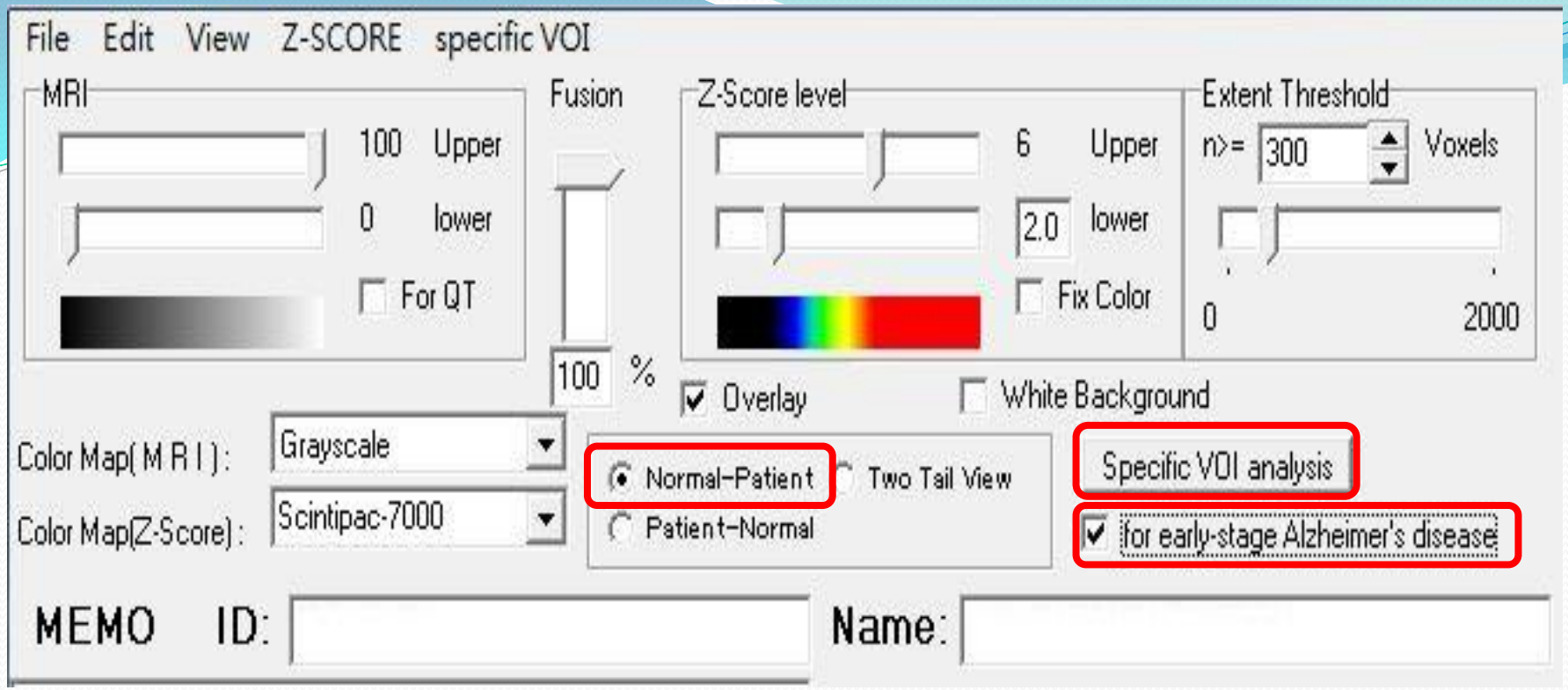

Rows 6
Columns 8
Start Slice 1
End Slice 68
I->S
S->I
Zoom: x1.0
Redraw
2.0
R
Research uses
Rows 6
Columns 7
Start Slice 1
End Slice 95
P->A
A->P
Zoom: x1.0
Redraw
2.0
R
Research uses
Rows 6
Columns 7
Start Slice 1
End Slice 79
L->R
R->L
Zoom: x1.0
Redraw
2.0
6
A
P
Research uses

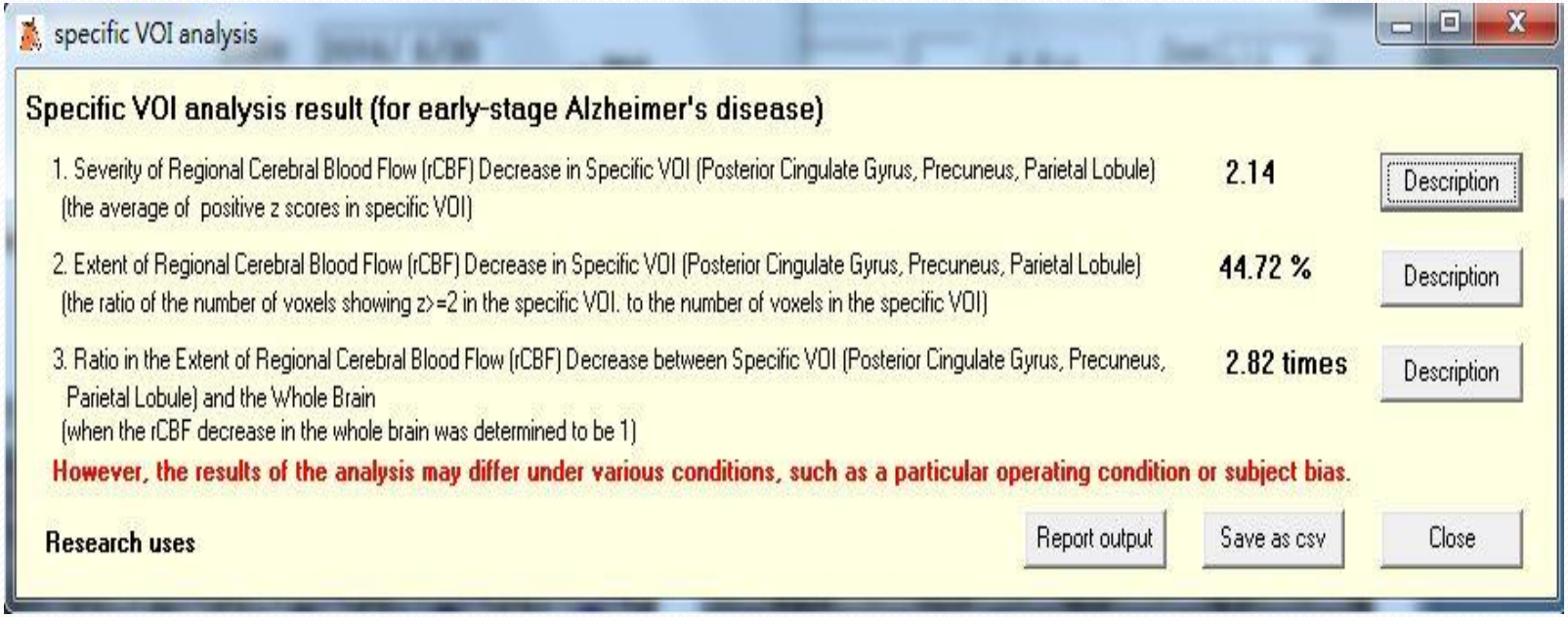
For Early Alzheimer's Disease

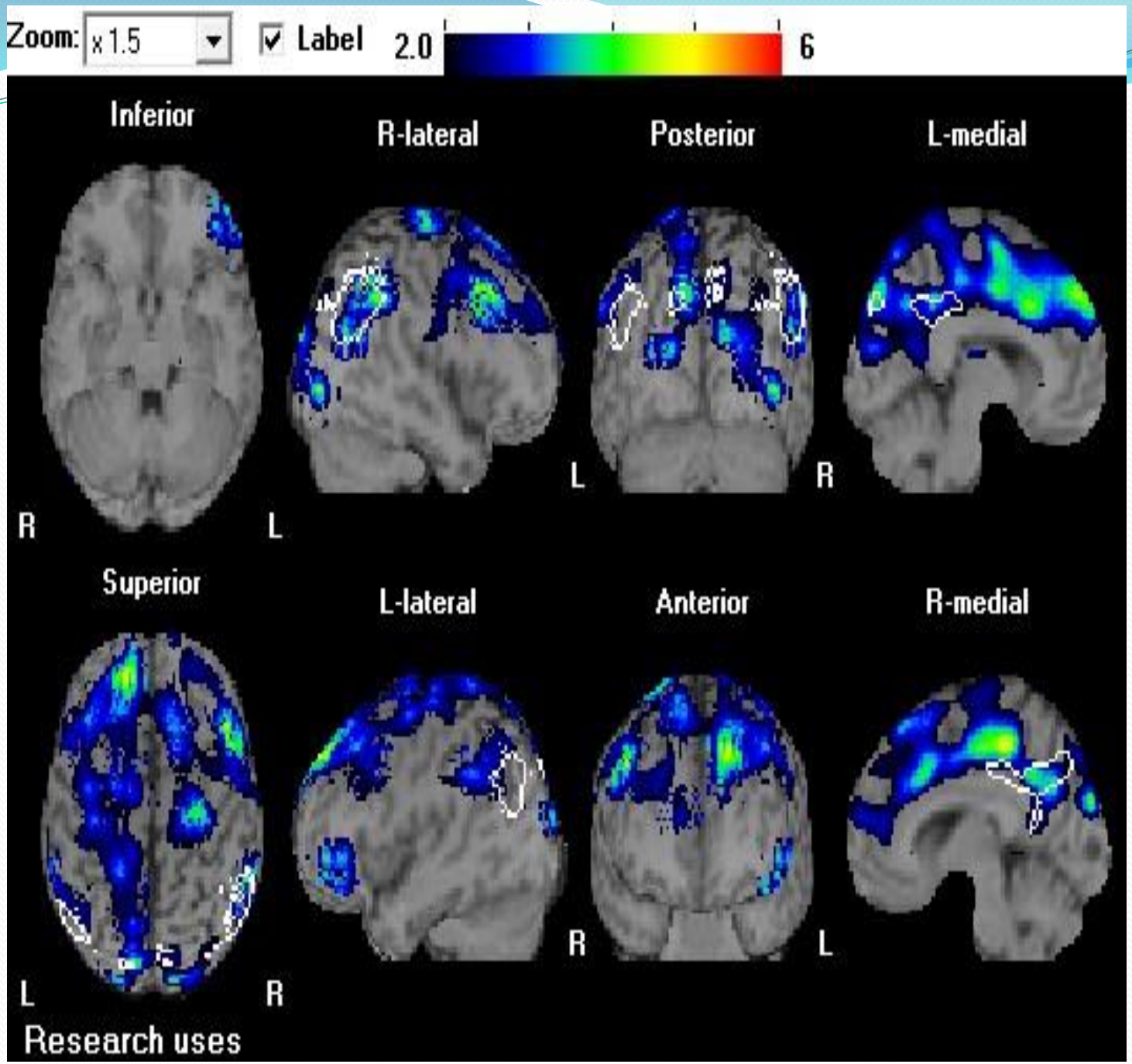
FDG-PET in 3 Major Dementias

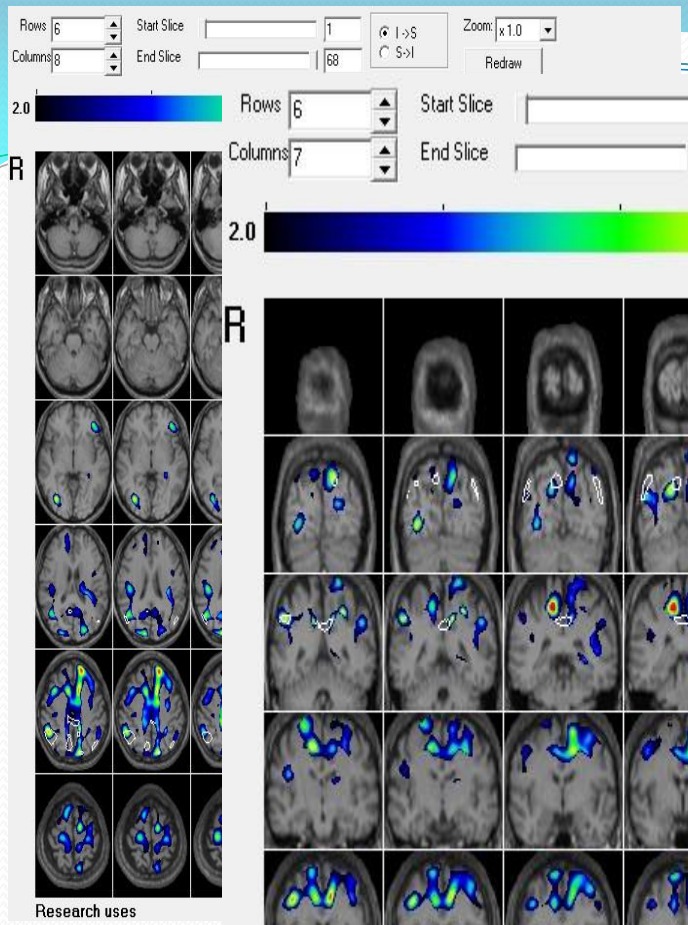
AD FTD DLB



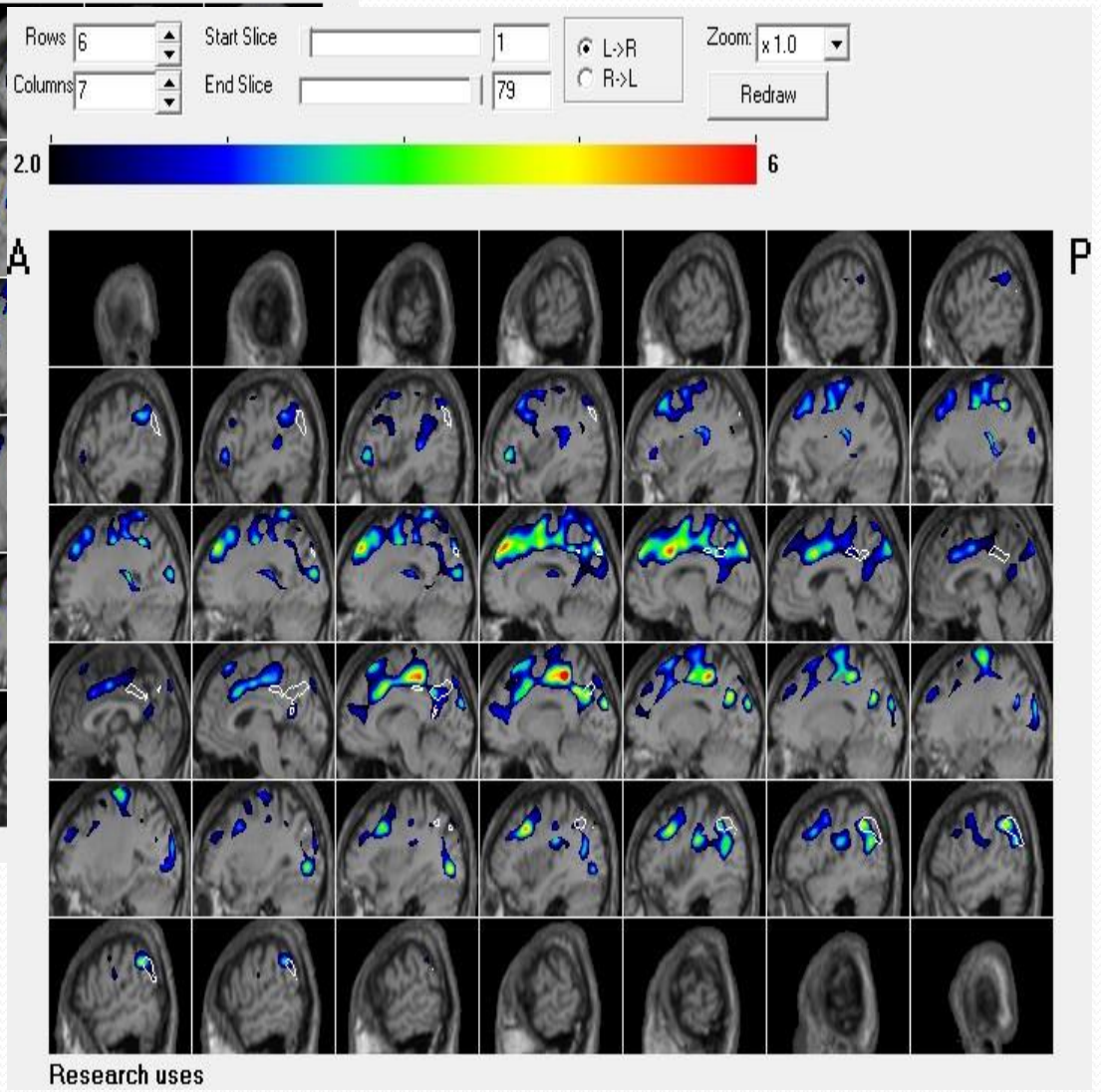

File Edit View Z-SCORE specific VOI
MRI
100 Upper
0 lower
For QT
Fusion
100 %
Z-Score level
6 Upper
2.0 lower
Fix Color
Extent Threshold
n>= 300 Voxels
0 2000
Overlay
White Background
Color Map(M R I):
Grayscale
Color Map(Z-Score):
Scintipac-7000
Normal-Patient
Two Tail View
Patient-Normal
Specific VOI analysis
for early-stage Alzheimer's disease
MEMO ID:
Name:

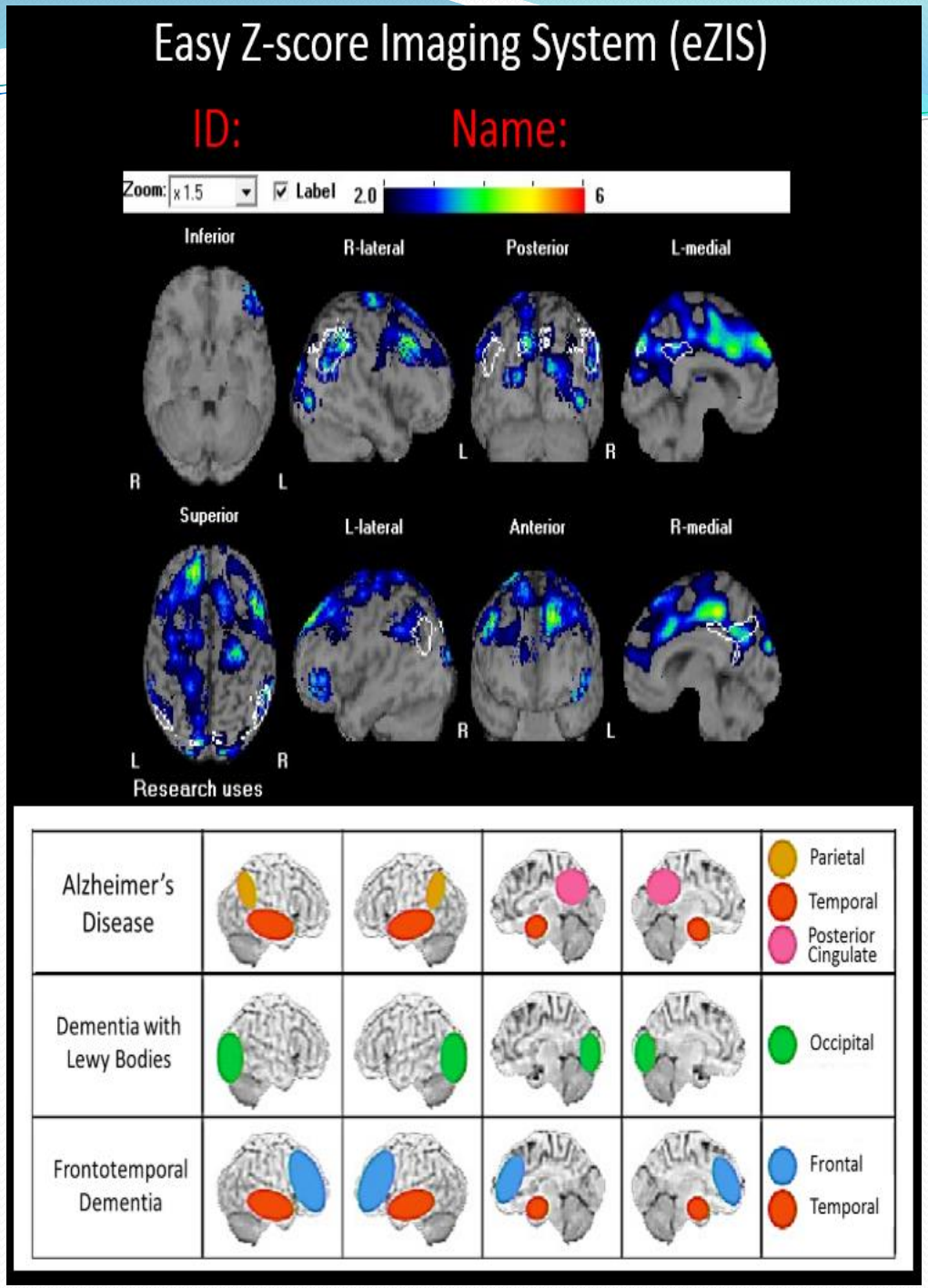

specific VOI analysis
Specific VOI analysis result (for early-stage Alzheimer's disease)
1. Severity of Regional Cerebral Blood Flow (rCBF) Decrease in Specific VOI (Posterior Cingulate Gyrus, Precuneus, Parietal Lobule)
(the average of positive z scores in specific VOI)
2.14
Description
2. Extent of Regional Cerebral Blood Flow (rCBF) Decrease in Specific VOI (Posterior Cingulate Gyrus, Precuneus, Parietal Lobule)
(the ratio of the number of voxels showing z>=2 in the specific VOI. to the number of voxels in the specific VOI)
44.72 %
Description
3. Ratio in the Extent of Regional Cerebral Blood Flow (rCBF) Decrease between Specific VOI (Posterior Cingulate Gyrus, Precuneus, Parietal Lobule) and the Whole Brain
(when the rCBF decrease in the whole brain was determined to be 1)
2.82 times
Description
However, the results of the analysis may differ under various conditions, such as a particular operating condition or subject bias.
Research uses
Report output
Save as csv
Close


Zoom: x 1.5
Label
2.0
6
Inferior
R-lateral
Posterior
L-medial
R
L
L
R
Superior
L-lateral
Anterior
R-medial
L
R
R
L
Research uses


Rows 6
Columns 8
Start Slice 1
End Slice 68
I->S
S->I
Zoom: x1.0
Redraw
2.0
R
Research uses

Rows 6
Columns 7
Start Slice 1
End Slice 95
P->A
A->P
Zoom: x1.0
Redraw
2.0
6
R
Research uses


Rows 6
Columns 7
Start Slice 1
End Slice 79
L->R
R->L
Zoom: x1.0
Redraw
2.0
6
A
P
Research uses


Easy Z-score Imaging System (eZIS)
ID:
Name:
Zoom: x1.5
Label
2.0
6
Inferior
R-lateral
Posterior
L-medial
R
L
L
R
Superior
L-lateral
Anterior
R-medial
L
R
R
L
Research uses
Alzheimer's Disease
Parietal
Temporal
Posterior Cingulate
Dementia with Lewy Bodies
Occipital
Frontotemporal Dementia
Frontal
Temporal

Regional Cerebral Blood Flow (rCBF) Decrease in Specific **VOI** (Posterior Cingulate Gyrus, Precuneus, Parietal Lobule)

ID: Name:

1. Severity: 2.14

   (the average of positive z scores in specific VOI)

2. Extent: 44.72%

   (the percent rate of the coordinates with a Z value exceeding the threshold value of 2)

3. Ratio: 2.82

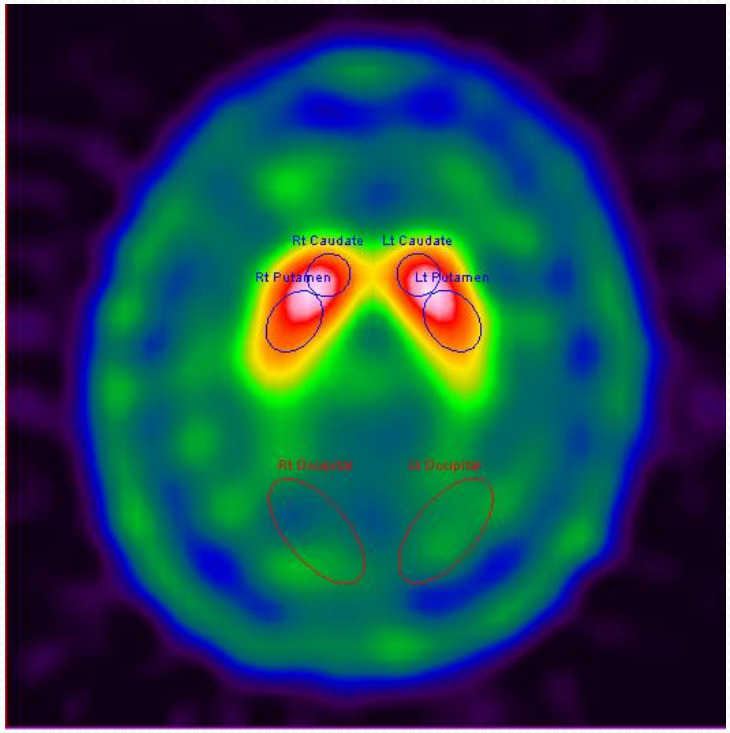
   (the extent of a region showing significant rCBF reduction in the VOI to the extent of a region showing significant rCBF reduction in the whole brain)

Cut-off level for diagnosing Alzheimer's Disease

1. Severity: 1.19
2. Extent: 14.2%
3. Ratio: 2.22

Eur J Nucl Med Mol Imaging 2004;31:975-980

TRODAT1-1 SPECT images semi-quantitative analysis



- Specific uptake ratio (SUR)

$$SUR = \frac{target - background}{background}$$

*target：striatum, caudate or putamen
*background：occipital cortex, frontal cortex or cerebellum
* unit：counts/voxel

- Asymmetry

$$Asymmetry = \frac{\left|SUR_{right\ striatum} - SUR_{left\ striatum}\right| \times 2}{SUR_{right\ striatum} + SUR_{left\ striatum}} \times 100\%$$

TRODAT Tool

Bang-Hung Yang & Tung-Hsin Wu

Department of Biomedical Imaging & Radiological Sciences
National Yang-Ming University

Processing (single file di...

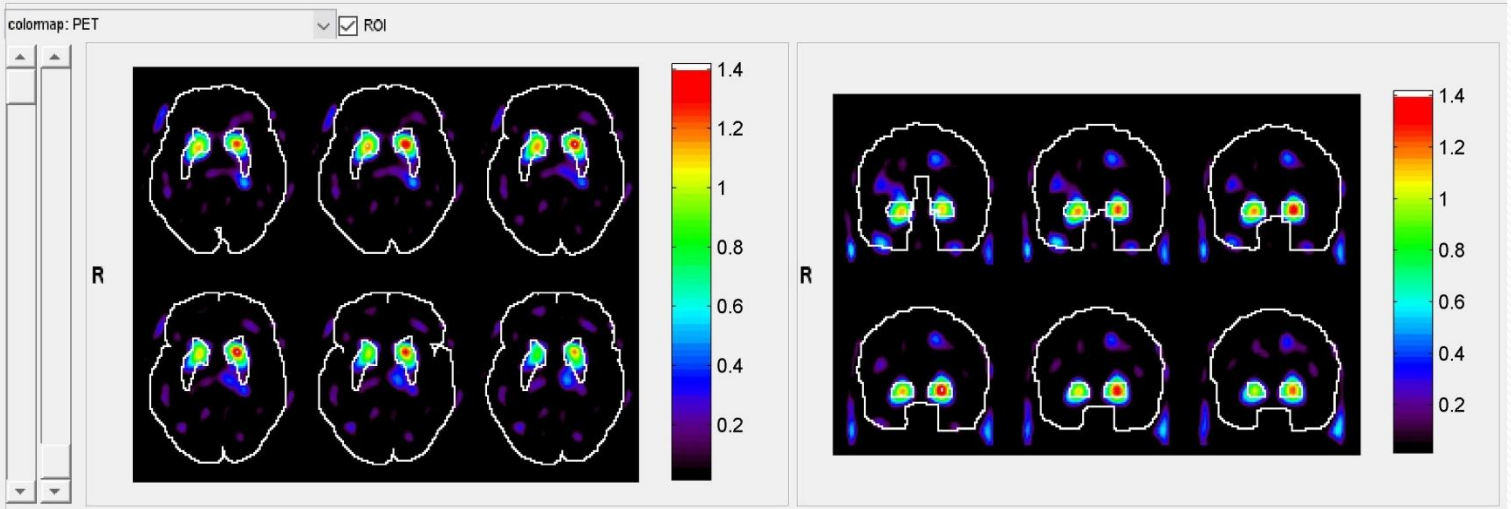
Parameter Setting

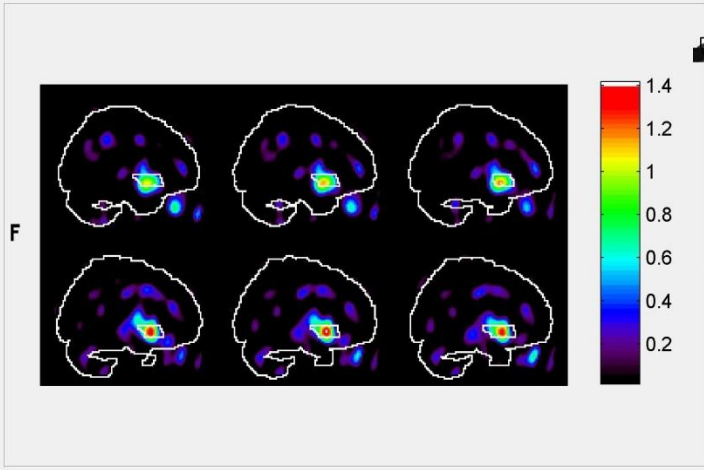
Parameter Defaults

Save

Reset

Quit





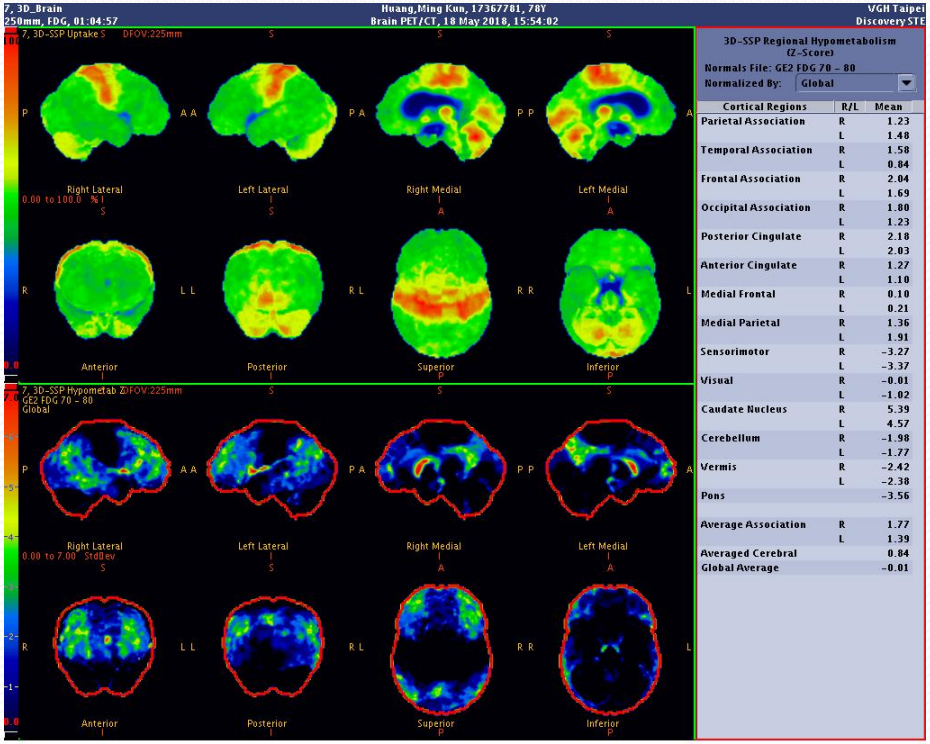
Tc-99m-TRODAT

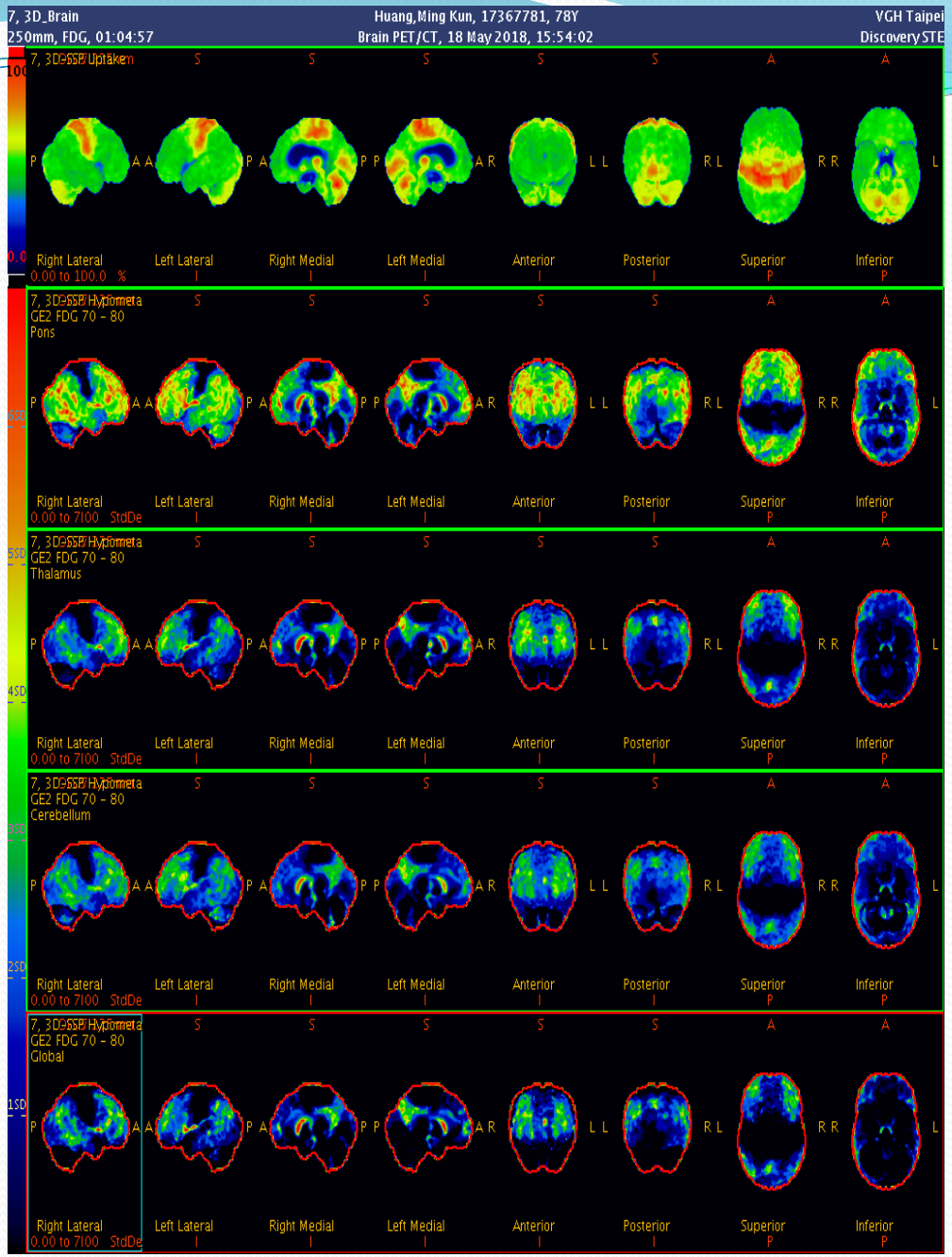
	SUR(R)	SUR(L)	Asymmetry	Global
caudate	0.7830	0.7480	-0.0457	
putamen	0.4156	0.6980	0.5071	
striatum	0.5603	0.6809	0.1943	

	SUR(R)	SUR(L)	Asymmetry	Cerebellum
caudate	1.2800	1.2353	-0.0355	
putamen	0.8103	1.1713	0.3644	
striatum	0.9953	1.1495	0.1438	

	SUR(R)	SUR(L)	Asymmetry	Occipital
caudate	1.5114	1.4621	-0.0331	
putamen	0.9940	1.3917	0.3334	
striatum	1.1978	1.3676	0.1324	

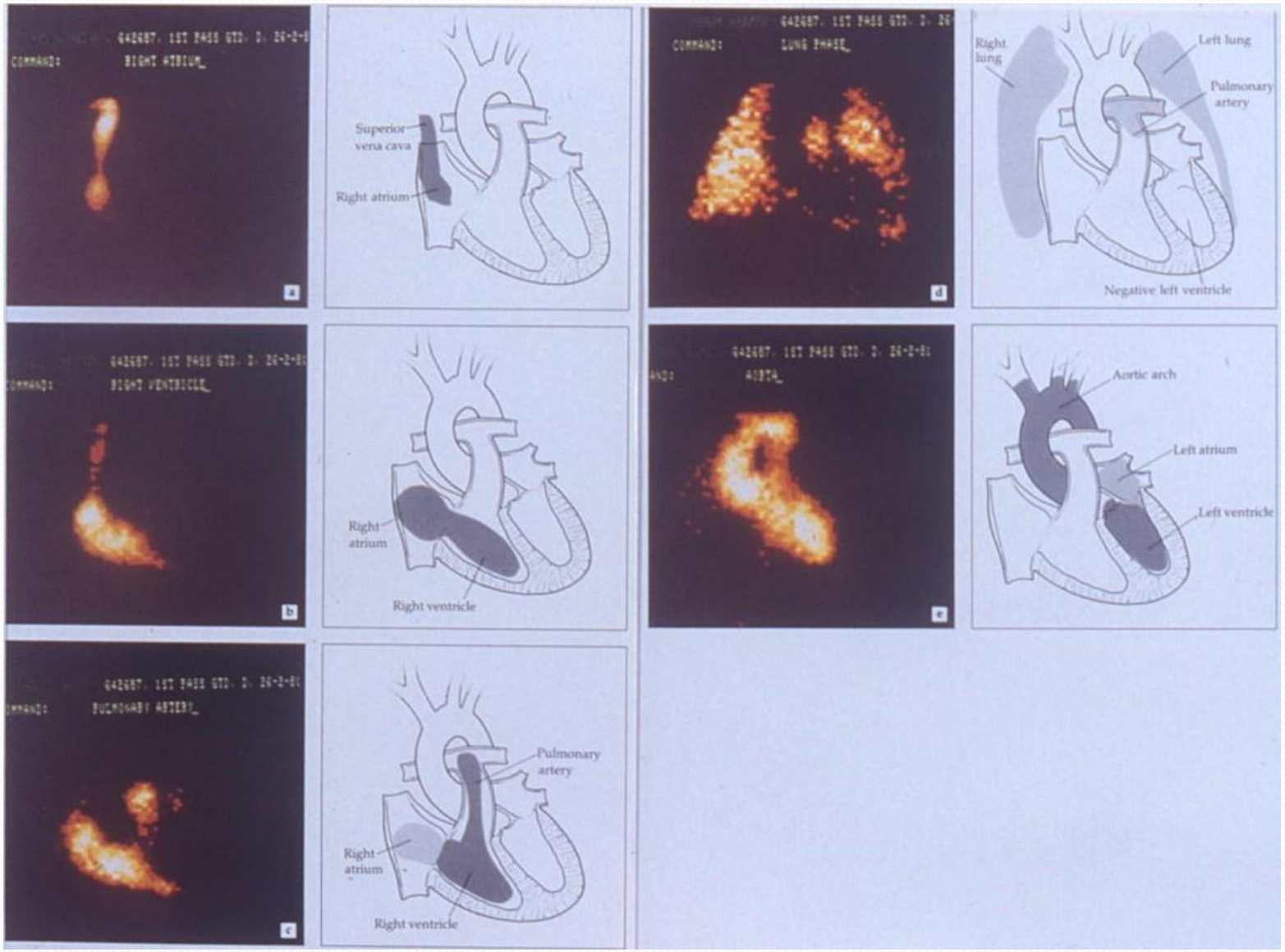
Cortex ID


7, 3D_Brain
250mm, FDG, 01:04:57
Huang,Ming Kun, 17367781, 78Y
Brain PET/CT, 18 May 2018, 15:54:02
VGH Taipei
Discovery STE
7, 3D-SSP Uptake S DFOV:225mm
Right Lateral
Left Lateral
Right Medial
Left Medial
0.00 to 100.0 %I
Anterior
Posterior
Superior
Inferior
7, 3D-SSP Hypometab ZDFOV:225mm
GE2 FDG 70 – 80
Global
0.00 to 7.00 StdDev
3D-SSP Regional Hypometabolism
(Z-Score)
Normals File: GE2 FDG 70 – 80
Normalized By: Global
Cortical Regions R/L Mean
Parietal Association R 1.23
L 1.48
Temporal Association R 1.58
L 0.84
Frontal Association R 2.04
L 1.69
Occipital Association R 1.80
L 1.23
Posterior Cingulate R 2.18
L 2.03
Anterior Cingulate R 1.27
L 1.10
Medial Frontal R 0.10
L 0.21
Medial Parietal R 1.36
L 1.91
Sensorimotor R -3.27
L -3.37
Visual R -0.01
L -1.02
Caudate Nucleus R 5.39
L 4.57
Cerebellum R -1.98
L -1.77
Vermis R -2.42
L -2.38
Pons -3.56
Average Association R 1.77
L 1.39
Averaged Cerebral 0.84
Global Average -0.01


7, 3D_Brain
250mm, FDG, 01:04:57
Huang,Ming Kun, 17367781, 78Y
Brain PET/CT, 18 May 2018, 15:54:02
VGH Taipei
Discovery STE
Uptake
Right Lateral
Left Lateral
Right Medial
Left Medial
Anterior
Posterior
Superior
Inferior
0.00 to 100.0 %
Hypometa
GE2 FDG 70 - 80
Pons
Thalamus
Cerebellum
Global
0.00 to 7100 StdDe

Cardiology

First pass analysis



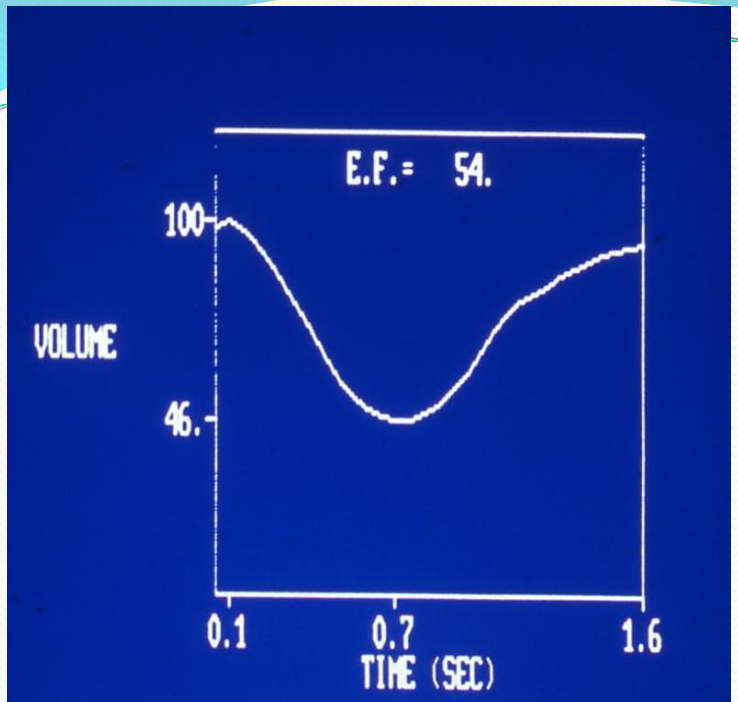
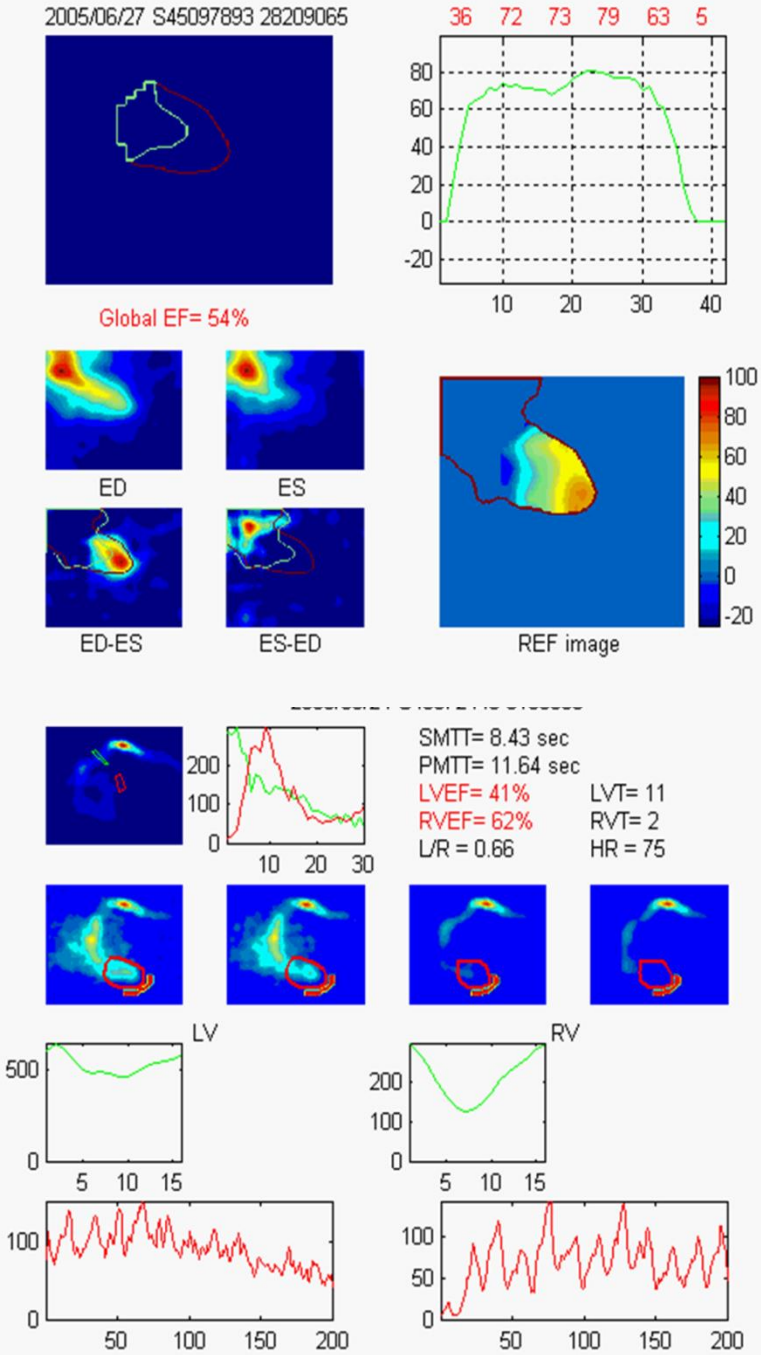


Figure 4-12 Time-activity curve. Typical left ventricular time-activity curve. Maximum activity is assigned a value of 100, and activity for the remainder of the cycle is scaled relative to this. E.F. = ejection fraction.

$$\text{Ejection fraction} = \frac{\text{ED} - \text{ES}}{\text{ED}}$$

A normal resting left ventricular ejection fraction is 50 percent or greater. With satisfactory exercise, the ejection fraction should rise at least 5 percentage points* above its resting value.[40,41]

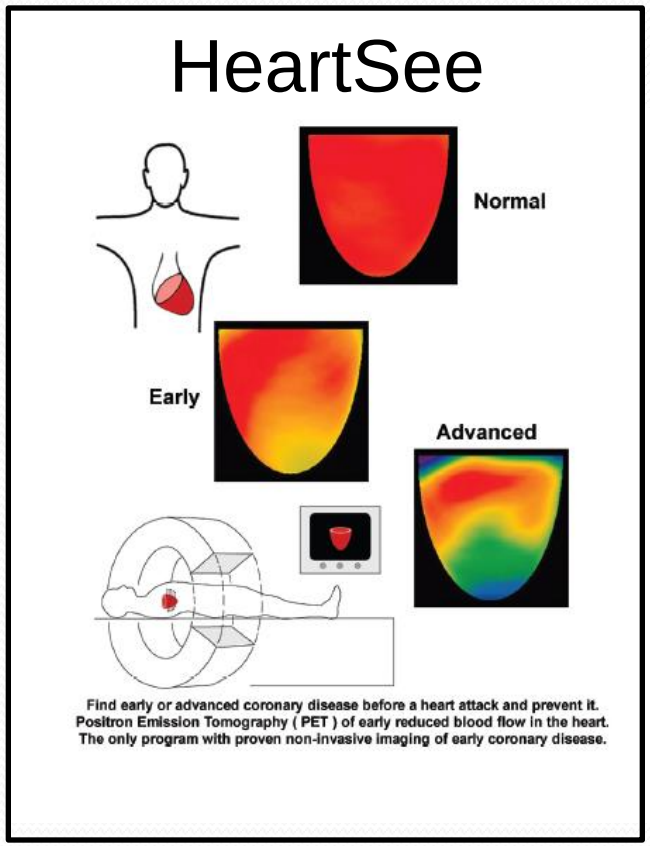


Father of Flow Quantitation

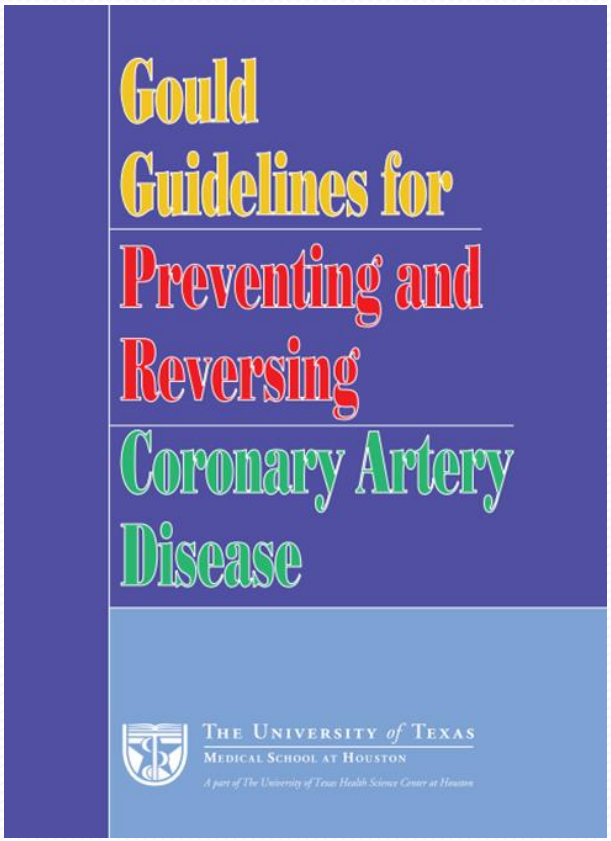
K. Lance Gould, M.D.

- Professor, Division of Cardiovascular Medicine, Weatherhead PET Center for Preventing and Reversing Atherosclerosis
- The Martin Bucksbaum Distinguished University Chair, The University of Texas Medical School at Houston

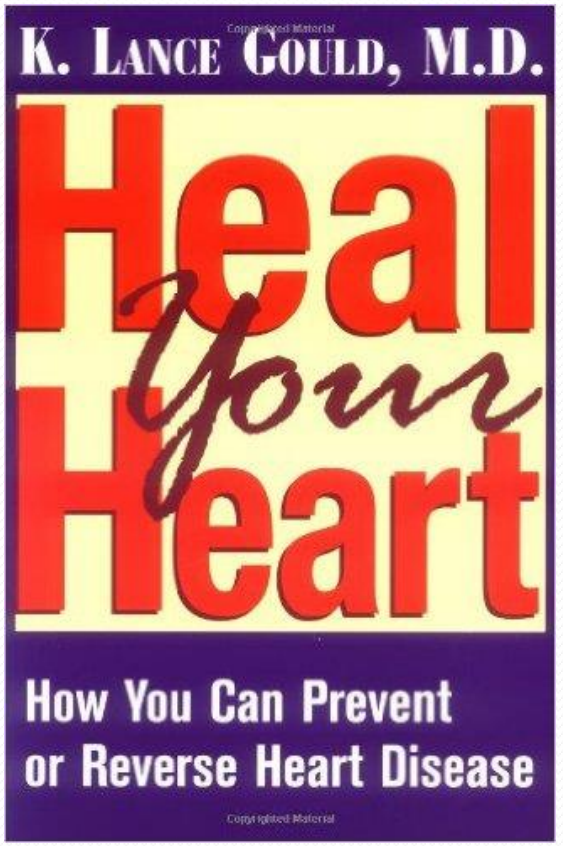
42 years, > 100 million USD



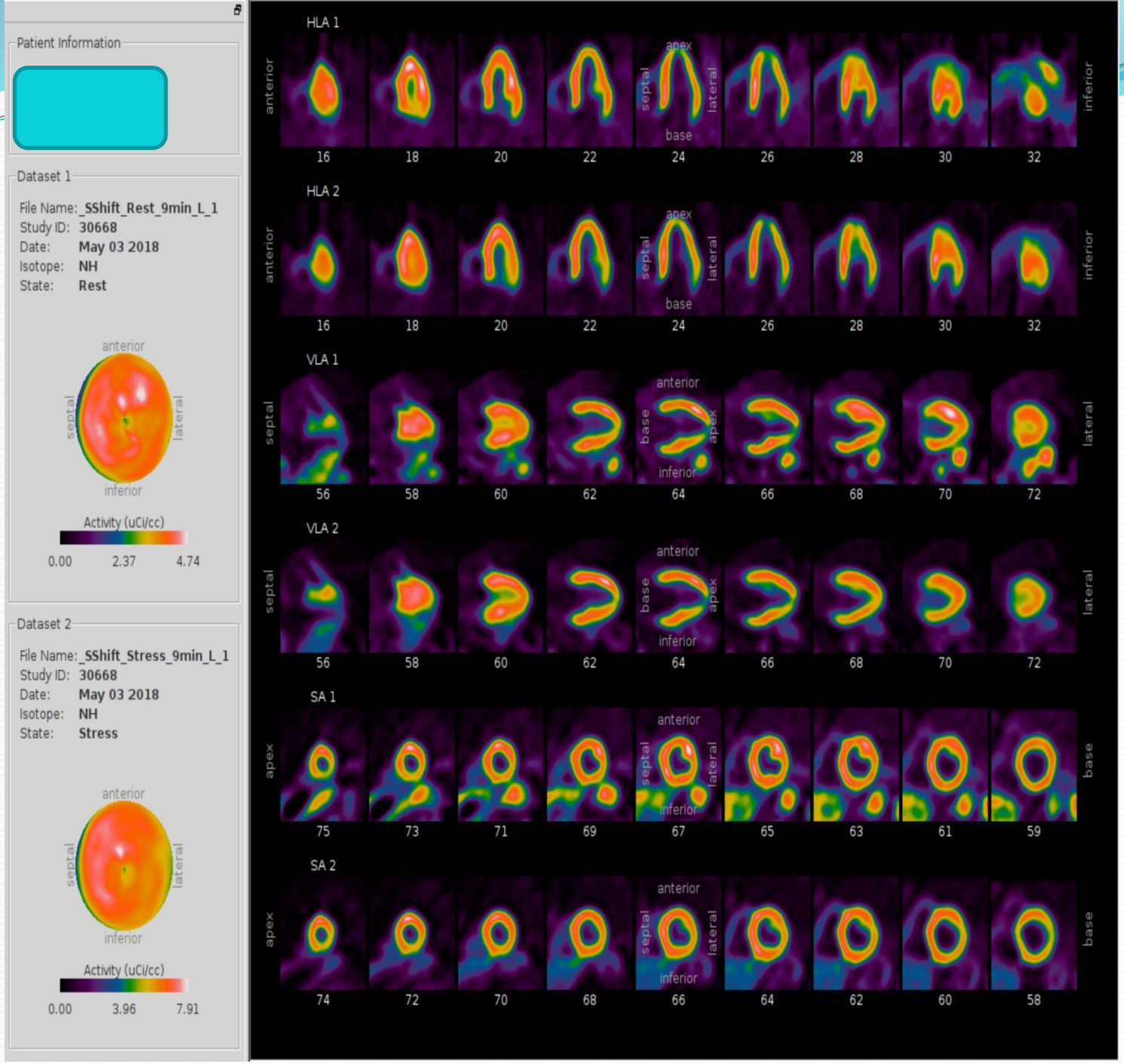
510(K) No. K143664



http://www.uth.tmc.edu/pet/



amazon


Patient Information
Dataset 1
File Name: _SShift_Rest_9min_L_1
Study ID: 30668
Date: May 03 2018
Isotope: NH
State: Rest
anterior
septal
lateral
inferior
Activity (uCi/cc)
0.00 2.37 4.74
Dataset 2
File Name: _SShift_Stress_9min_L_1
Study ID: 30668
Date: May 03 2018
Isotope: NH
State: Stress
anterior
septal
lateral
inferior
Activity (uCi/cc)
0.00 3.96 7.91
HLA 1
anterior
apex
septal
lateral
base
inferior
16 18 20 22 24 26 28 30 32
HLA 2
anterior
apex
septal
lateral
base
inferior
16 18 20 22 24 26 28 30 32
VLA 1
septal
anterior
base
apex
inferior
lateral
56 58 60 62 64 66 68 70 72
VLA 2
septal
anterior
base
apex
inferior
lateral
56 58 60 62 64 66 68 70 72
SA 1
apex
anterior
septal
lateral
inferior
base
75 73 71 69 67 65 63 61 59
SA 2
apex
anterior
septal
lateral
inferior
base
74 72 70 68 66 64 62 60 58

Coronary Flow Report

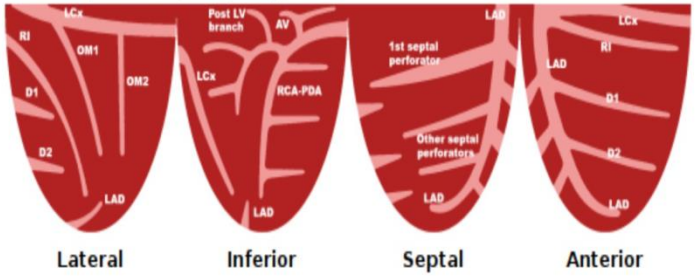
Date: May 03 2018 Isotope: NH

Partial Volume Corrections: Art=1 Myo=0.9

Rest Arterial=5.32 Stress Arterial=3.63

Rest Location=High Ascending Aorta Stress Location=High Ascending Aorta

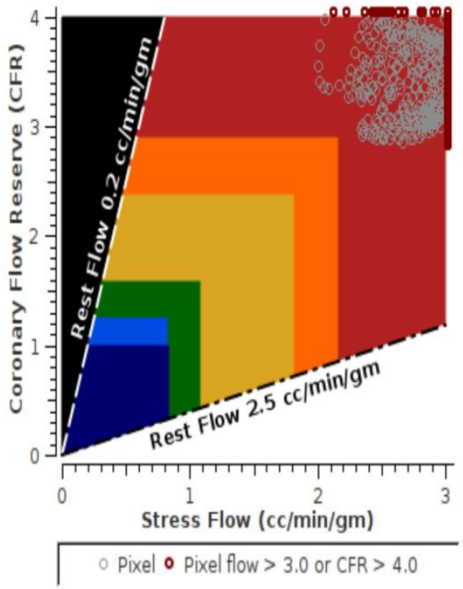
Coronary Flow Capacity Map



Lateral Inferior Septal Anterior

100% Normal flow capacity comparable to healthy young volunteers.
0% No ischemia. Minimally reduced flow capacity.
0% No ischemia. Mildly reduced flow capacity.
0% Moderately reduced, sometimes angina or STΔ with dipyridamole stress.
0% Severely reduced, usually angina and STΔ with dipyridamole stress.

Plot of Flow Values for Capacity Map



Coronary Flow Capacity Color Scale

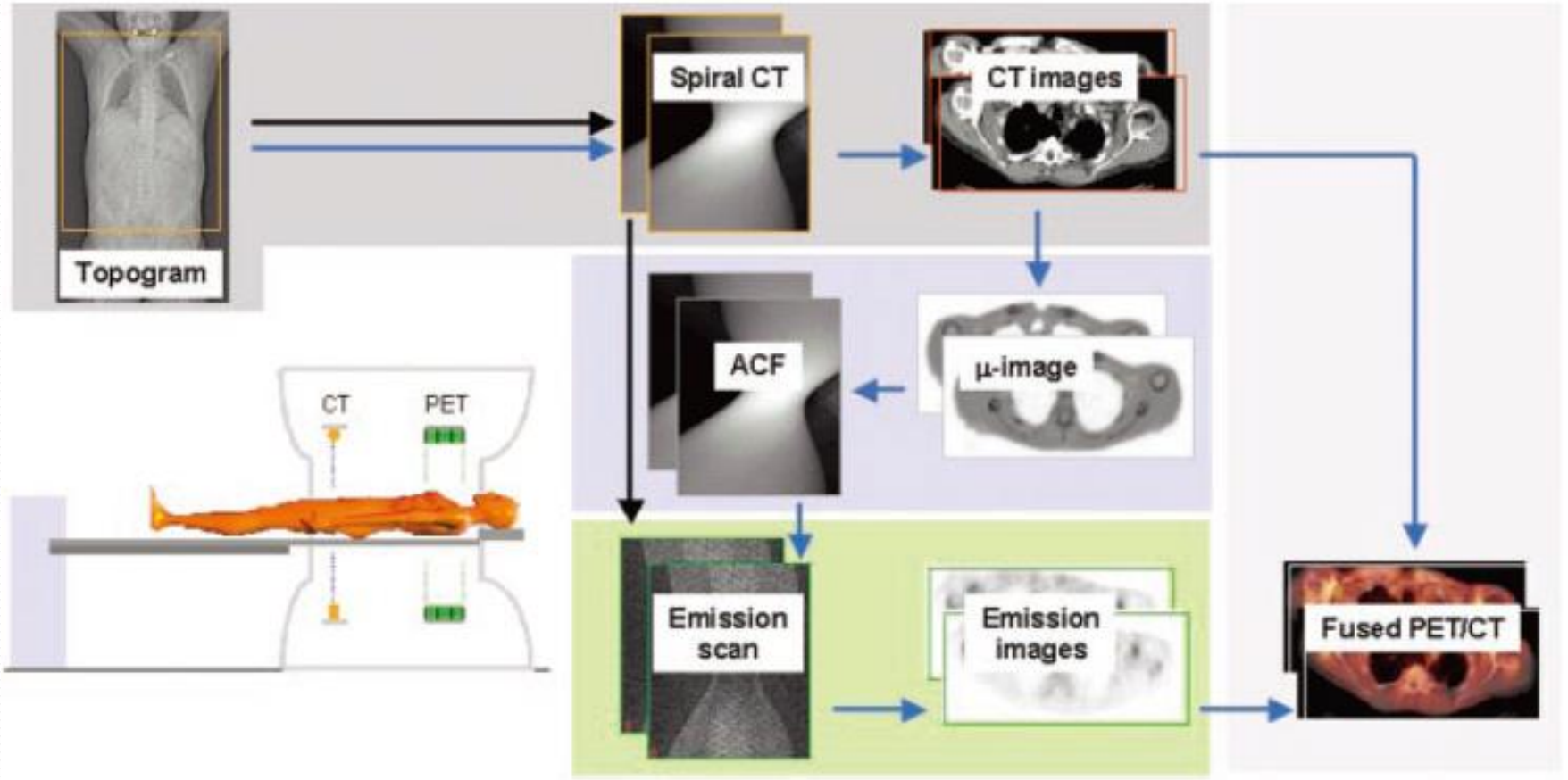
Healthy young volunteers
Minimally reduced (risk factors only)
Mildly reduced (stable CAD)
Moderately reduced (possible ischemia)
Severely reduced (definite ischemia)
Myocardial steal (definite ischemia)

核醫全身電腦斷層衰減校正之輻射劑量與假影介紹

楊邦宏 博士

臺北榮總 核醫部暨迴旋加速中心

Standard FDG-PET/CT imaging protocol



J Nucl Med 2004; 45:25S-35S

PET + CT→ Attenuation Correction

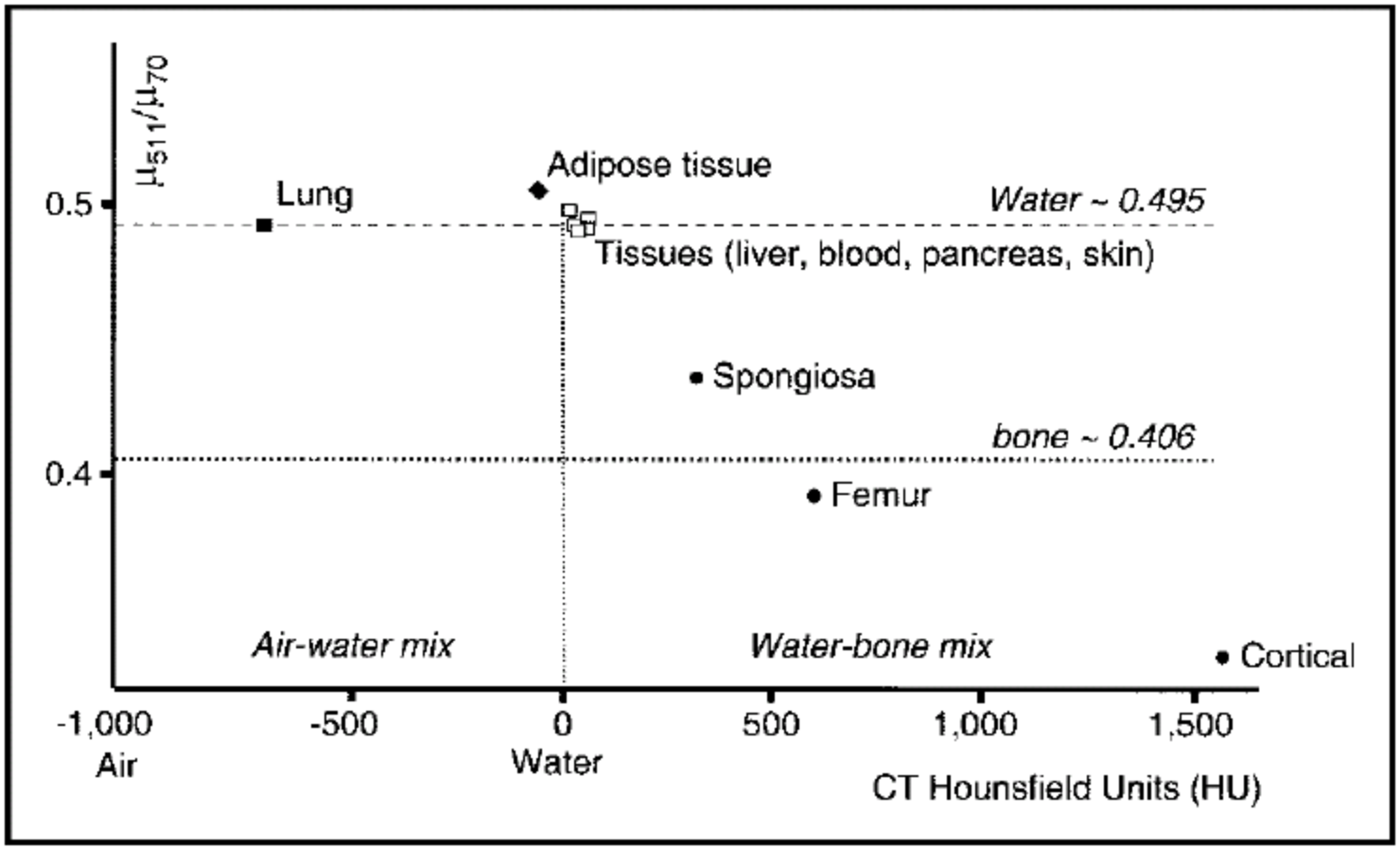
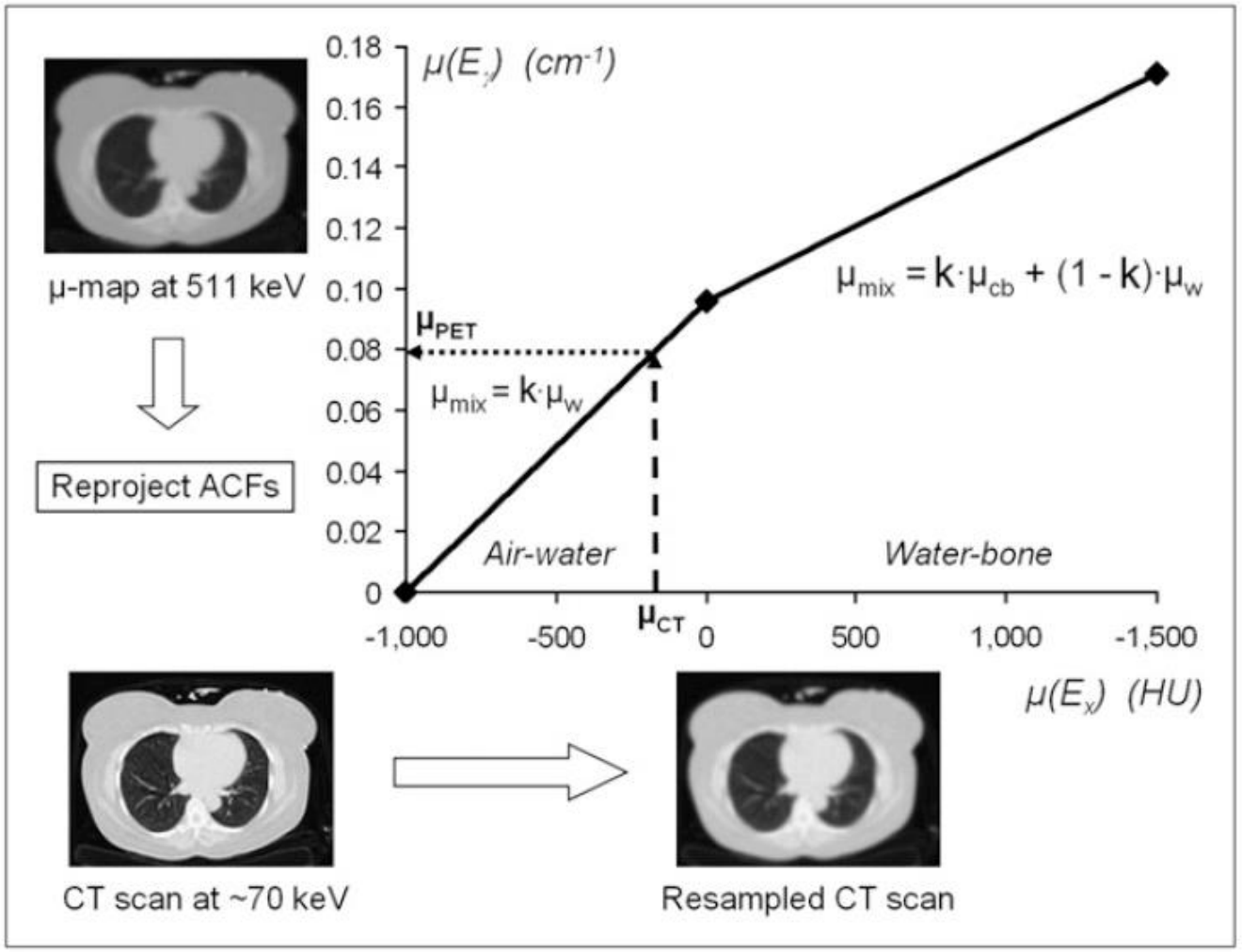


FIGURE 5. Plot of ratio of μ(511 keV)/μ(70 keV) as function of CT Hounsfield unit (HU) for reference tissues, as given by International Commission on Radiological Protection in 1975 (*25*). Scaling factors used in algorithm of Kinahan et al. (*26*) for soft tissue (water) and bone are indicated by horizontal lines.

CT-BASED ATTENUATION CORRECTION (CT-AC)



J Nucl Med 2008; 49:938–955

Bilinear scaling function

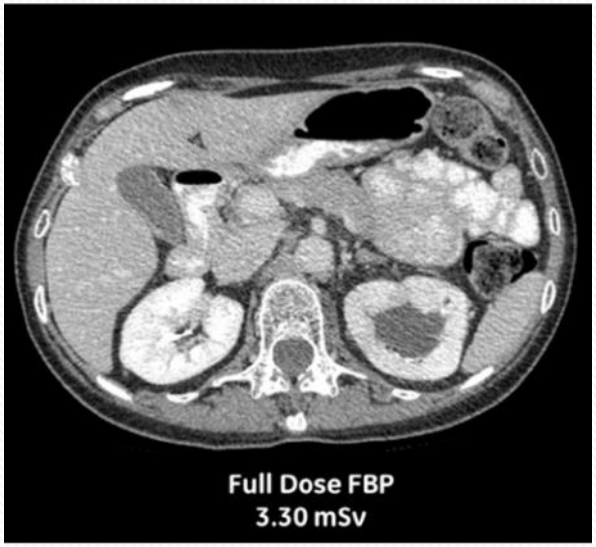
計畫目的

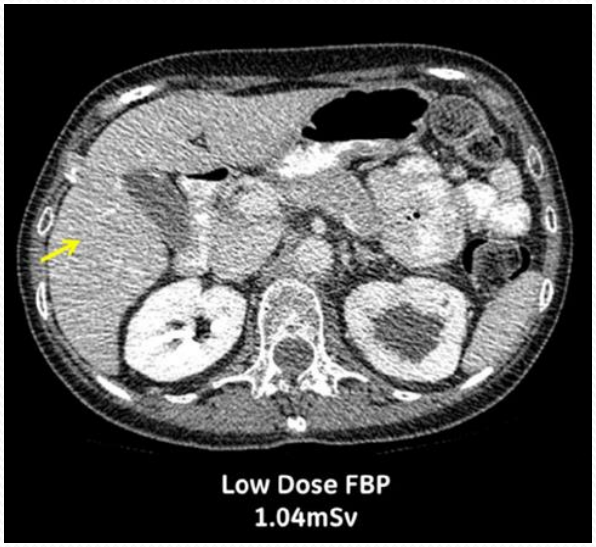
- 過去的PET/CT及SPECT/CT造影系統皆搭載濾波反投影影像重建法(filter back-projection reconstruction, FBP)來進行CT影像的重建，爾後提供PET或SPECT做影像衰減校正使用，主要原因為 FBP影像重建法對於龐大的CT影像資料處理速度既快速又簡便。
- 疊代影像重建法(iterative reconstruction, IR)為降低輻射劑量策略中最有效的方法之一，使得CT造影時可使用低劑量造影參數，達到更好的影像品質。因此，本計畫目的為建立核醫影像品質與低劑量造影參數之最佳化。

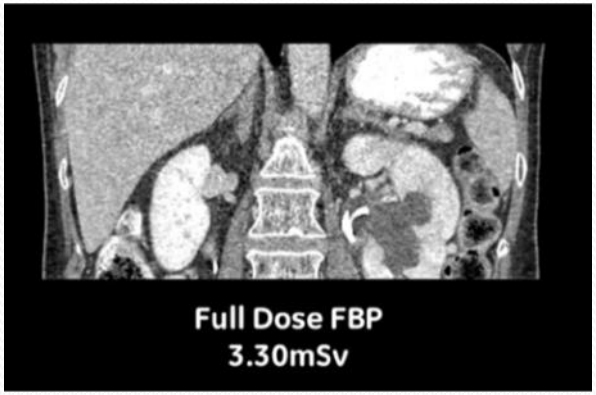
imagination at work

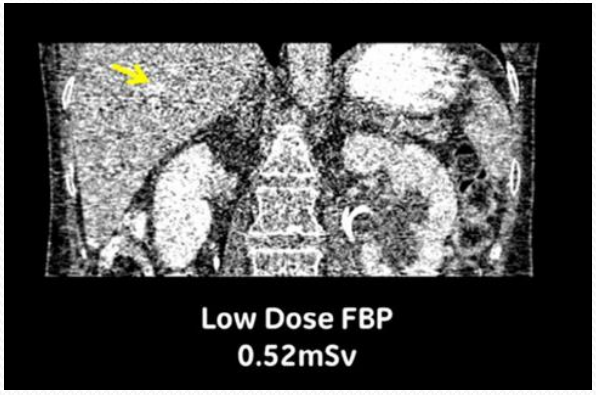
Benefits of ASiR-V* Reconstruction for Reducing Patient Radiation Dose and Preserving Diagnostic Quality in CT Exams

Authors: Jiahua Fan, Meghan Yue, and Roman Melnyk

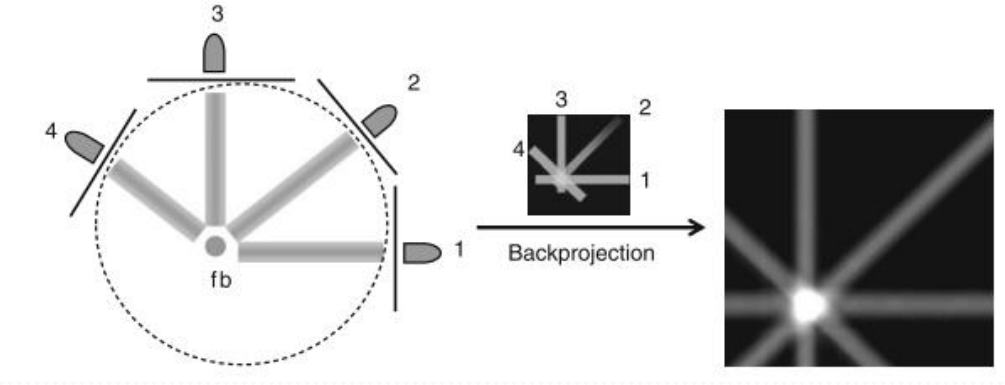


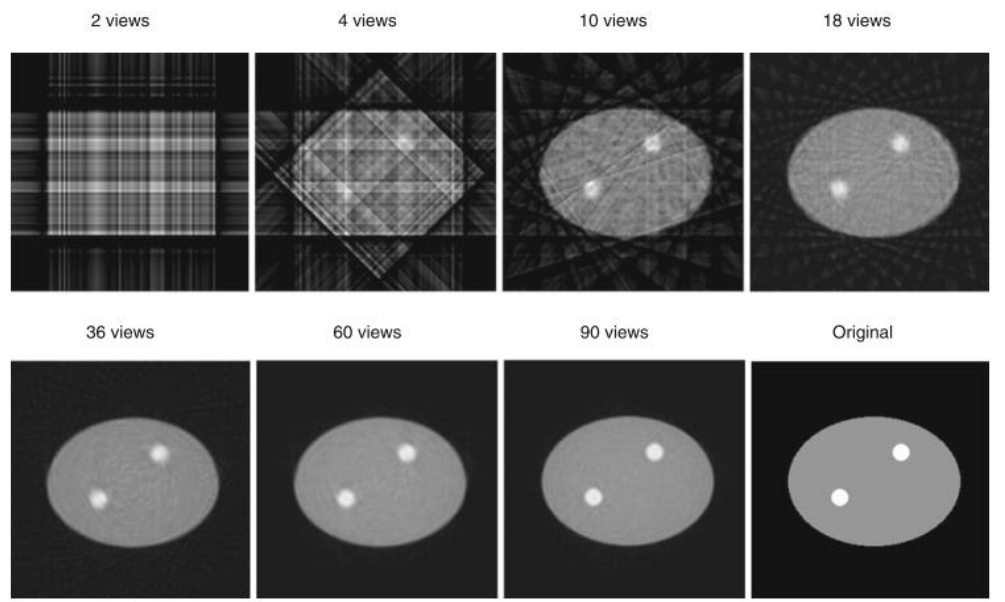






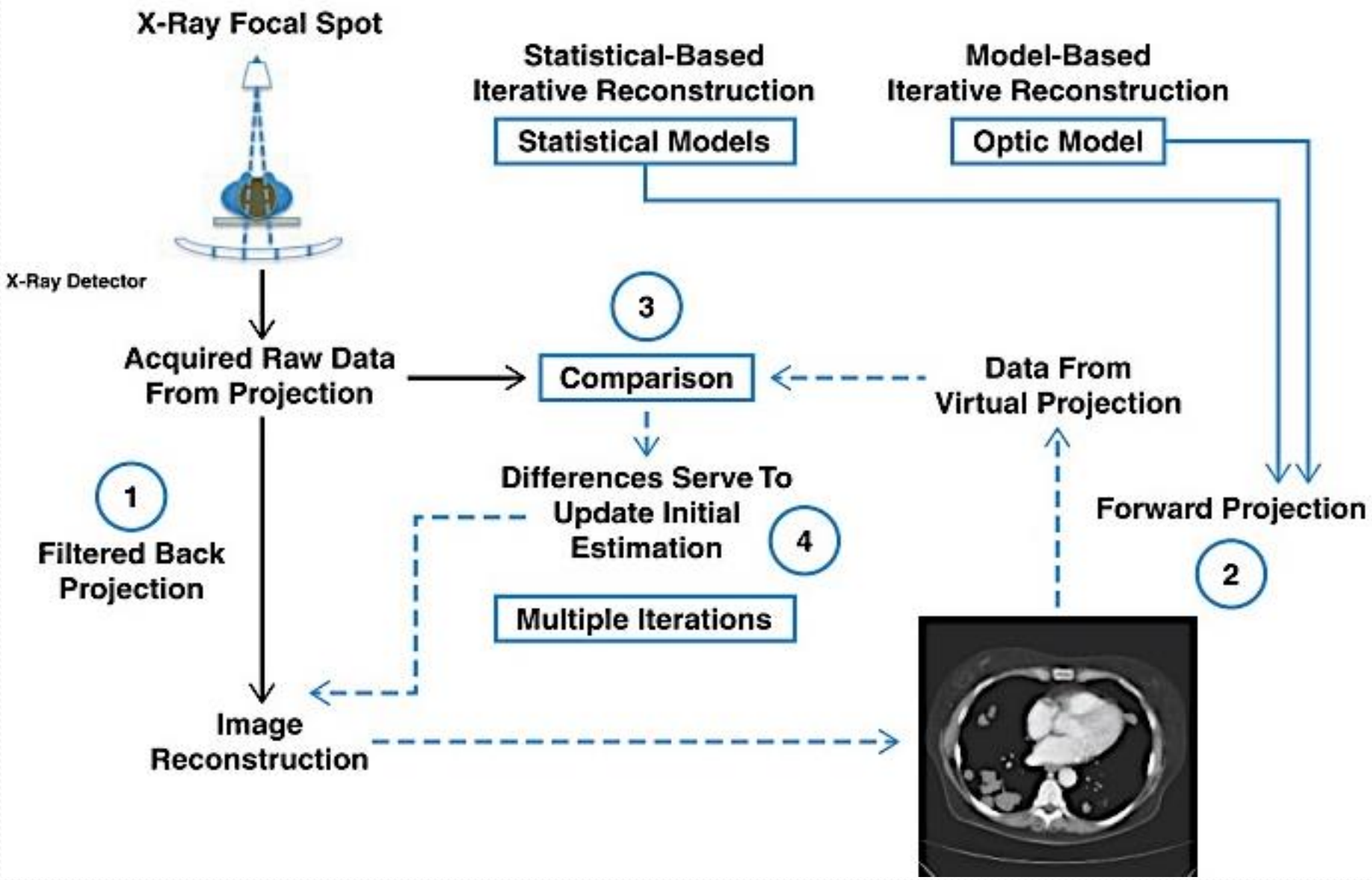
Filtered Back Projection (FBP)





- Image reconstruction using simple backprojection.
- Filtered backprojection (FBP) using different viewing angles.

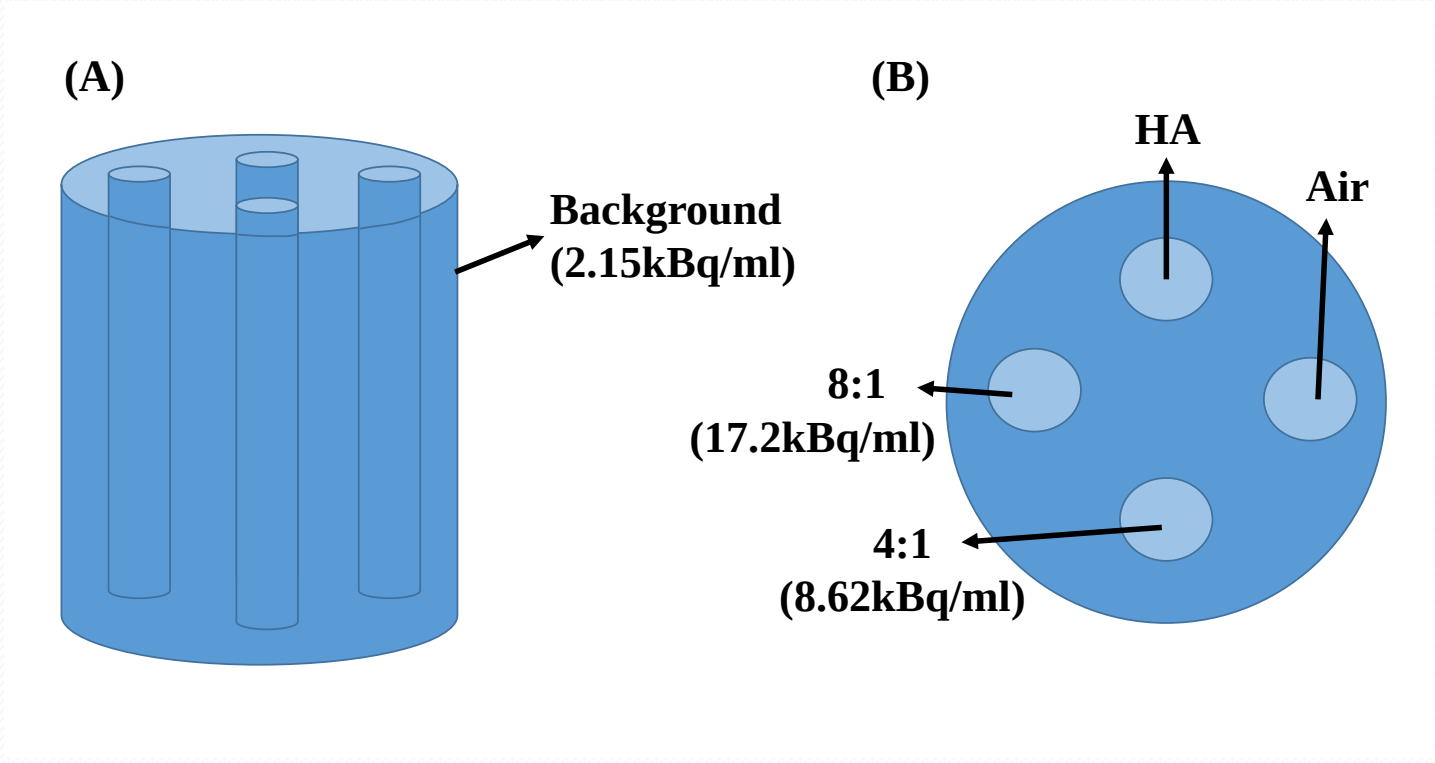
Iterative reconstruction



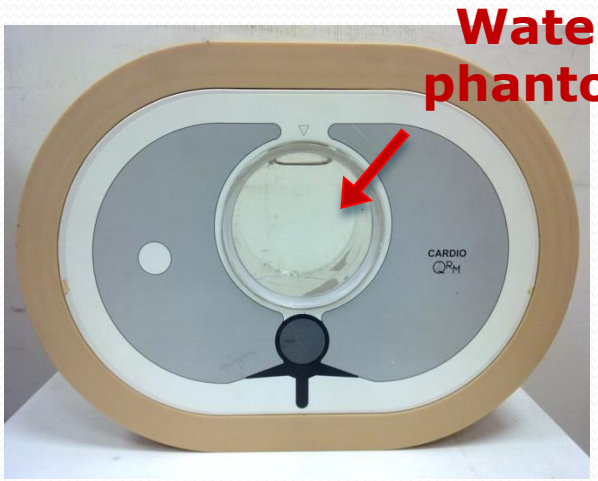
AJR. 2015;205(1): W19-31.

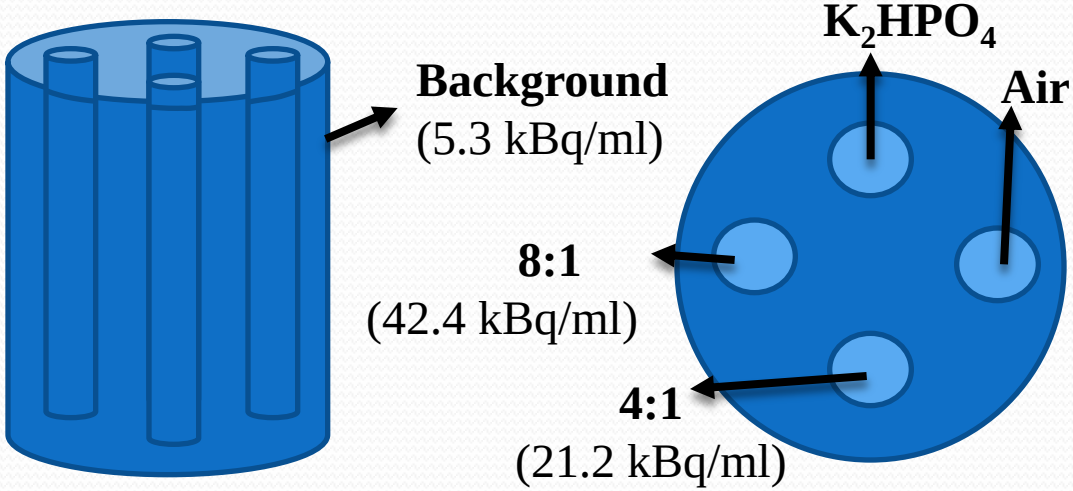
PET/CT影像收集

使用水假體進行影像擷取，背景值(background)為^{18}F-FDG (Fludeoxyglucose)放射性同位素水溶液(圖2A)，水假體內將放置四支試管，分別為：a.空氣、b.鈣化物質(hydroxyapatite, HA; 200mg/cm^3)用來模擬骨頭等效組織、c.與背景質濃度比4:1的放射性同位素水溶液、d.與背景質濃度比8:1的放射性同位素水溶液(圖2B)，目的在於模擬不同組織的密度及不同濃度的hot spot。



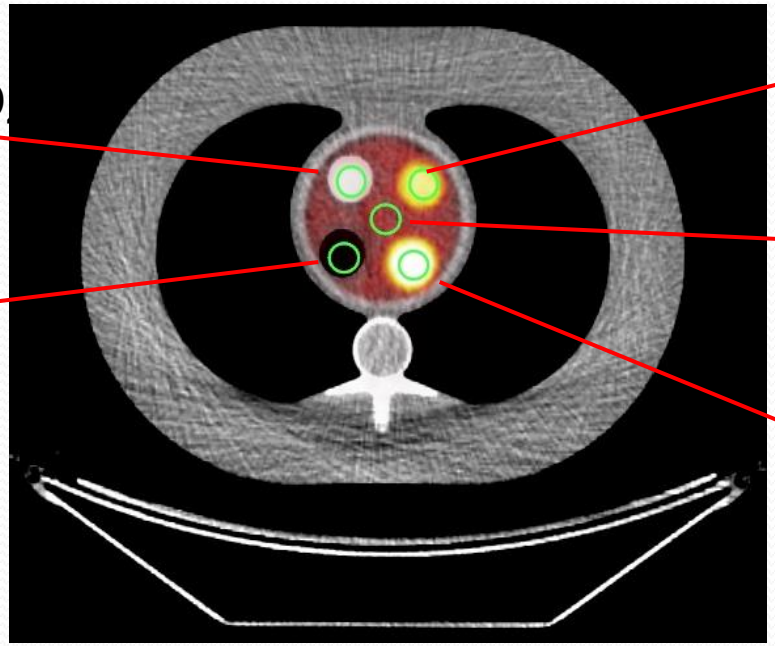
Low-dose CTAC Evaluation

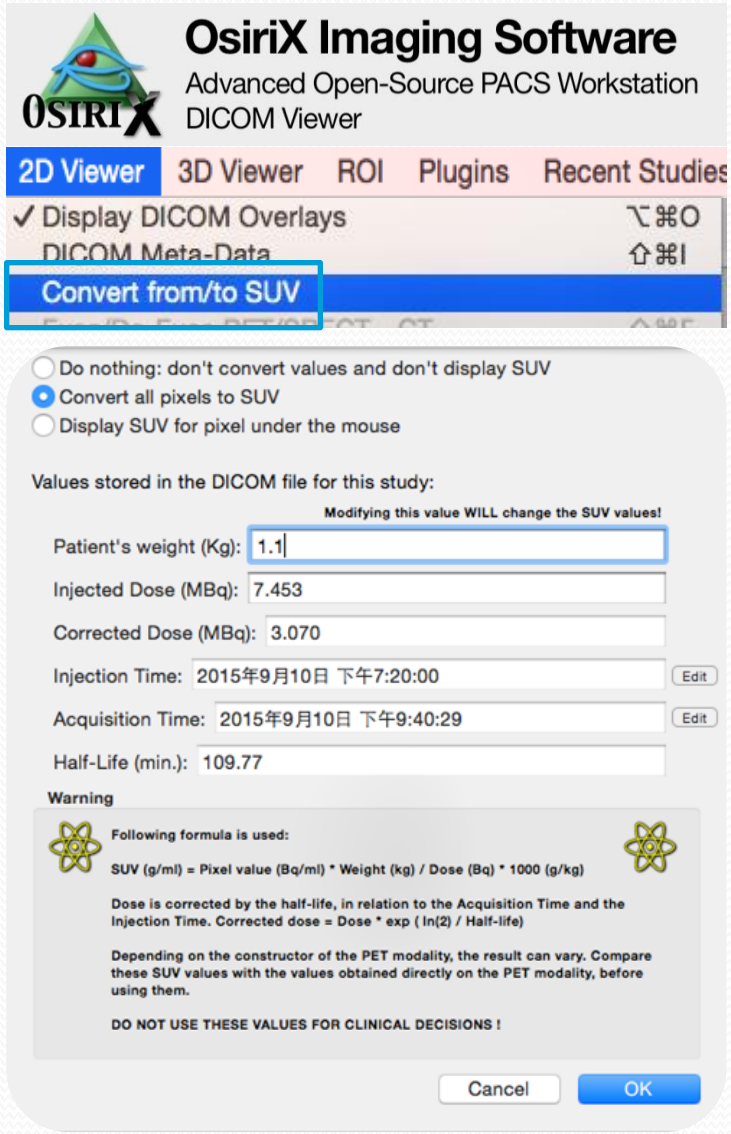




Description	Classification	Parameters
CT	**kVp**	120
	mA	120, 80, 60, 40, 20, 10
	Rotation time (s)	0.5
	Pitch	1.35
	Scan mode	spiral
	Reconstruction	FBP, ASiR 10%, ASiR 30%, ASiR 50%, ASiR 70%, ASiR 90%, ASiR 100%
PET	**Emission time (min)**	10
	Scan mode	3-D mode
	FOV	70

PET Imaging Analysis



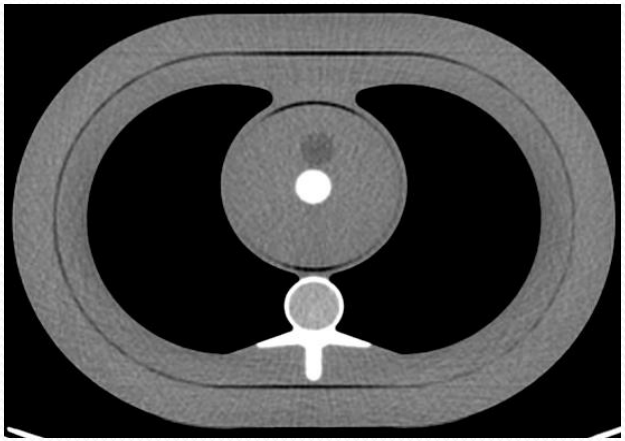


- Standard Uptake Value, SUV

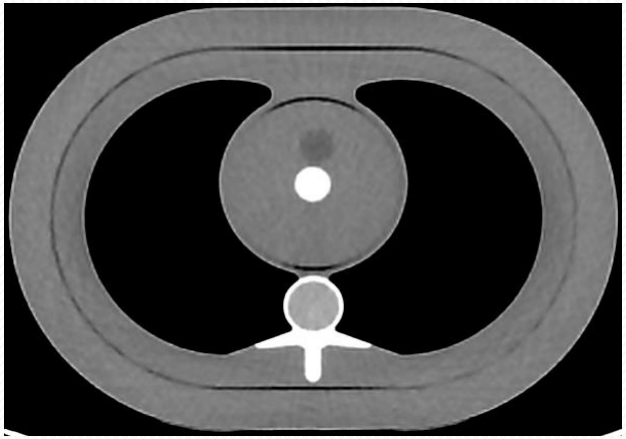
$$\frac{Pixel\,Value\,(\frac{Bq}{ml}) \times Weight(kg)}{Dose(Bq)} \times 1000(\frac{g}{kg})$$

- Statistic analysis：Independent t-test,

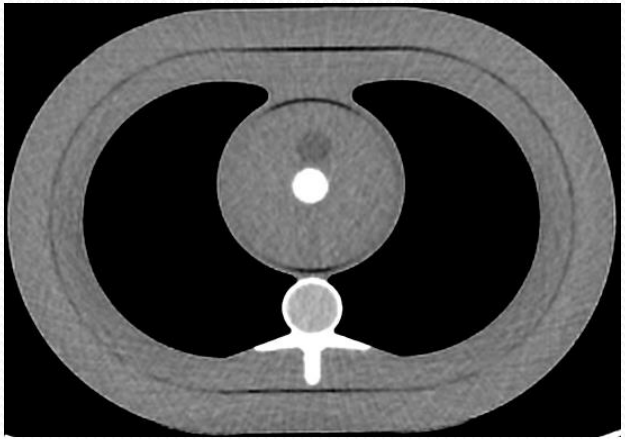
CT images



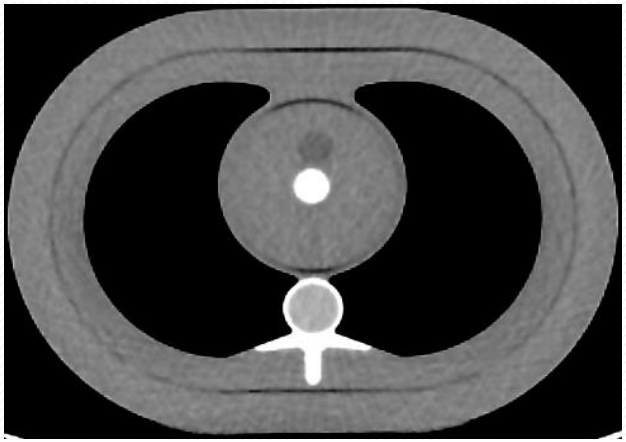
(A) CT $_{\text{FBP(120mA)}}$



(B) CT $_{\text{ASiR100(120mA)}}$



(C) CT $_{\text{ASiR70(40mA)}}$



(D)CT $_{\text{ASiR100(40mA)}}$

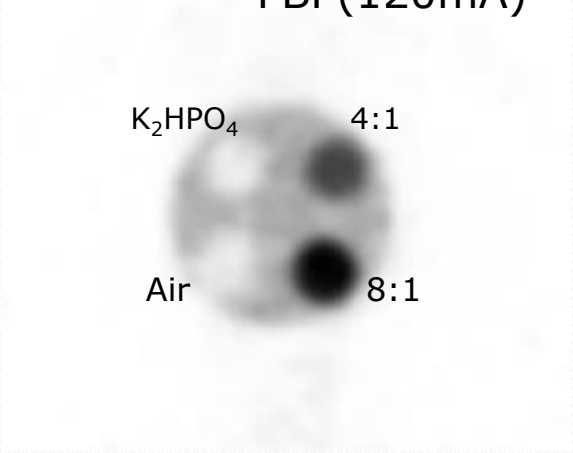
	CT parameter			
kVp	mA	s	Reconstruction methods	
120	10	0.5	FBP ASiR10% ASiR30% ASiR50%	ASiR70% ASiR90% ASiR100%
120	20	0.5	FBP ASiR10% ASiR30% ASiR50%	ASiR70% ASiR90% ASiR100%
120	40	0.5	FBP ASiR10% ASiR30% ASiR50%	ASiR70% ASiR90% ASiR100%
120	60	0.5	FBP ASiR10% ASiR30% ASiR50%	ASiR70% ASiR90% ASiR100%
120	80	0.5	FBP ASiR10% ASiR30% ASiR50%	ASiR70% ASiR90% ASiR100%
120	120	0.5	FBP ASiR10% ASiR30% ASiR50%	ASiR70% ASiR90% ASiR100%

PET parameter	
PET-CTAC	
$PET_{FBP\text{-}10mA}$ $PET_{ASiR10\text{-}10mA}$ $PET_{ASiR30\text{-}10mA}$ $PET_{ASiR50\text{-}10mA}$	$PET_{ASiR70\text{-}10mA}$, $PET_{ASiR90\text{-}10mA}$, $PET_{ASiR100\text{-}10mA}$
$PET_{FBP\text{-}20mA}$, $PET_{ASiR10\text{-}20mA}$ $PET_{ASiR30\text{-}20mA}$ $PET_{ASiR50\text{-}20mA}$	$PET_{ASiR70\text{-}20mA}$, $PET_{ASiR90\text{-}20mA}$, $PET_{ASiR100\text{-}20mA}$
$PET_{FBP\text{-}40mA}$ $PET_{ASiR10\text{-}40mA}$ $PET_{ASiR30\text{-}40mA}$ $PET_{ASiR50\text{-}40mA}$	$PET_{ASiR70\text{-}40mA}$ $PET_{ASiR90\text{-}40mA}$ $PET_{ASiR100\text{-}40mA}$
$PET_{FBP\text{-}60mA}$ $PET_{ASiR10\text{-}60mA}$ $PET_{ASiR30\text{-}60mA}$ $PET_{ASiR50\text{-}60mA}$	$PET_{ASiR70\text{-}60mA}$, $PET_{ASiR90\text{-}60mA}$, $PET_{ASiR100\text{-}60mA}$
$PET_{FBP\text{-}80mA}$ $PET_{ASiR10\text{-}80mA}$ $PET_{ASiR30\text{-}80mA}$ $PET_{ASiR50\text{-}80mA}$	$PET_{ASiR70\text{-}80mA}$ $PET_{ASiR90\text{-}80mA}$ $PET_{ASiR100\text{-}80mA}$
$PET_{FBP\text{-}120mA}$, $PET_{ASiR10\text{-}120mA}$ $PET_{ASiR30\text{-}120mA}$ $PET_{ASiR50\text{-}120mA}$	$PET_{ASiR70\text{-}120mA}$, $PET_{ASiR90\text{-}120mA}$ $PET_{ASiR100\text{-}120mA}$

結果與討論

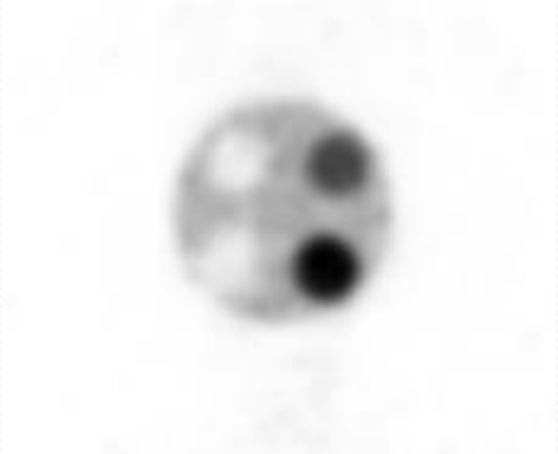
Result (PET SUV)

$PET_{FBP(120mA)}$

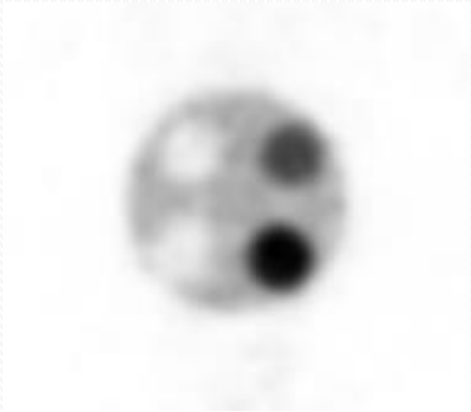


$PET_{FBP(80mA)}$

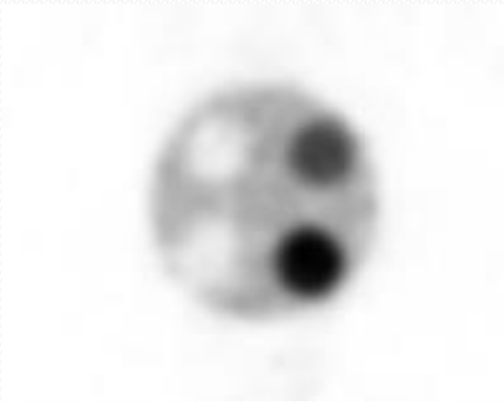
$PET_{FBP(60mA)}$



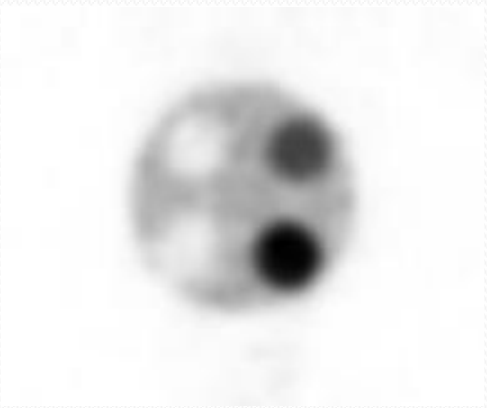
$PET_{FBP(40mA)}$



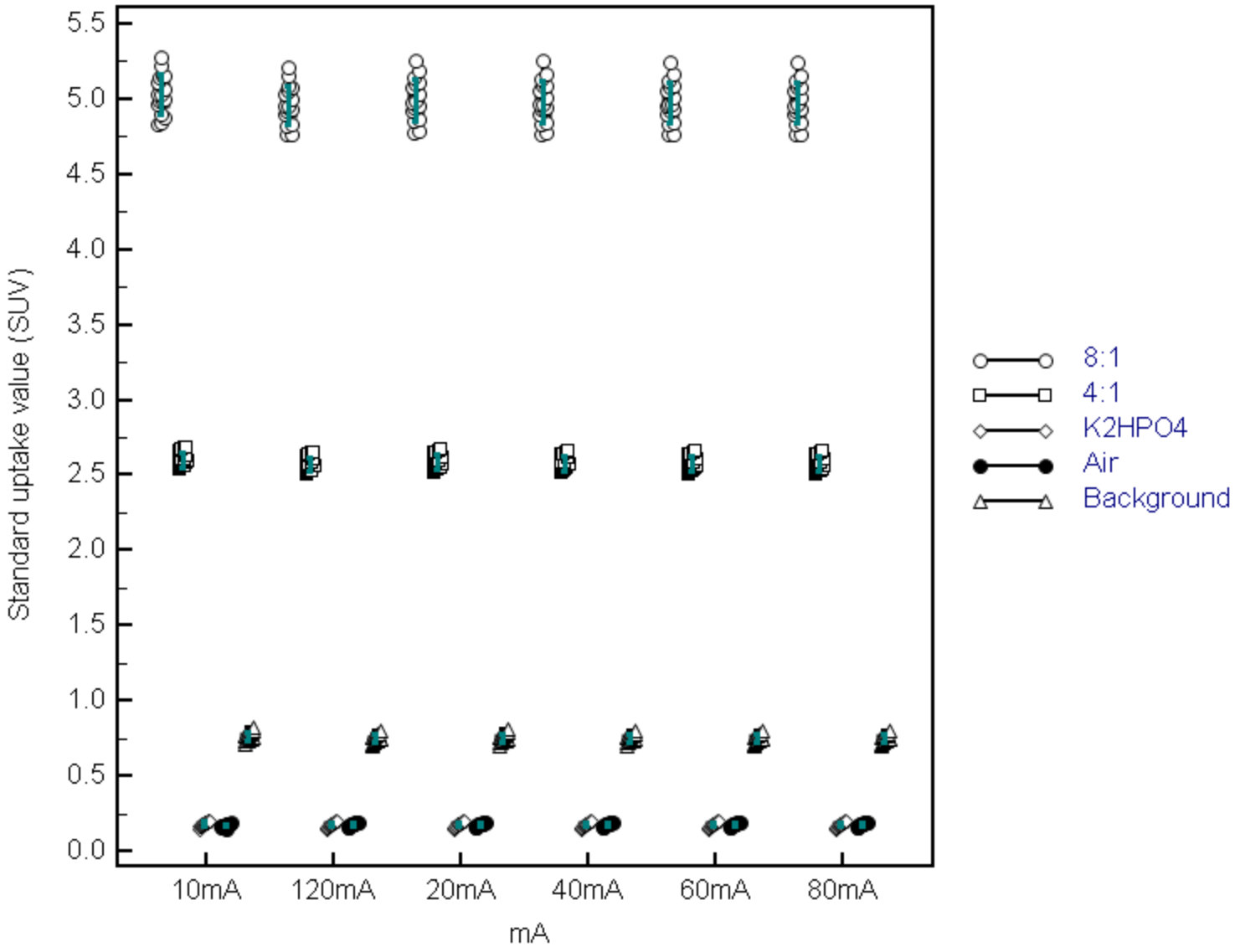
$PET_{FBP(20mA)}$



$PET_{FBP(10mA)}$



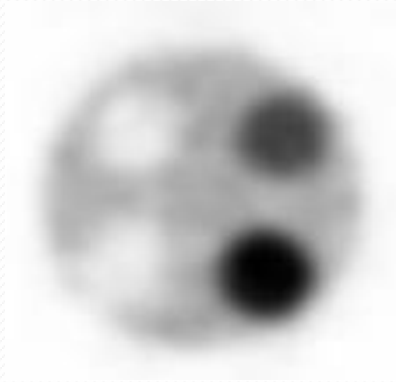
SUV	8:1		4:1		K_2HPO_4		Air		Background	
PET Classification	Mean±SD	R^2	Mean±SD	R^2	Mean±SD	R^2	Mean±SD	R^2	Mean±SD	R^2
FBP(120mA)	4.96±0.69	1	2.57±0.32	1	0.18±0.06	1	0.18±0.06	1	0.75±0.05	1
FBP(80mA)	4.97±0.69	0.998	2.58±0.33	0.995	0.18±0.06	1	0.18±0.06	1	0.75±0.05	0.987
FBP(60mA)	4.98±0.69	0.997	2.58±0.33	0.991	0.18±0.06	1	0.18±0.06	1	0.75±0.05	0.991
FBP(40mA)	4.98±0.69	0.998	2.57±0.33	0.989	0.18±0.06	1	0.18±0.06	0.972	0.75±0.05	0.985
FBP(20mA)	4.99±0.69	0.998	2.59±0.33	0.995	0.18±0.06	0.985	0.18±0.06	0.947	0.75±0.05	0.985
FBP(10mA)	5.03±0.70	0.999	2.6±0.33	0.997	0.18±0.06	0.935	0.17±0.06	0.871	0.76±0.05	0.982


Standard uptake value (SUV)
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
10mA
120mA
20mA
40mA
60mA
80mA
mA
8:1
4:1
K2HPO4
Air
Background

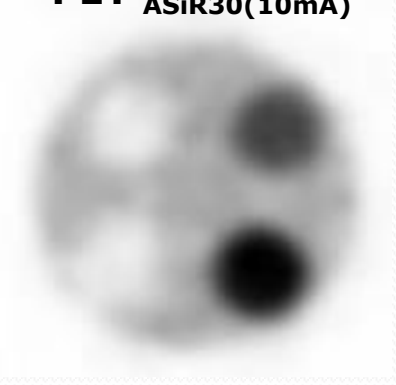
FBP VS OSEM

PET FBP(10mA)

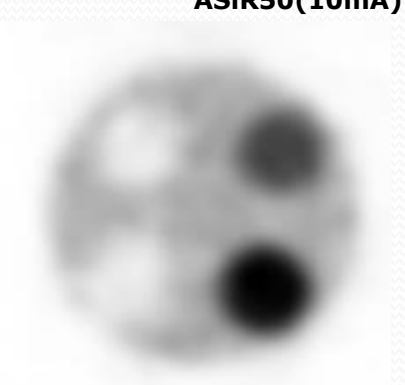
PET ASiR10(10mA)



PET ASiR30(10mA)

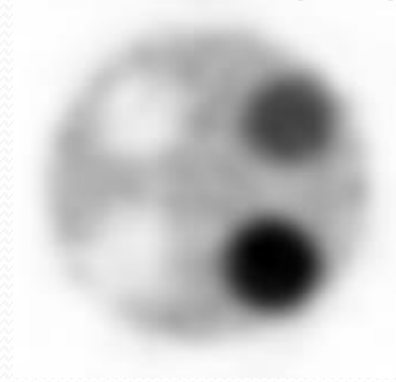


PET ASiR50(10mA)

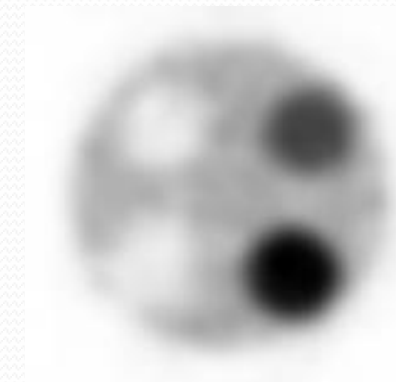


PET ASiR70(10mA)

PET ASiR90(10mA)

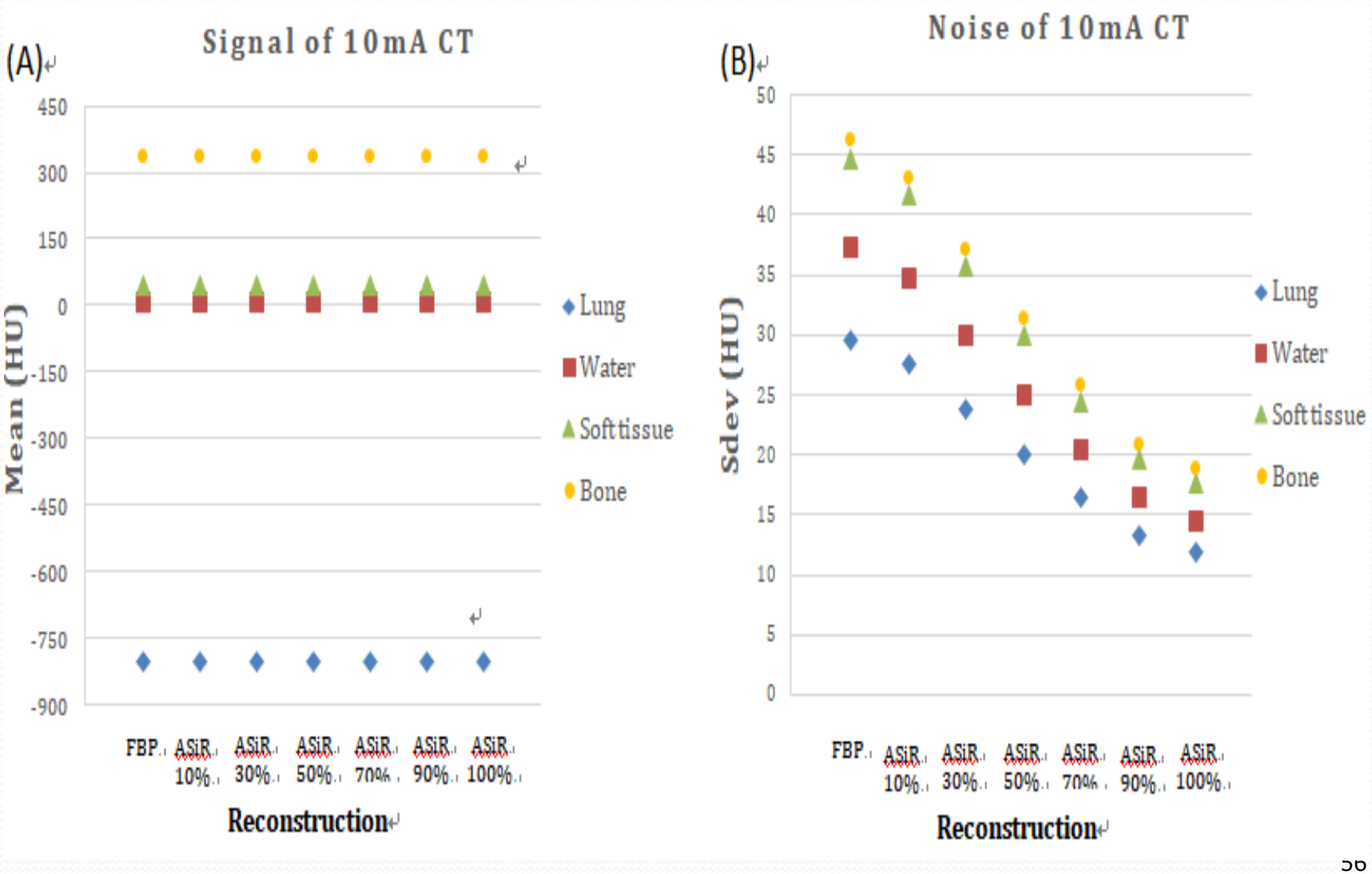


PET ASiR100(10mA)



SUV	8:1		4:1		K_2HPO_4		Air		Background	
PET Classification	Mean±SD	R^2	Mean±SD	R^2	Mean±SD	R^2	Mean±SD	R^2	Mean±SD	R^2
FBP(10mA)	5.03±0.70	1	2.60±0.33	1	0.18±0.06	1	0.17±0.06	1	0.76±0.05	1
ASiR10 (10mA)	5.03±0.70	1	2.60±0.33	1	0.18±0.06	1	0.17±0.06	1	0.76±0.05	1
ASiR30 (10mA)	5.03±0.70	1	2.60±0.33	0.999	0.18±0.06	1	0.17±0.06	0.966	0.76±0.05	1
ASiR50 (10mA)	5.03±0.70	0.999	2.60±0.33	0.999	0.18±0.06	1	0.17±0.06	0.966	0.76±0.05	1
ASiR70 (10mA)	5.03±0.70	0.999	2.60±0.33	0.998	0.18±0.06	0.984	0.17±0.06	0.966	0.76±0.05	1
ASiR90 (10mA)	5.03±0.70	0.999	2.60±0.33	0.998	0.18±0.06	0.984	0.17±0.06	0.966	0.76±0.05	1
ASiR100 (10mA)	5.03±0.70	0.999	2.60±0.33	0.997	0.18±0.06	0.984	0.17±0.06	0.913	0.76±0.05	1

FBP VS OSEM


(A)
Signal of 10mA CT
Mean (HU)
450
300
150
0
-150
-300
-450
-600
-750
-900
FBP
ASiR 10%
ASiR 30%
ASiR 50%
ASiR 70%
ASiR 90%
ASiR 100%
Reconstruction
Lung
Water
Soft tissue
Bone
(B)
Noise of 10mA CT
Sdev (HU)
50
45
40
35
30
25
20
15
10
5
0
FBP
ASiR 10%
ASiR 30%
ASiR 50%
ASiR 70%
ASiR 90%
ASiR 100%
Reconstruction
Lung
Water
Soft tissue
Bone

Radiation Dose Concerns

- From Image Wisely (web of ACR and RSNA)

Typical acquisition techniques used for whole-body FDG-PET-CT imaging

Study	Injected Activity	Effective Dose Estimate
PET[5, 7]	[5-15] mCi ^{18}F-FDG Injected (185-555 MBq)	3.5-10.5 mSv
CT for diagnostic purposes[8]	[110-200] mAs[1] CTDIvol = [8-14] mGy	11-20 mSv
CT for anatomic localization[8]	[30-60] mAs[3] CTDIvol = [2-4] mGy	3-6 mSv
CT for attenuation correction only[8]	[5-10] mAs[4] CTDIvol = [0.3-1.0] mGy	0.5-1.0 mSv

For ease of comparison, all CT studies presented are performed with 120 kVp, pitch 1.375, 40 mm collimation, 900 mm scan range, average tube current-time product.

PET Diagnostic Accuracy: Improvement with In-Line PET-CT System: Initial Results

TABLE 1
Differentiation of Classified Lesions

Classification	PET Alone	PET–10-mA CT	PET–40-mA CT	PET–80-mA CT	PET–120-mA CT
Tumor	137	135	135	137	137
Inflammation	40	50	56	55	55
Other lesion	44	54	57	59	59
Total (n = 287)	221 (77)	239 (83)	248 (86)	251 (87)	251 (87)

Note.—Numbers in parentheses are percentages.

TABLE 2
Analysis of Lesions Classified as Tumors

Lesion	PET Alone	PET–10-mA CT	PET–40-mA CT	PET–80-mA CT	PET–120-mA CT
Tumor	137	135	135	137	137
TP	123	133	133	135	135
FP	6	1	1	1	1
FN	8	1	1	1	1

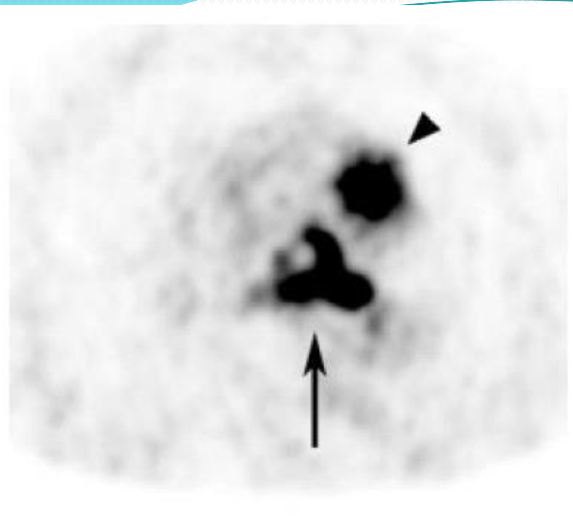
Radiology 2002; 225:575–581

TABLE 3
Analysis of Lesions Classified as Tumors Compared with Standard of Reference

Result	PET Alone	PET–10-mA CT	PET–40-mA CT	PET–80-mA CT	PET–120-mA CT
TP	123	133	133	135	135
TN	84	109	112	115	115
FP	6	1	1	1	1
FN	13	5	5	3	3
Undecided	61 (21)	39 (14)	36 (13)	33 (12)	33 (12)
Sensitivity (%)	90	96	96	98	98
Specificity (%)	93	99	99	99	99
Accuracy (%)	91	97	97	98	98
Significance of differences*					
Between PET-CT and PET alone		<.01	<.05	<.05	<.05
Between PET-CT techniques		NS	NS	NS	NS

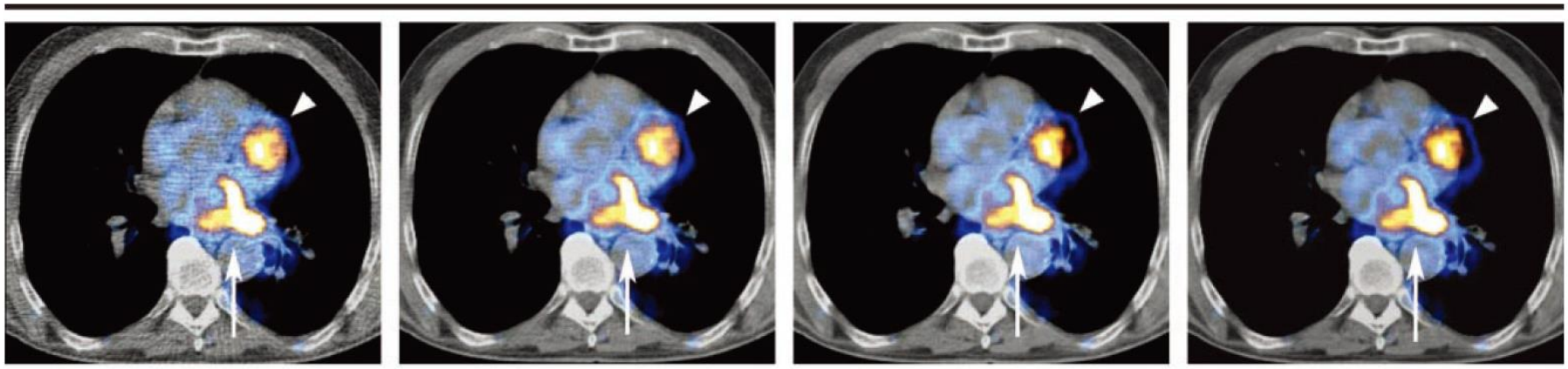
Note.—Numbers in parentheses are percentages of 287 lesions.
* McNemar test (χ^2), step-by-step analysis. NS = not significant.

Radiology 2002; 225:575–581



a.

Left-sided intrapulmonary mass (sarcomatoid tumor) in a 76-year-old male patient. **(a) Transverse FDG PET image** shows pathologic uptake of FDG (arrow in a–e) in the infracarinal region and physiologic uptake of FDG (arrowhead in a–e) in the heart**. (b) Transverse PET–10-mA CT scan** at the same level as a shows the tumor to be in the left atrium. **(c) PET–40-mA CT, (d) PET–80-mA CT, and (e) PET–120-mA CT** images at the same level as a and b do not give additional information.



b. c. d. e.

Radiology 2002; 225:575–581

結語

- 透過上述的分析結果，可以得知低劑量CT造影條件對CT、PET、SPECT影像品質造成的影響並不是很大，甚至在低劑量影像之間是幾乎沒有影響；適當運用IR影像重建法可以有效改善低劑量影像之雜訊，提高影像品質，證明低劑量CT在核醫影像檢查具有臨床診斷價值，進一步達到降低病人醫療輻射曝露累積劑量的效果。

Imaging Artifacts from CTAC

Imaging Artifacts from CT

1. Metal Artifacts

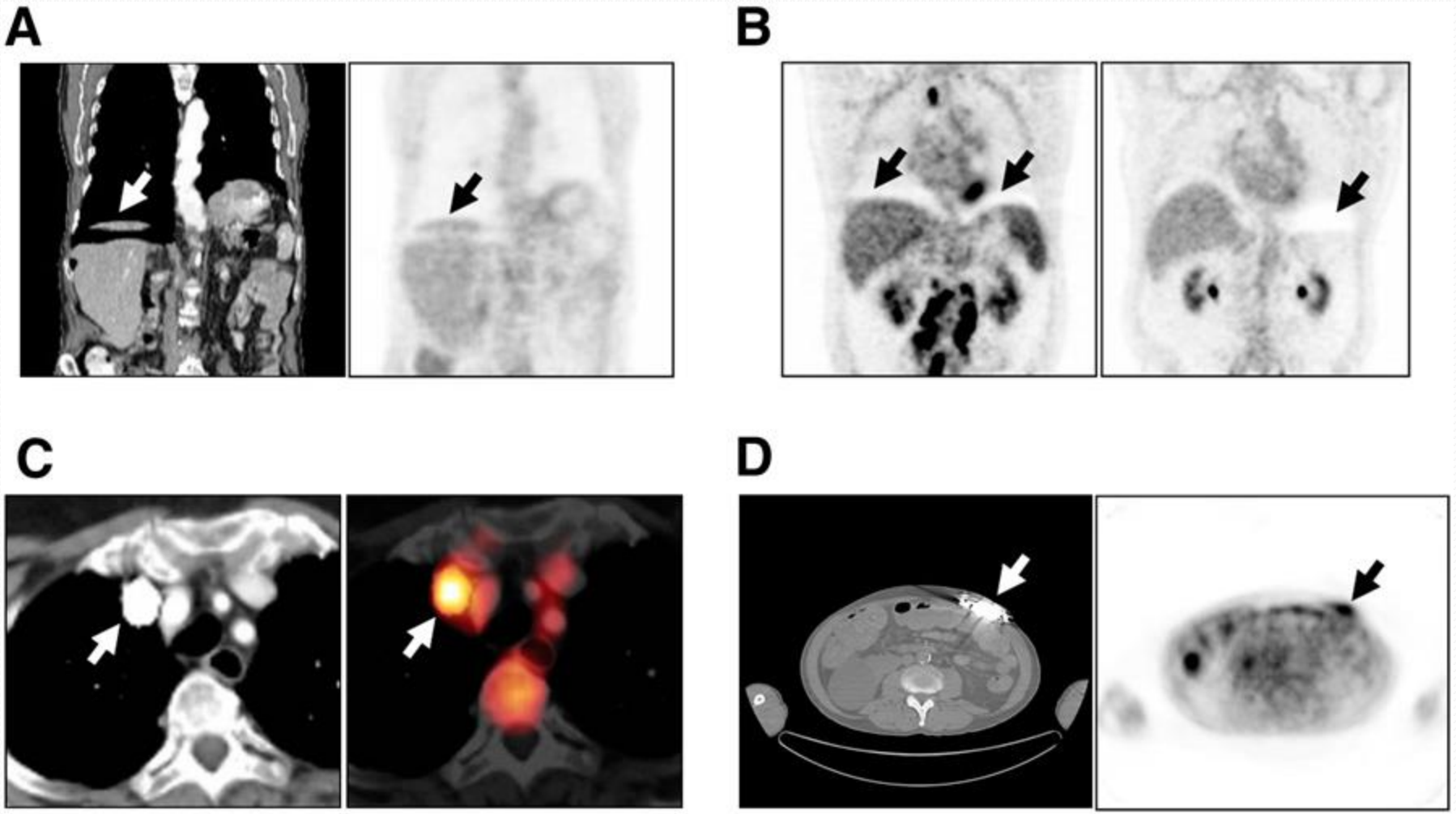
假牙、金屬關節、對比劑、鋇劑、ECG墊片、人工血管等等

2.Motion Artifacts

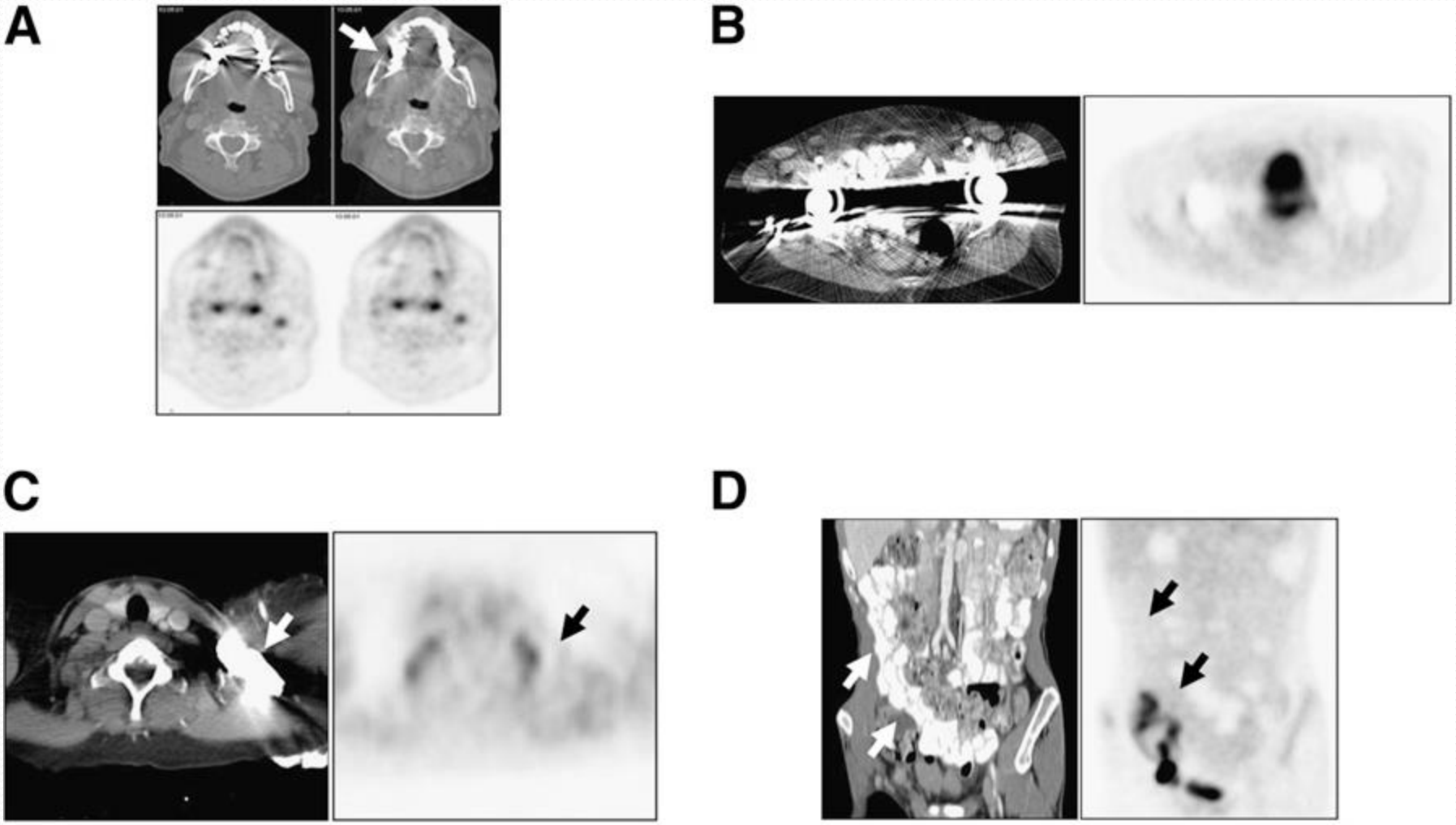
呼吸移動、躁動

衣服有亮片（CT）

Potential image artifacts generated from CT-AC

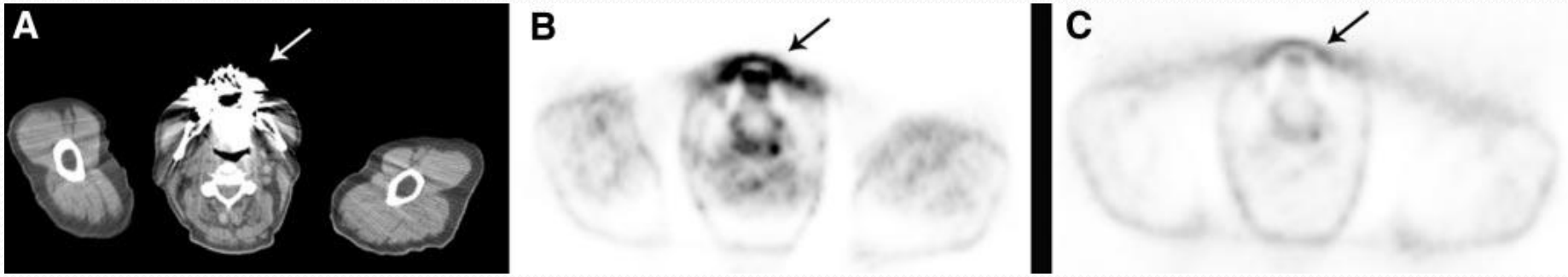


J Nucl Med 2008; 49:938–955



J Nucl Med 2008; 49:938–955

Metal Artifacts

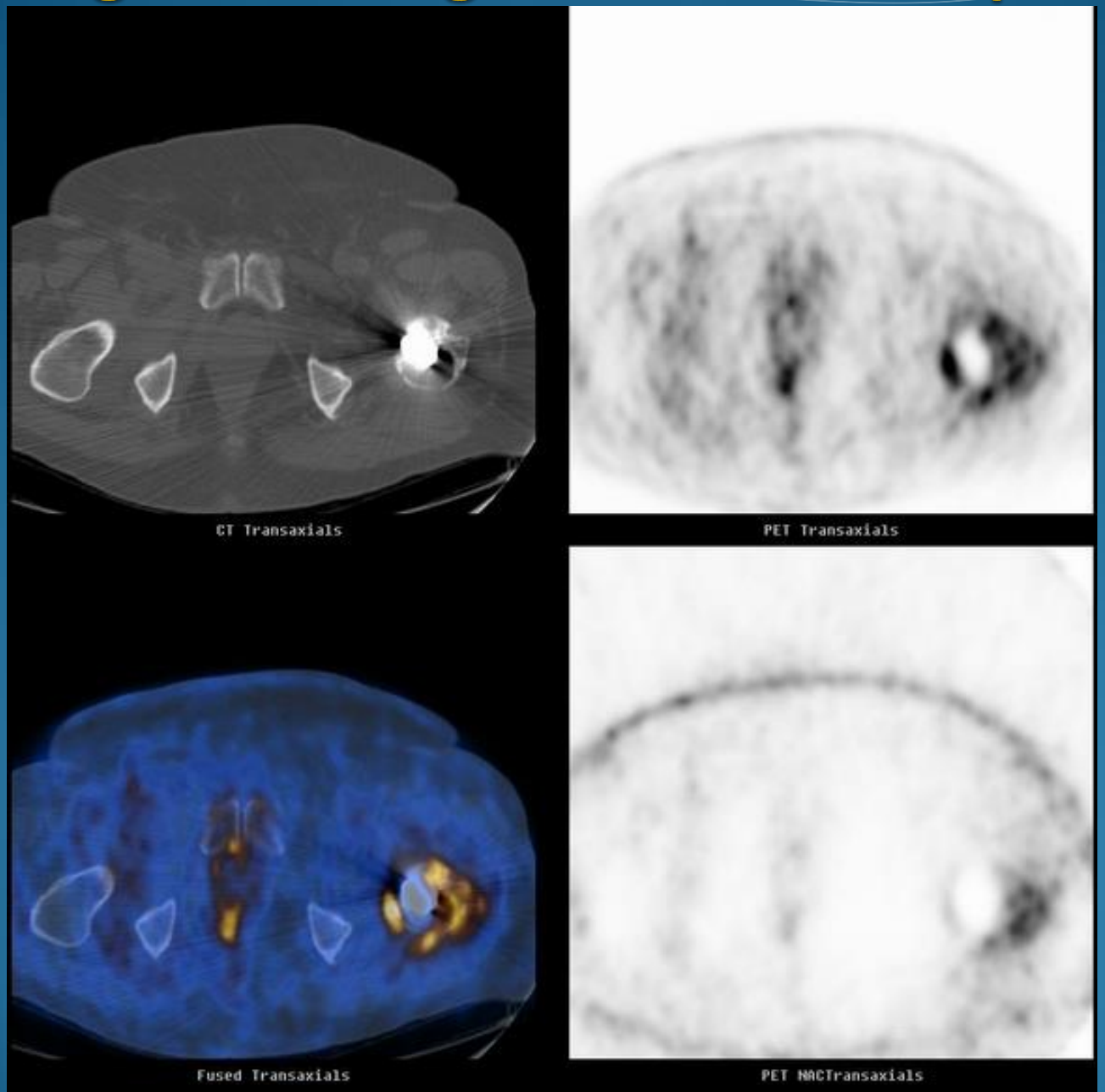


A:嘴巴有金屬而形成CT streaking artifacts
B:PET 影像因AC 的過度補償而形成嘴巴的uptake增高
C:PET 影像無AC 的影像

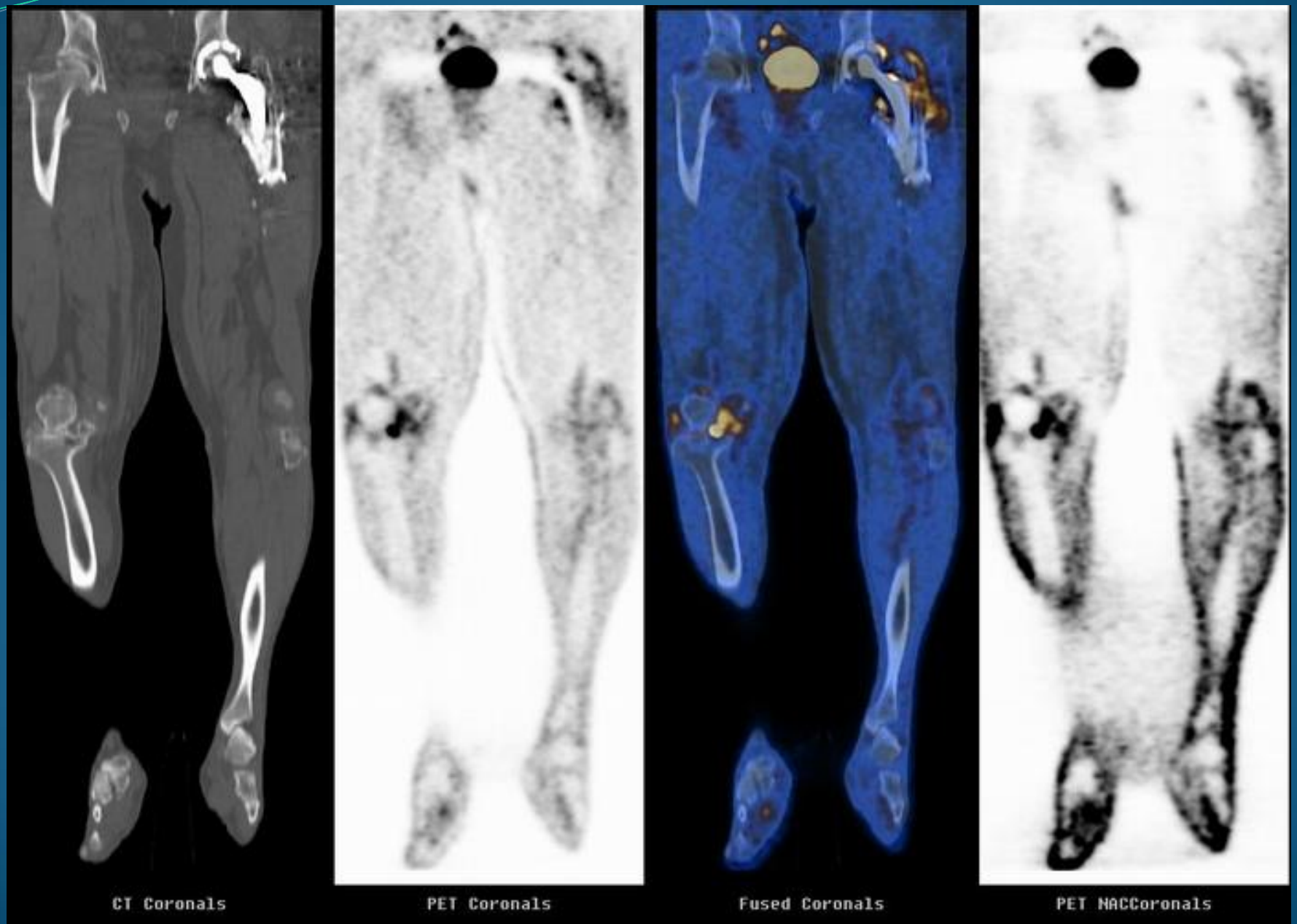
(*J Nucl Med Technol 2005; 33:156-161*)

Hip Prosthesis

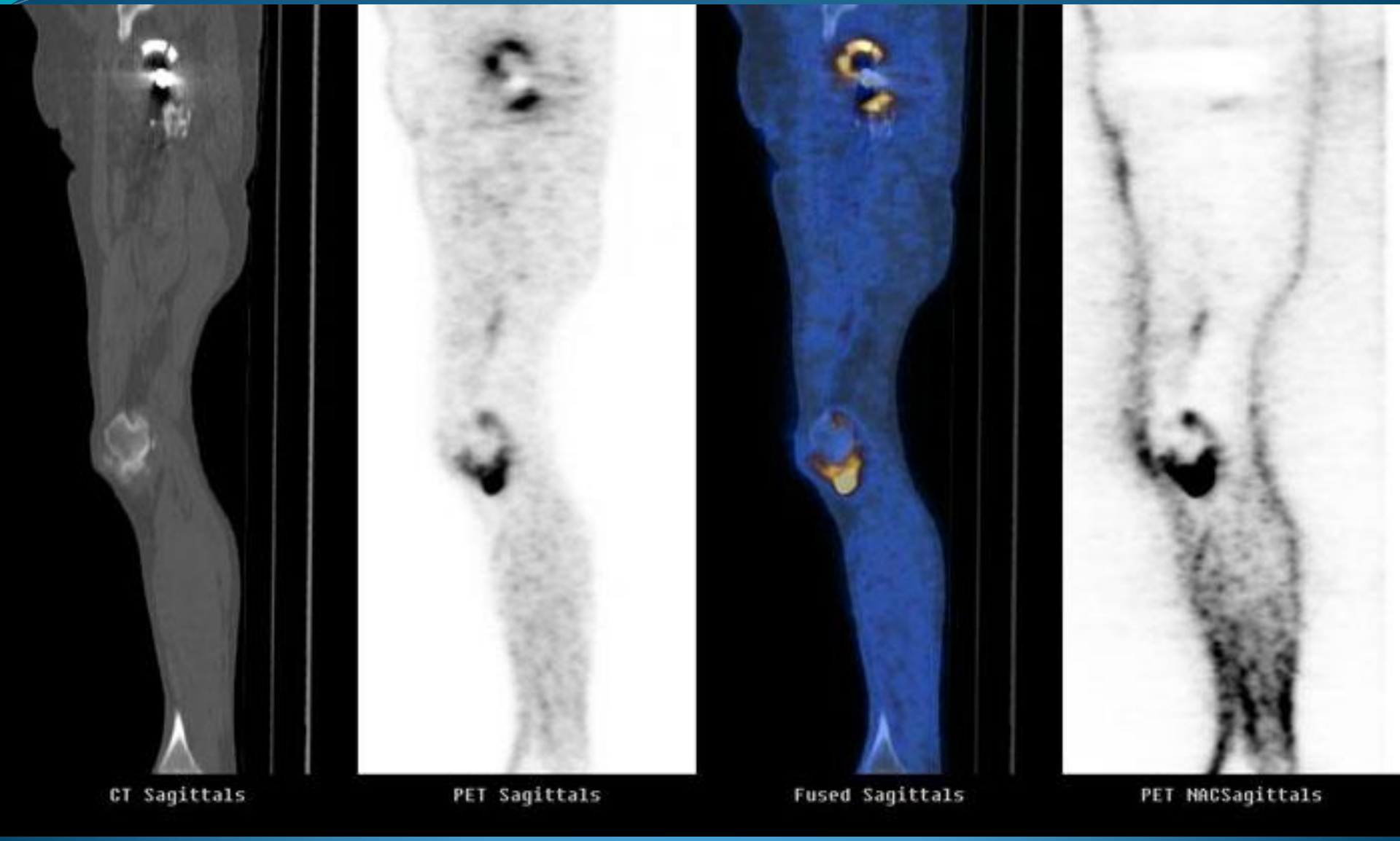
Benign Pathological Variants: Hip Prosthesis



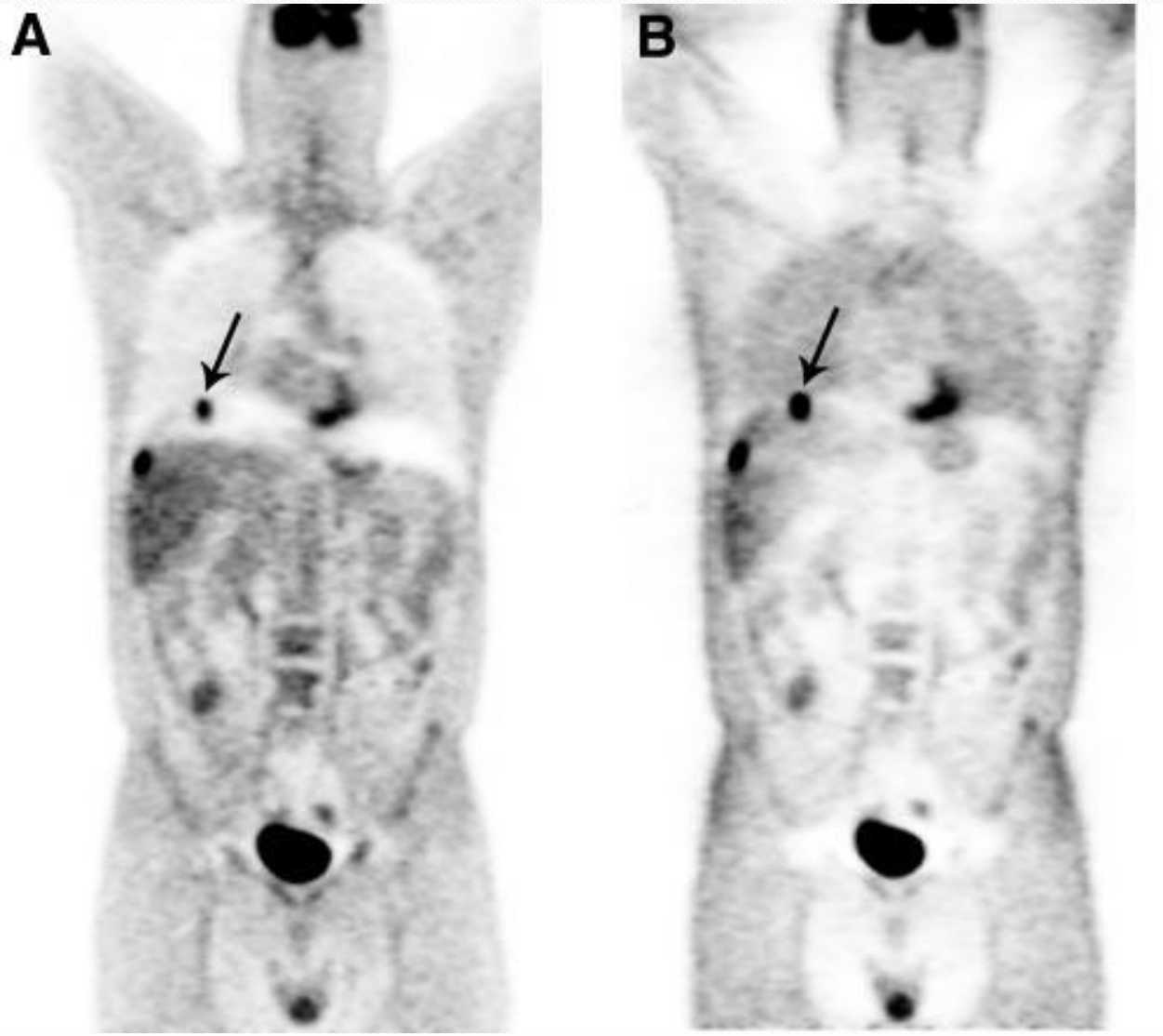
Benign Pathological Variants: Hip Prosthesis



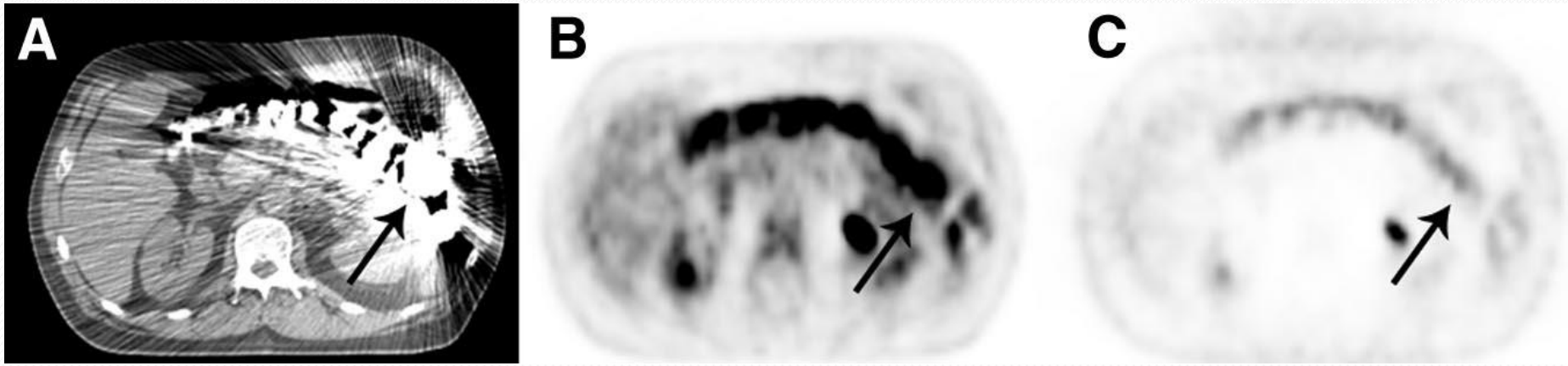
Benign Pathological Variants: Hip Prosthesis



Motion

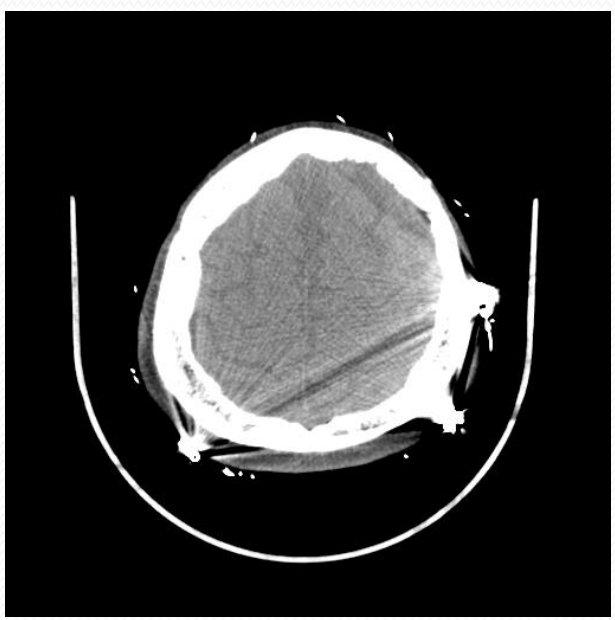


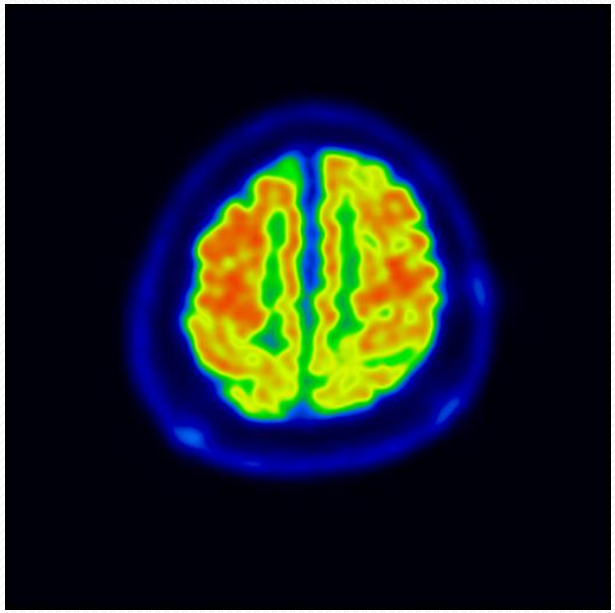
Barium

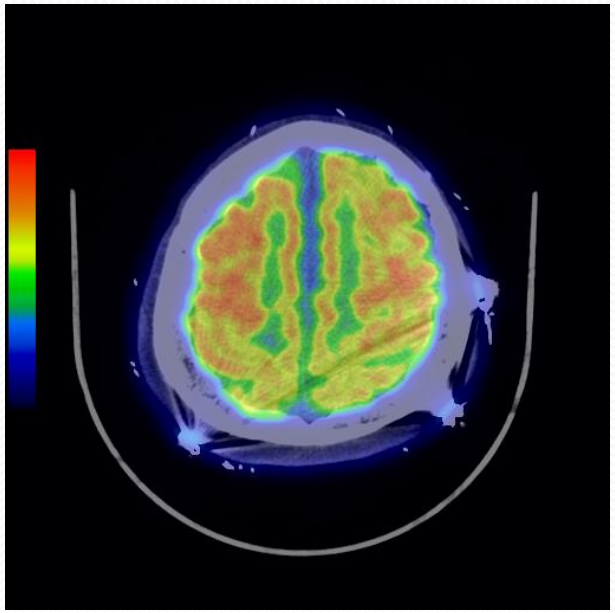


A 檢查前一天有做鋇劑腸胃造影
B:PET影像 高AC 的補償
C:PET 影像 No AC的補償

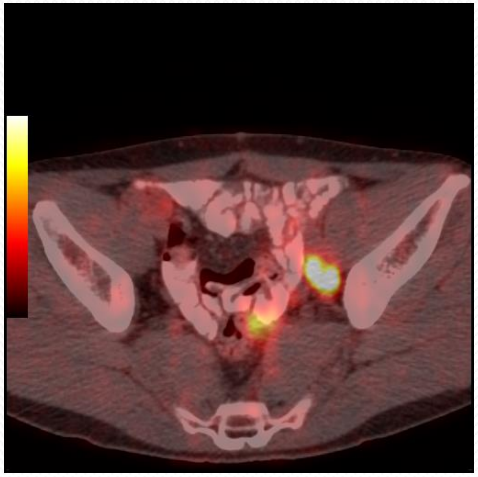
Epilepsy

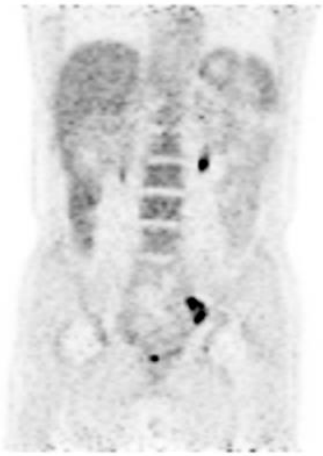


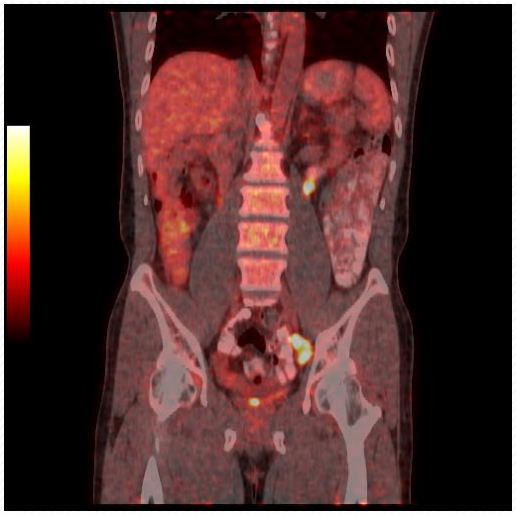


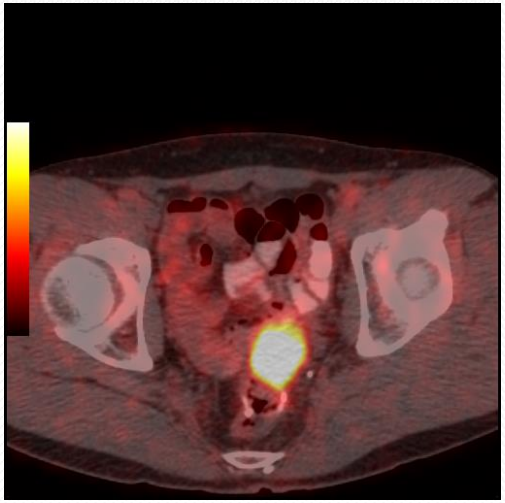


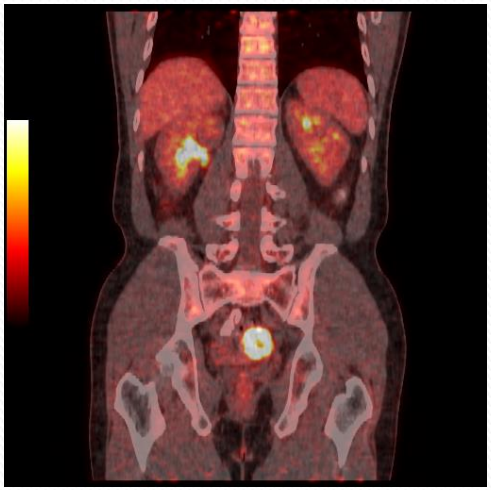
Oral CM



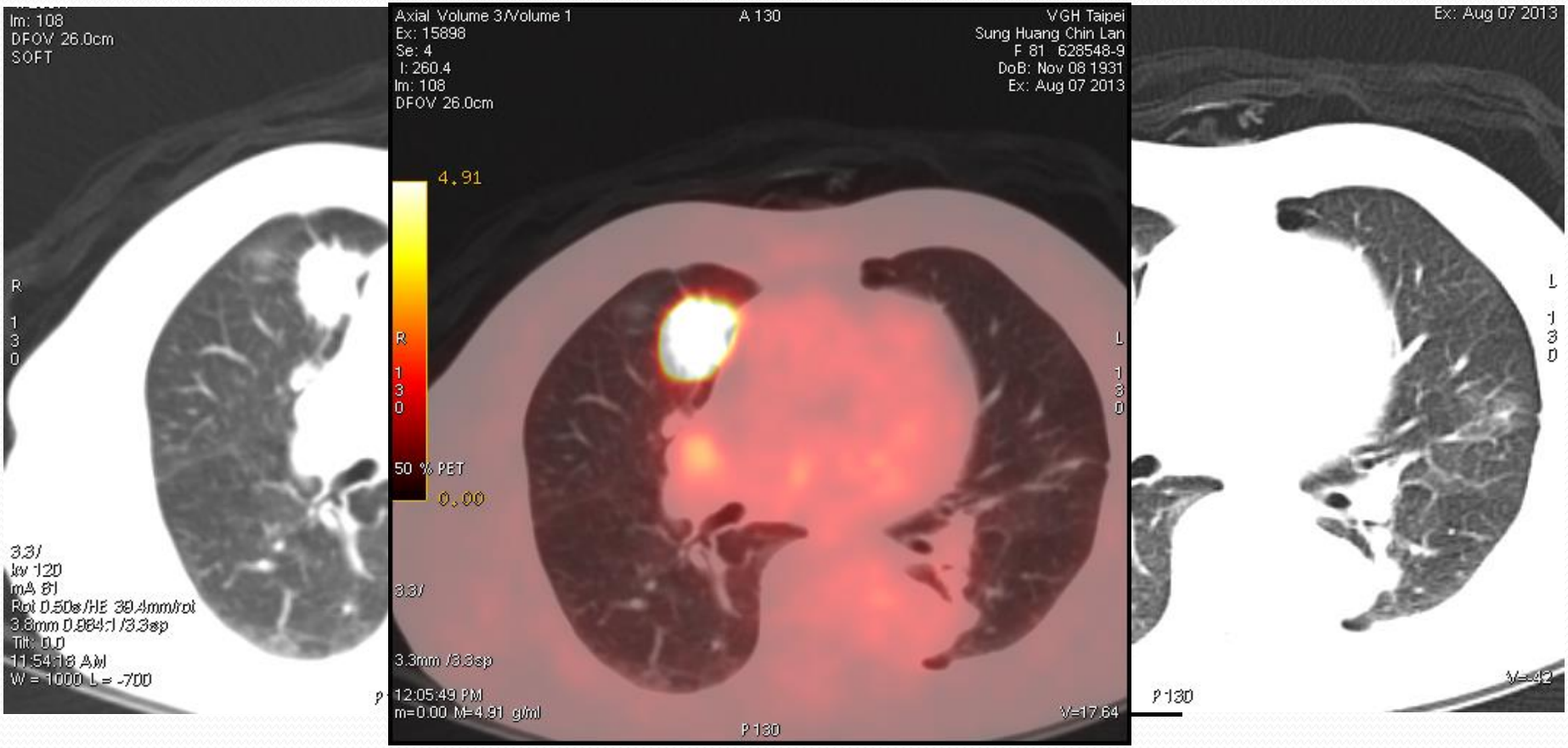


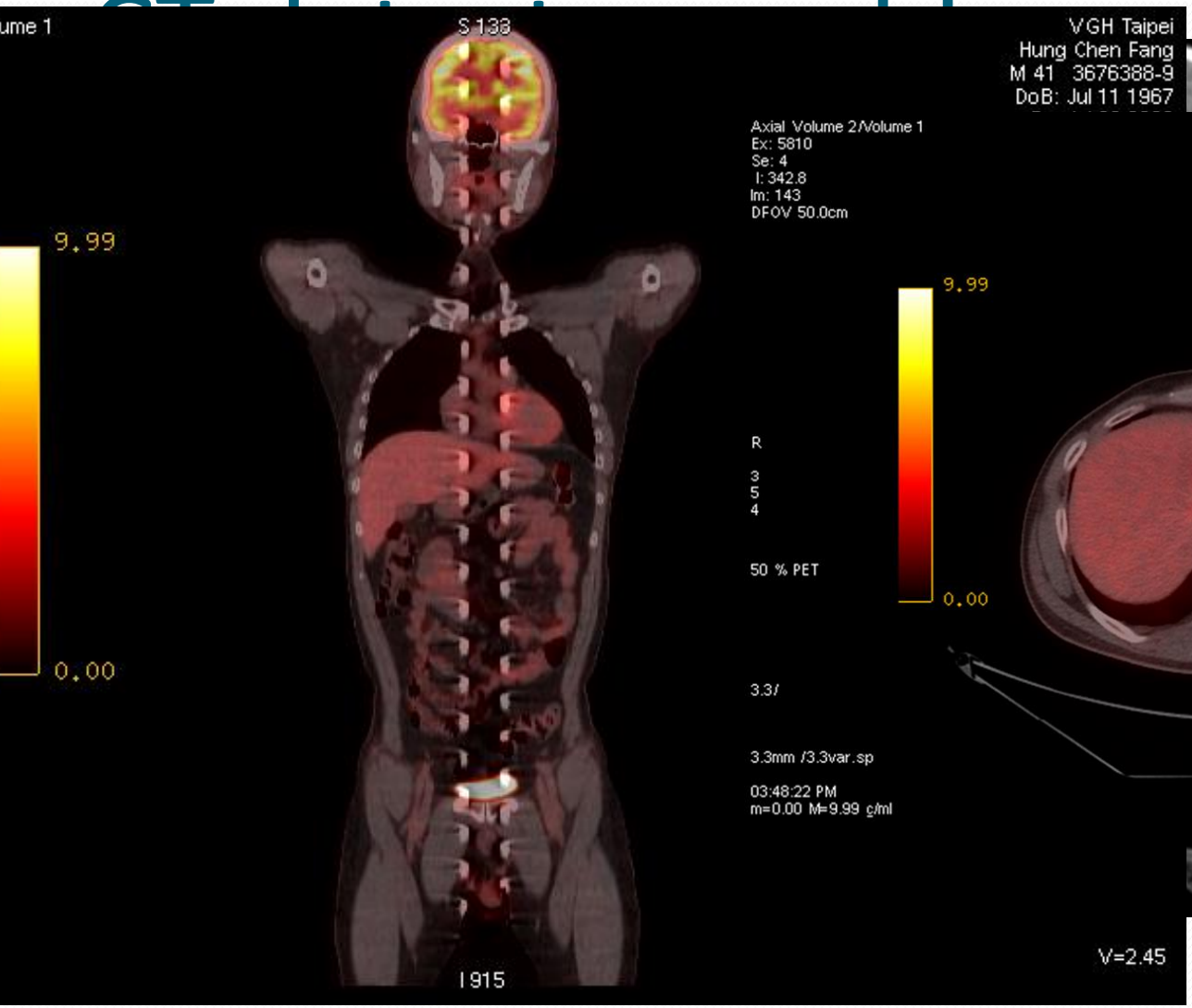






What's different?

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S 138
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0.00
I 915
VGH Taipei
Hung Chen Fang
M 41 3676388-9
DoB: Jul 11 1967
Axial Volume 2/Volume 1
Ex: 5810
Se: 4
I: 342.8
Im: 143
DFOV 50.0cm
R
3
5
4
50 % PET
3.3/
3.3mm /3.3var.sp
03:48:22 PM
m=0.00 M=9.99 g/ml
9.99
0.00
V=2.45


A 250
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L
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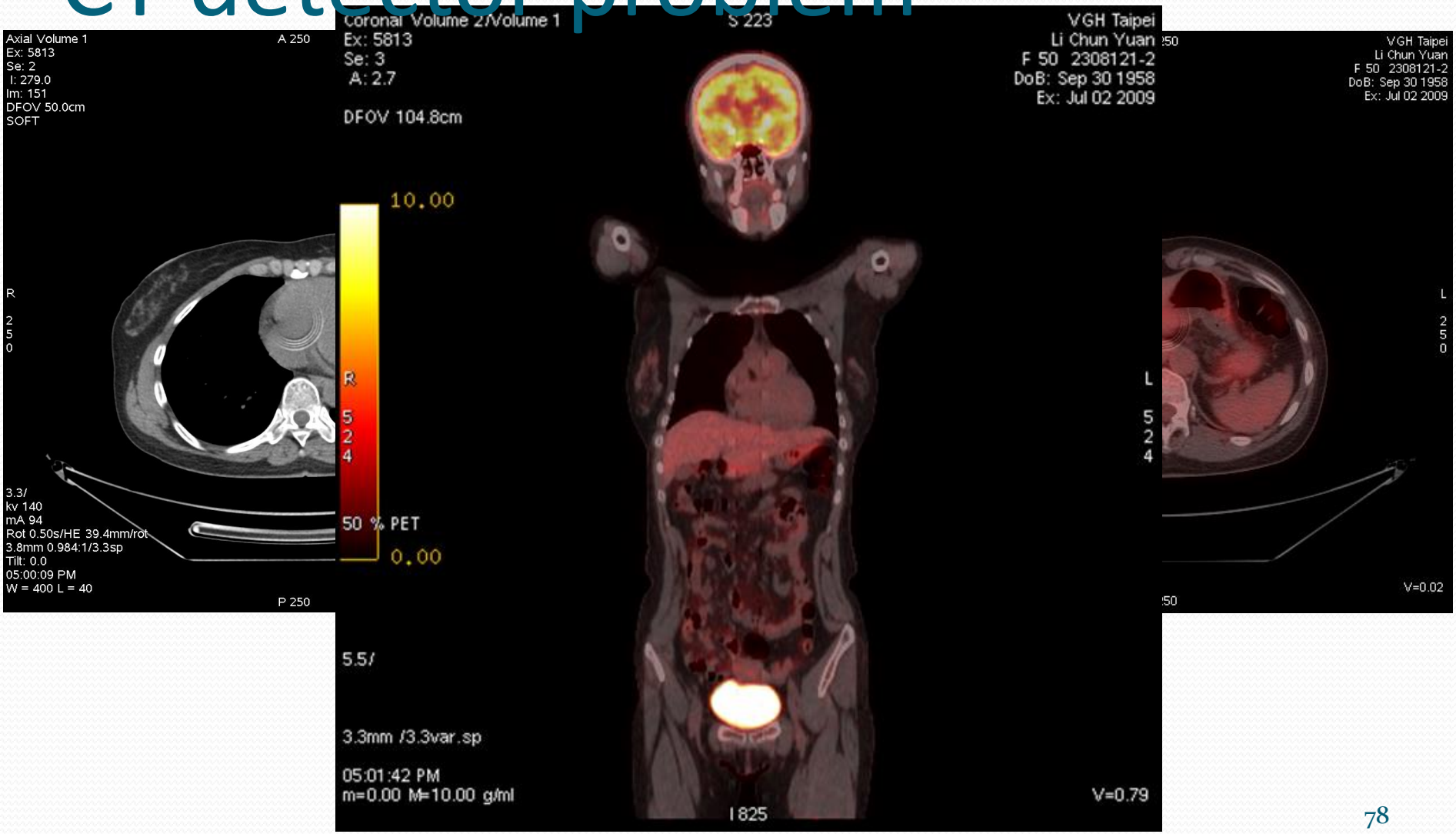
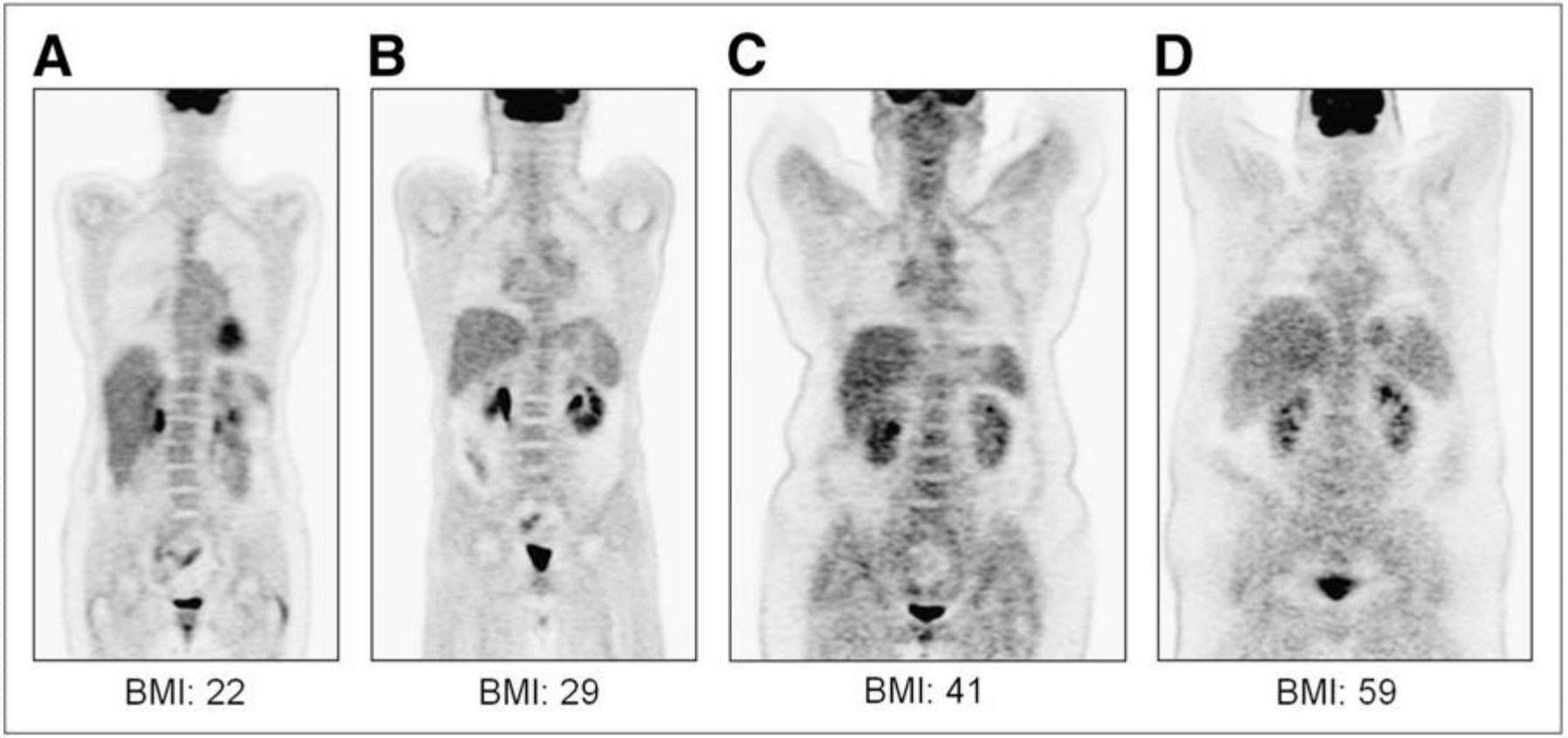
V=2.45
P 250

CT detector problem

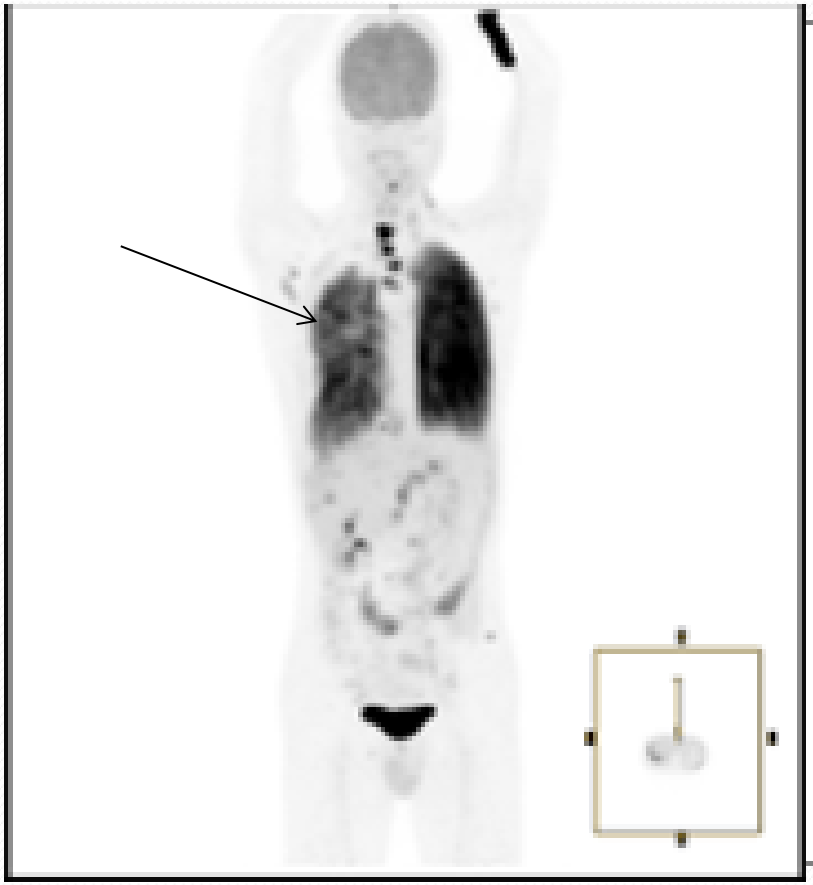


Imaging Artifacts from physiological function

Degradation of image quality as function of patient BMI.



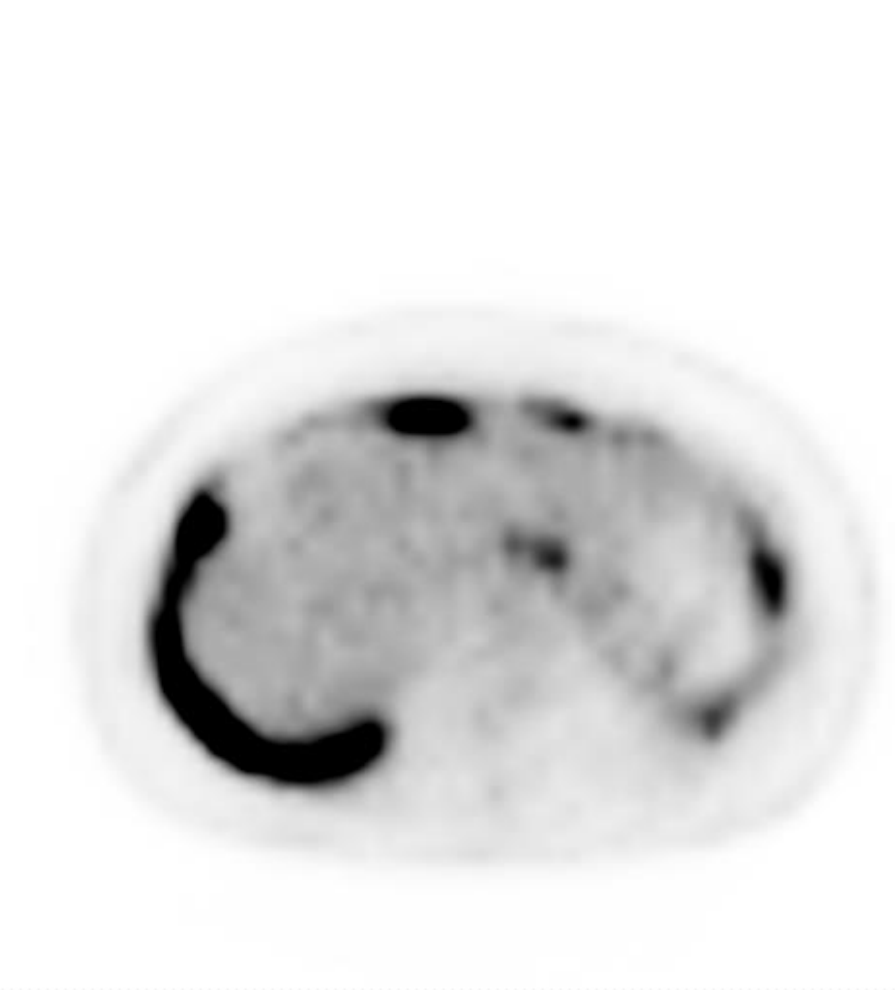
J Nucl Med 2008; 49:938–955

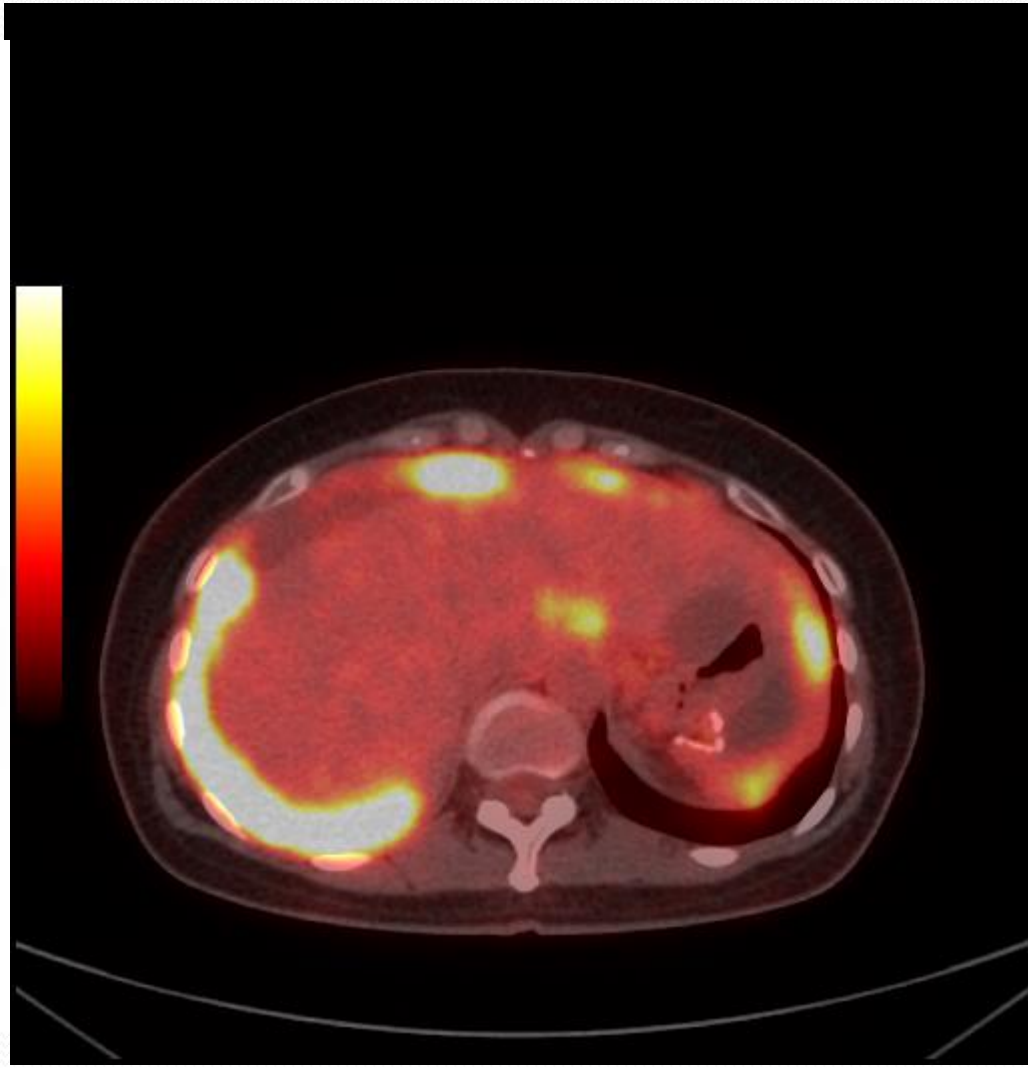


- 化療10天的病人

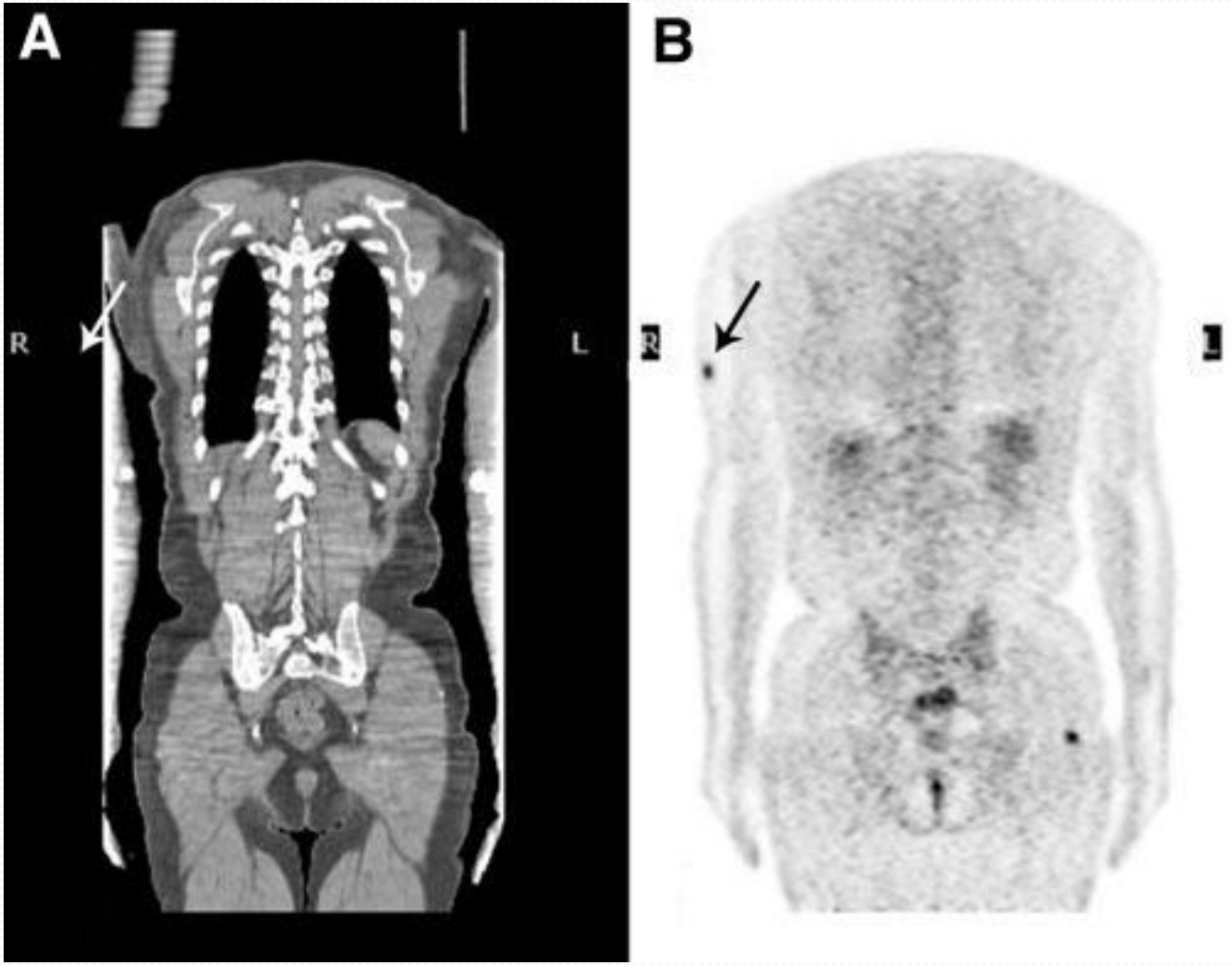
- 手術3天

腹水





Truncation



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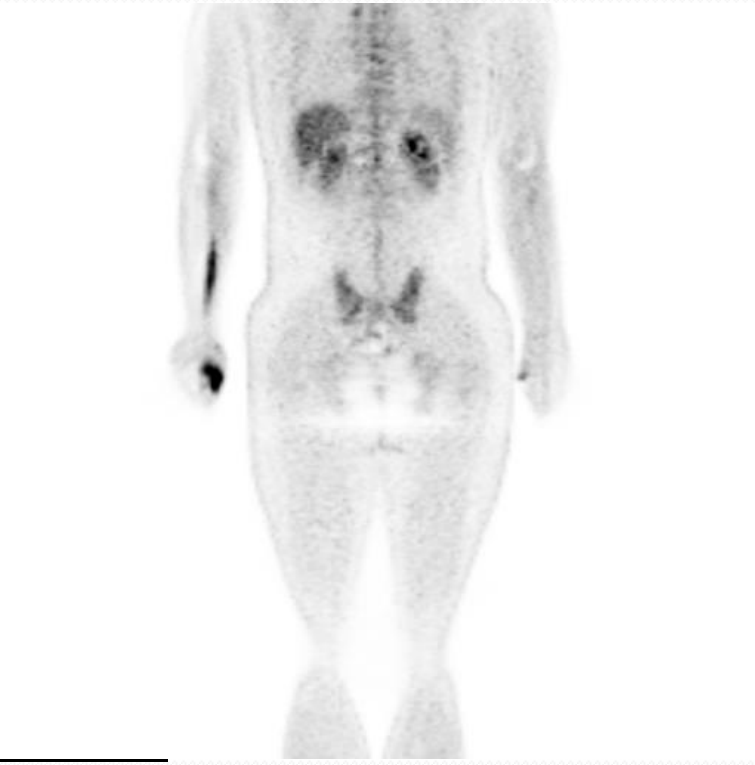

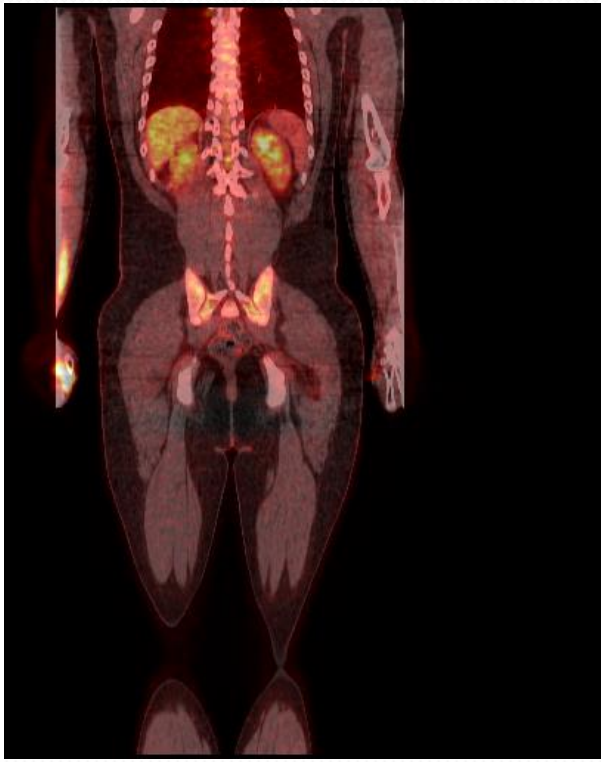

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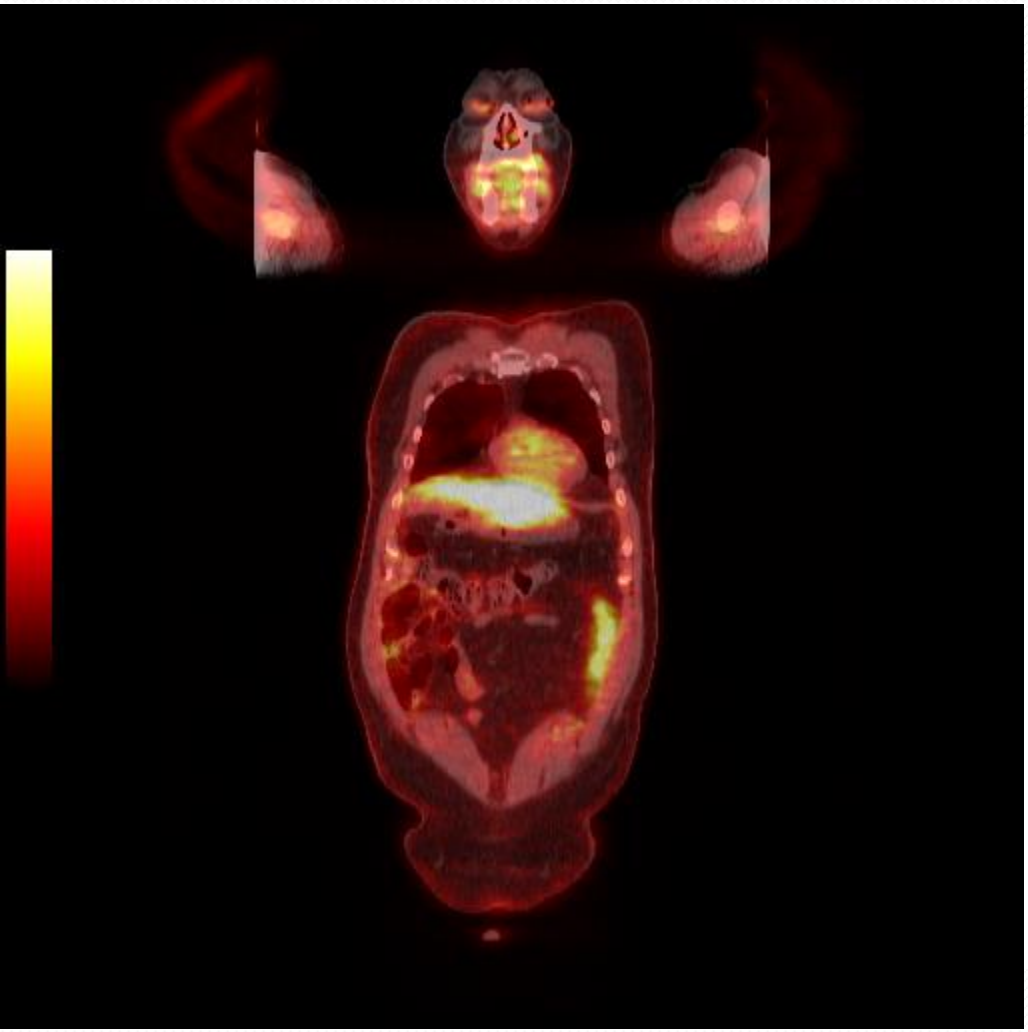
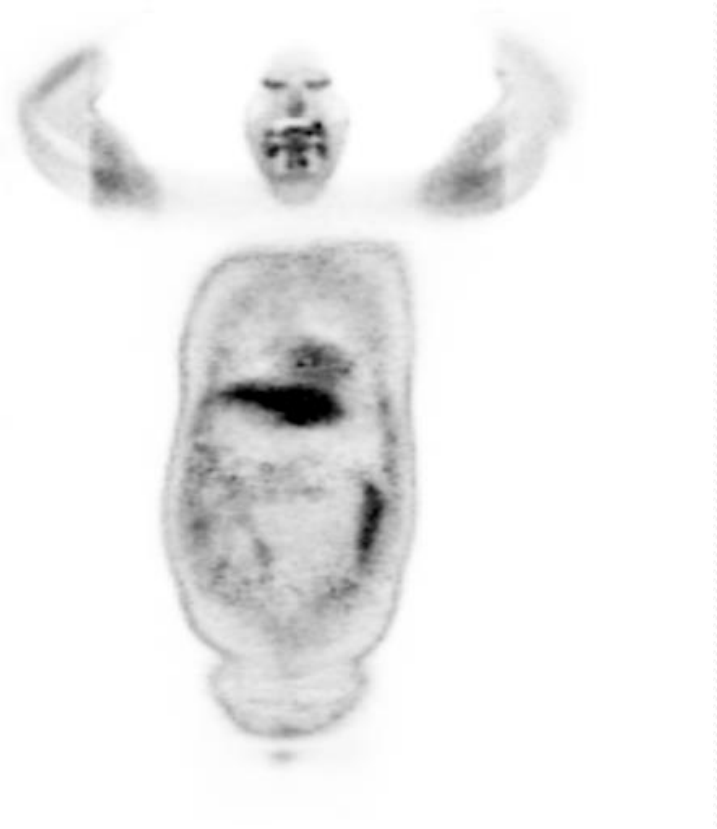
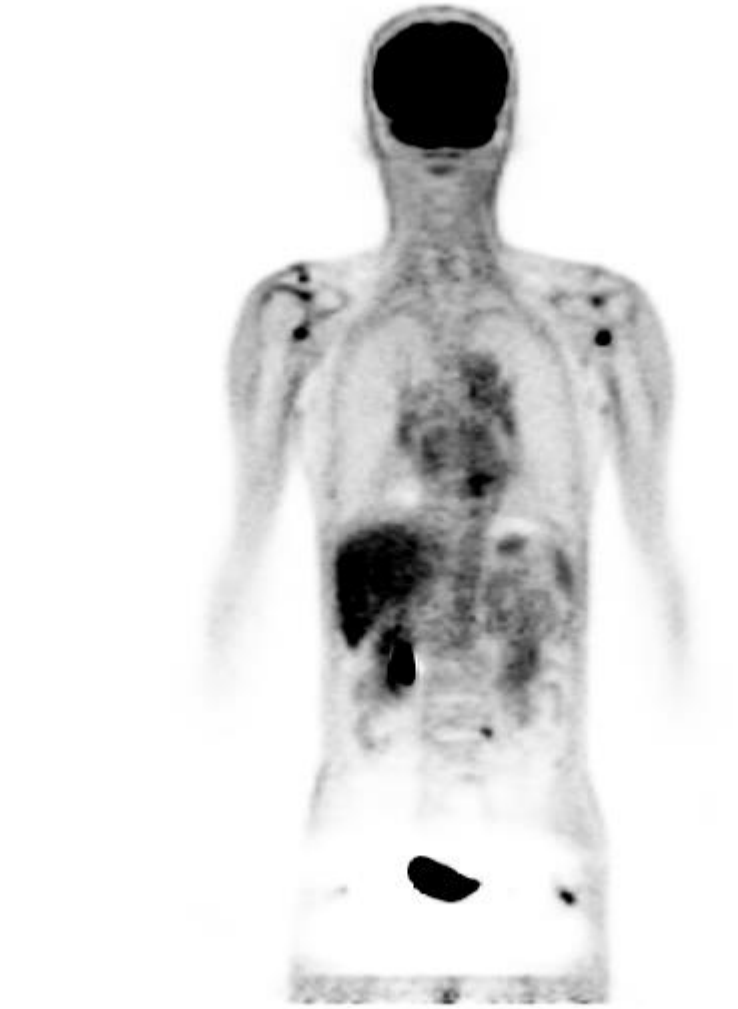
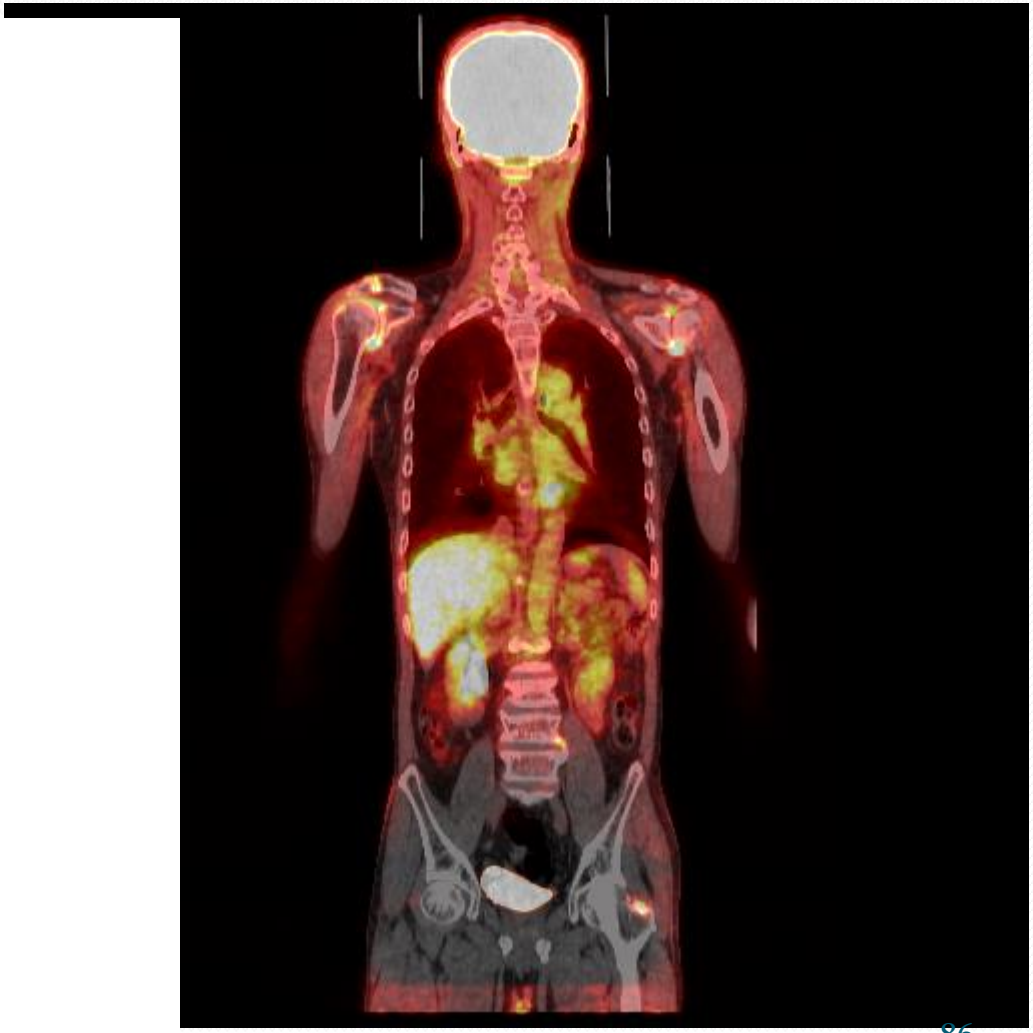




Overflow





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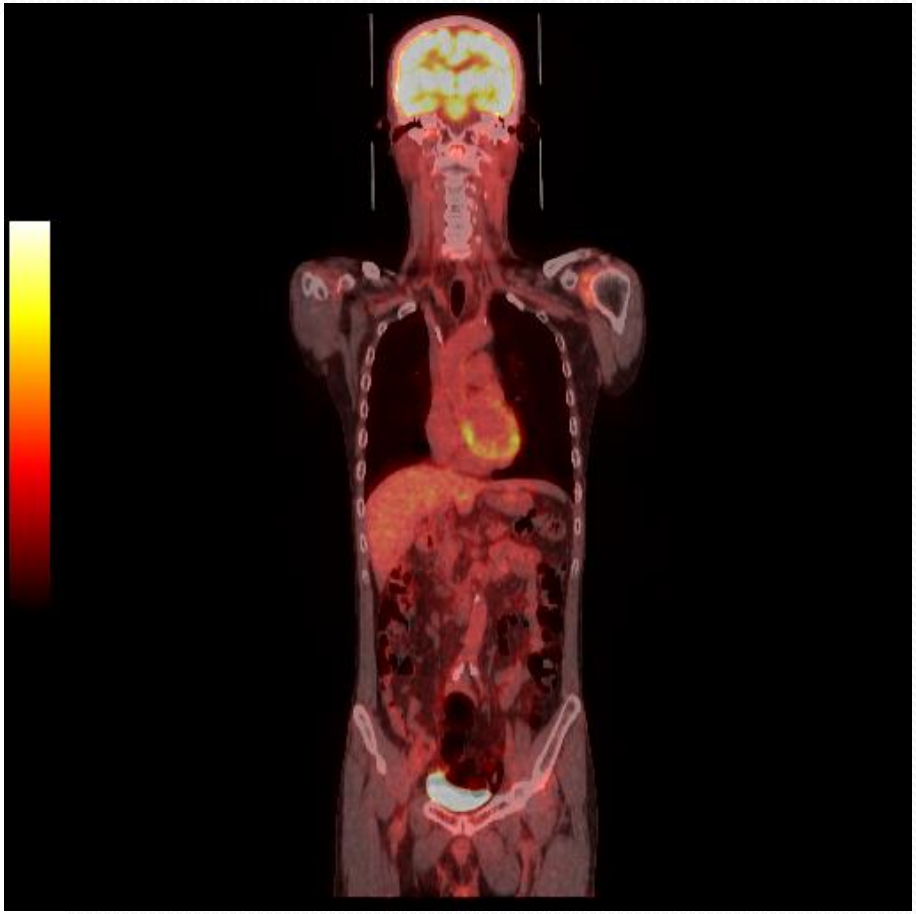
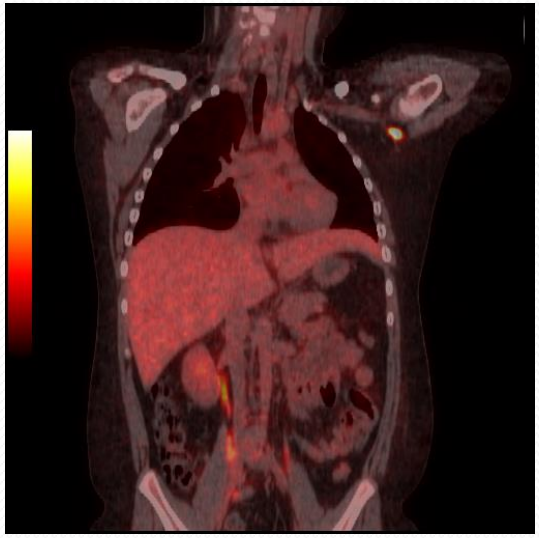
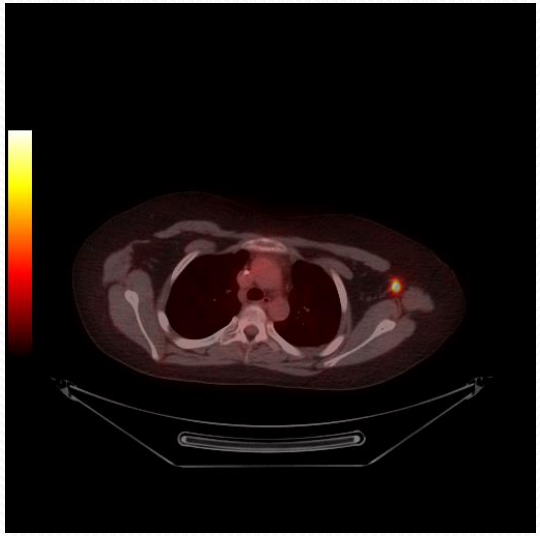
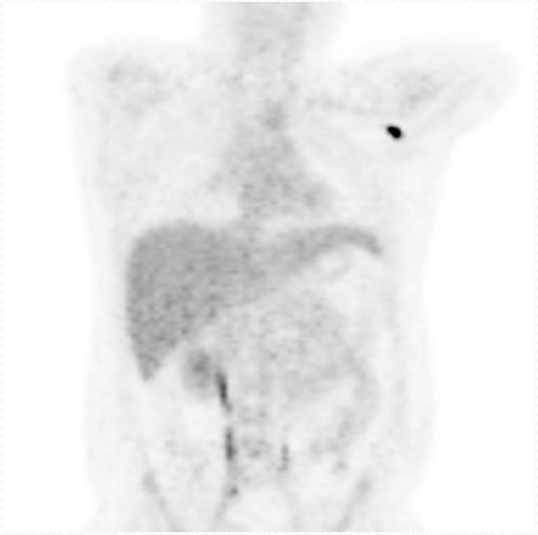


IV site

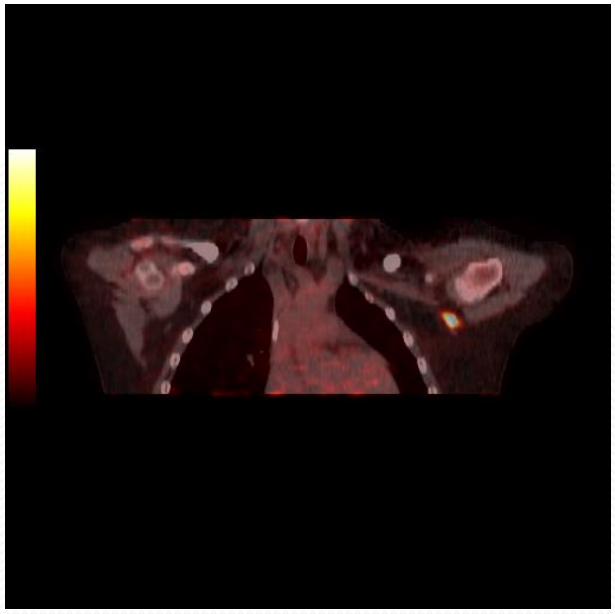


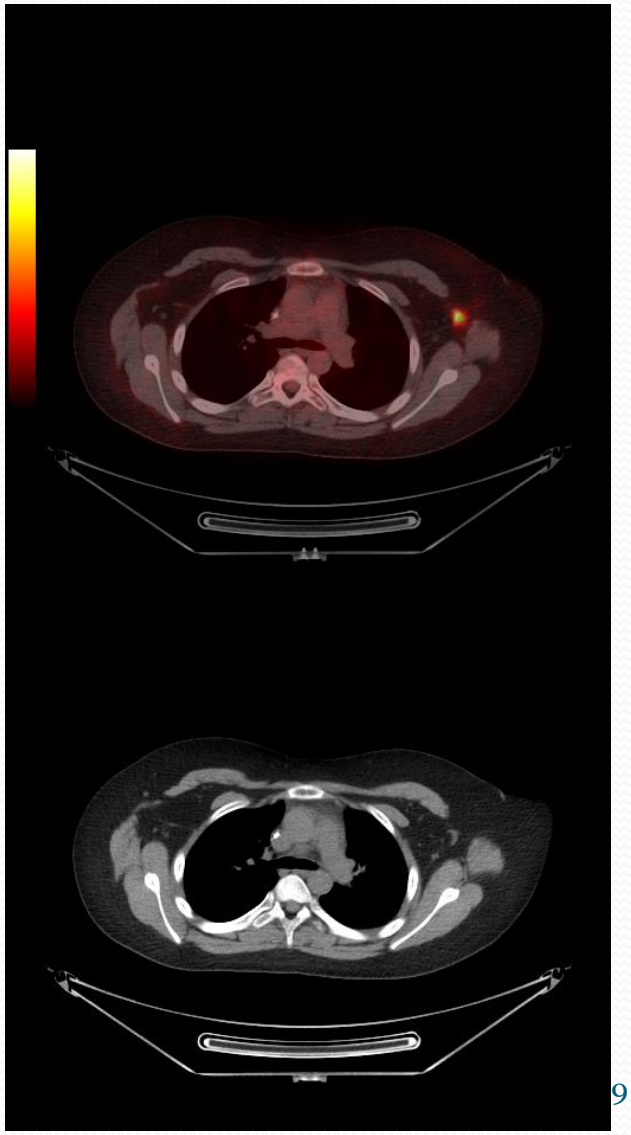




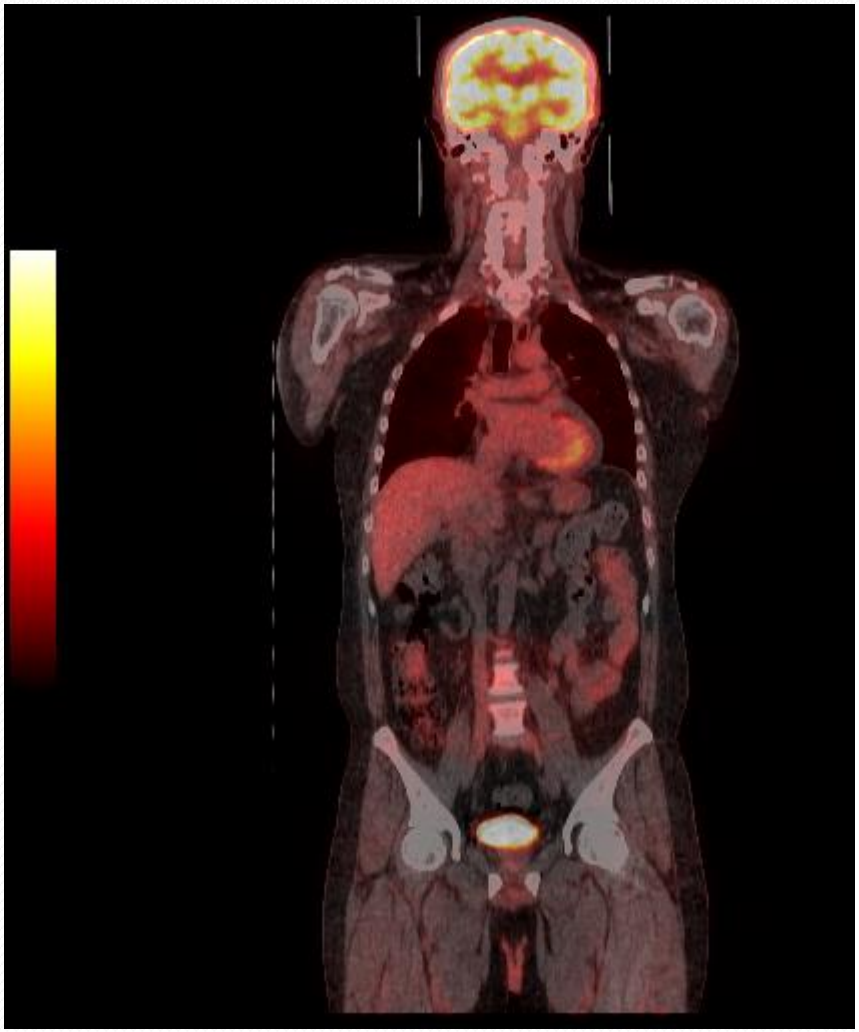
Early phase

IV site

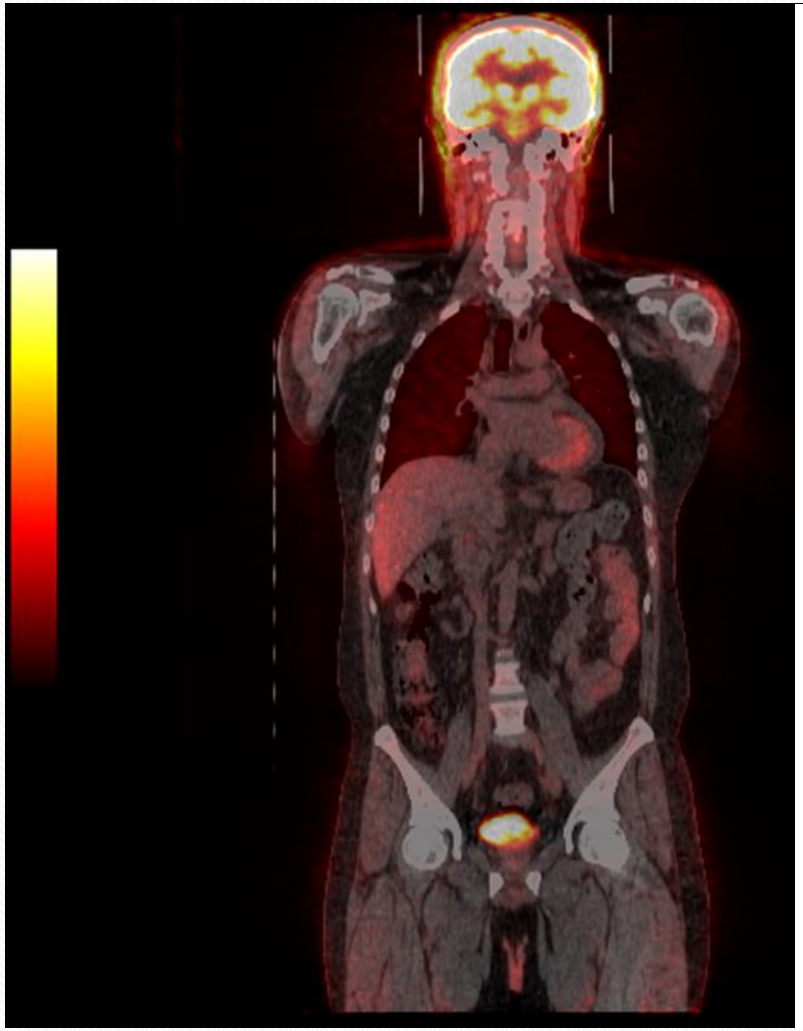




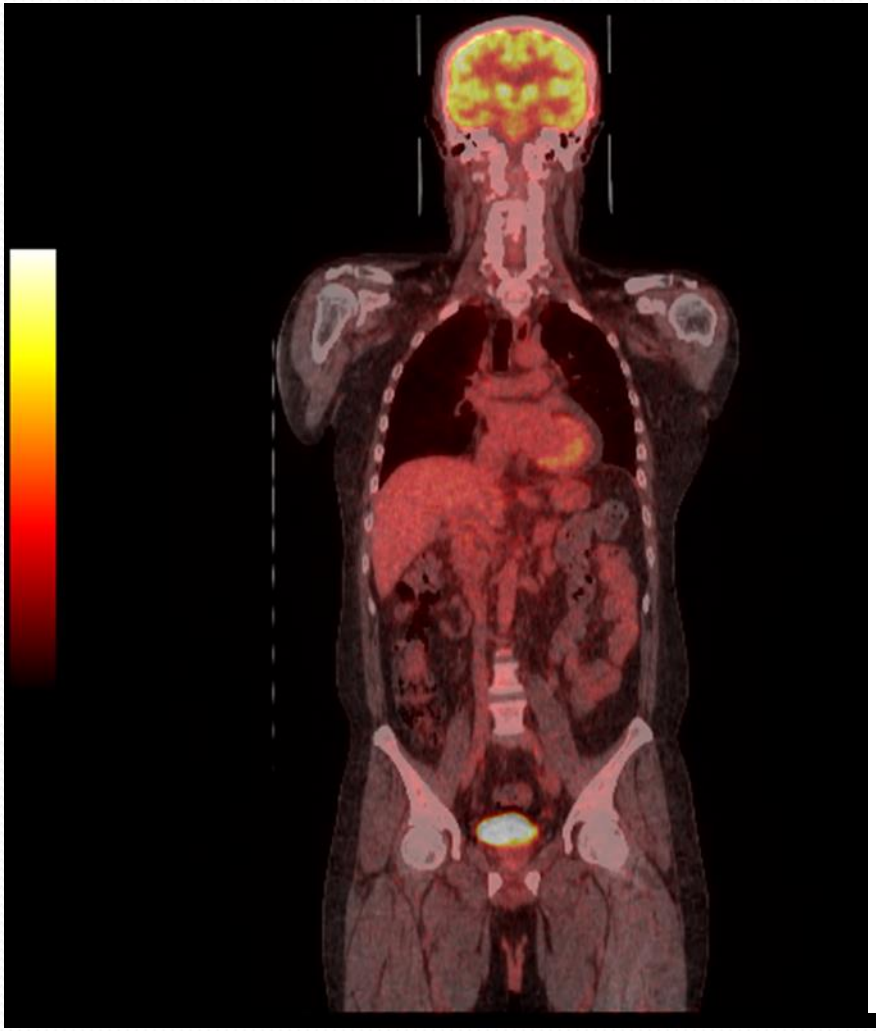
Delay phase

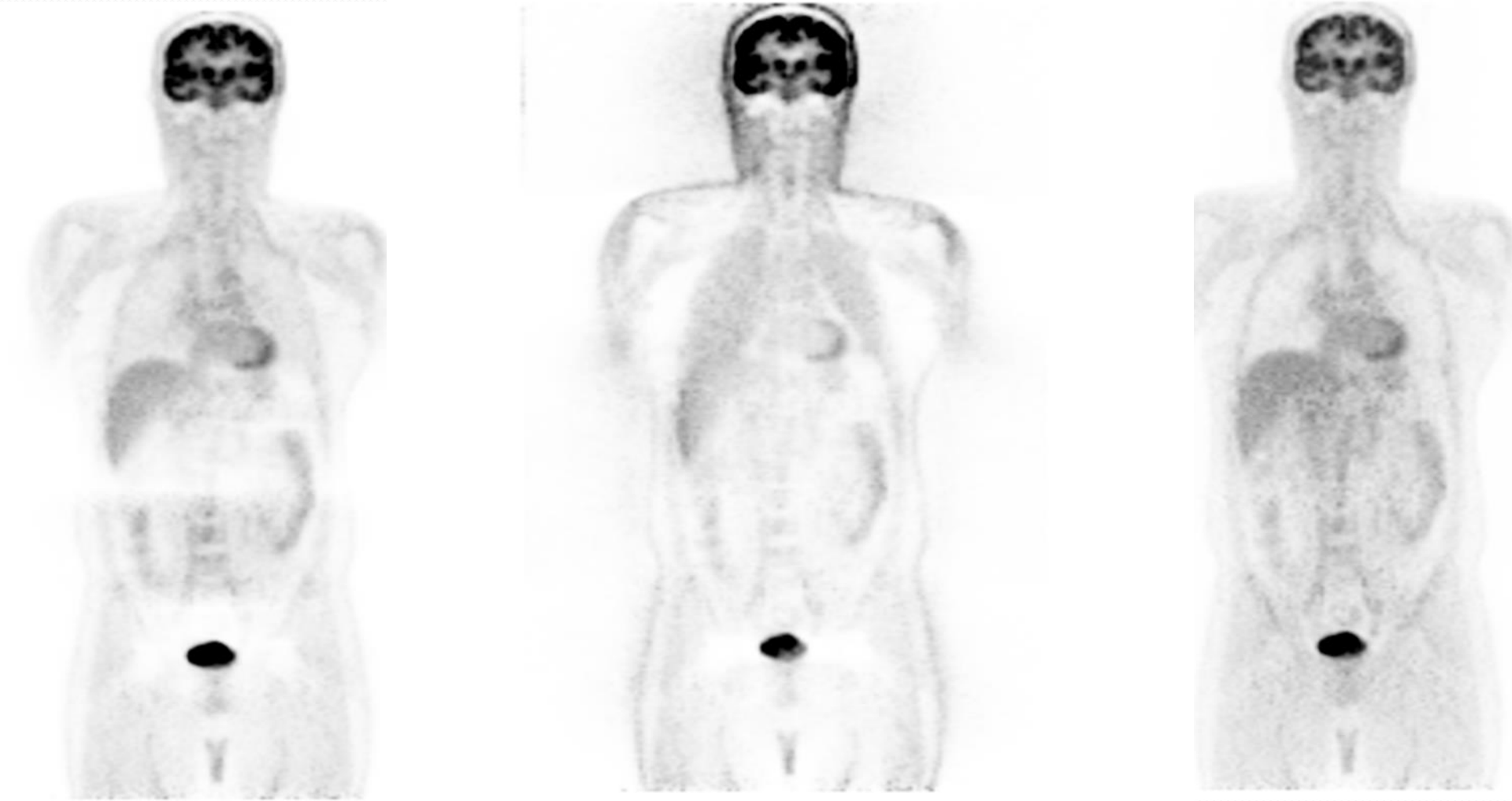


W/O AC

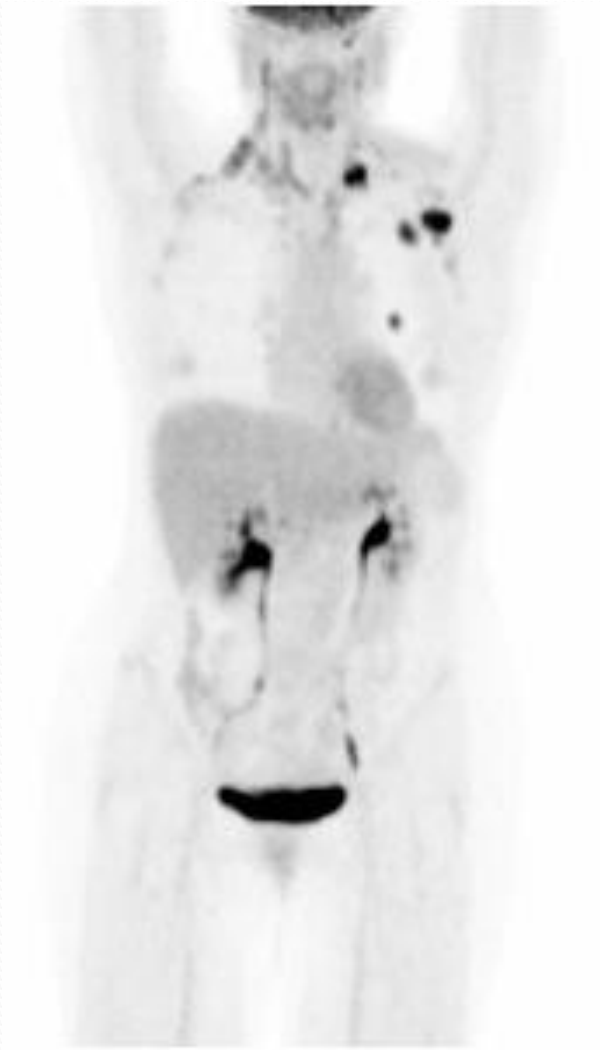


W/O SC

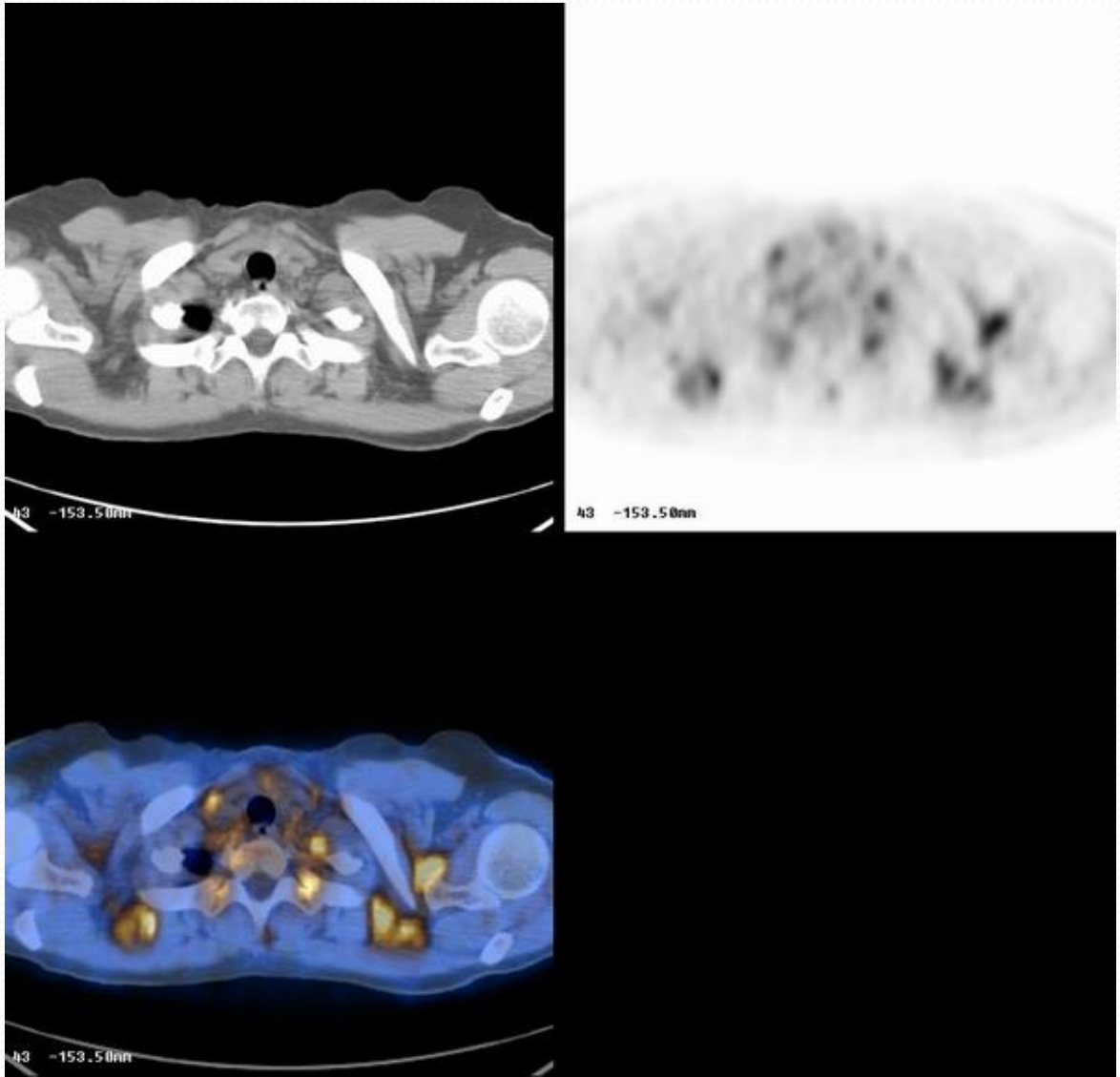




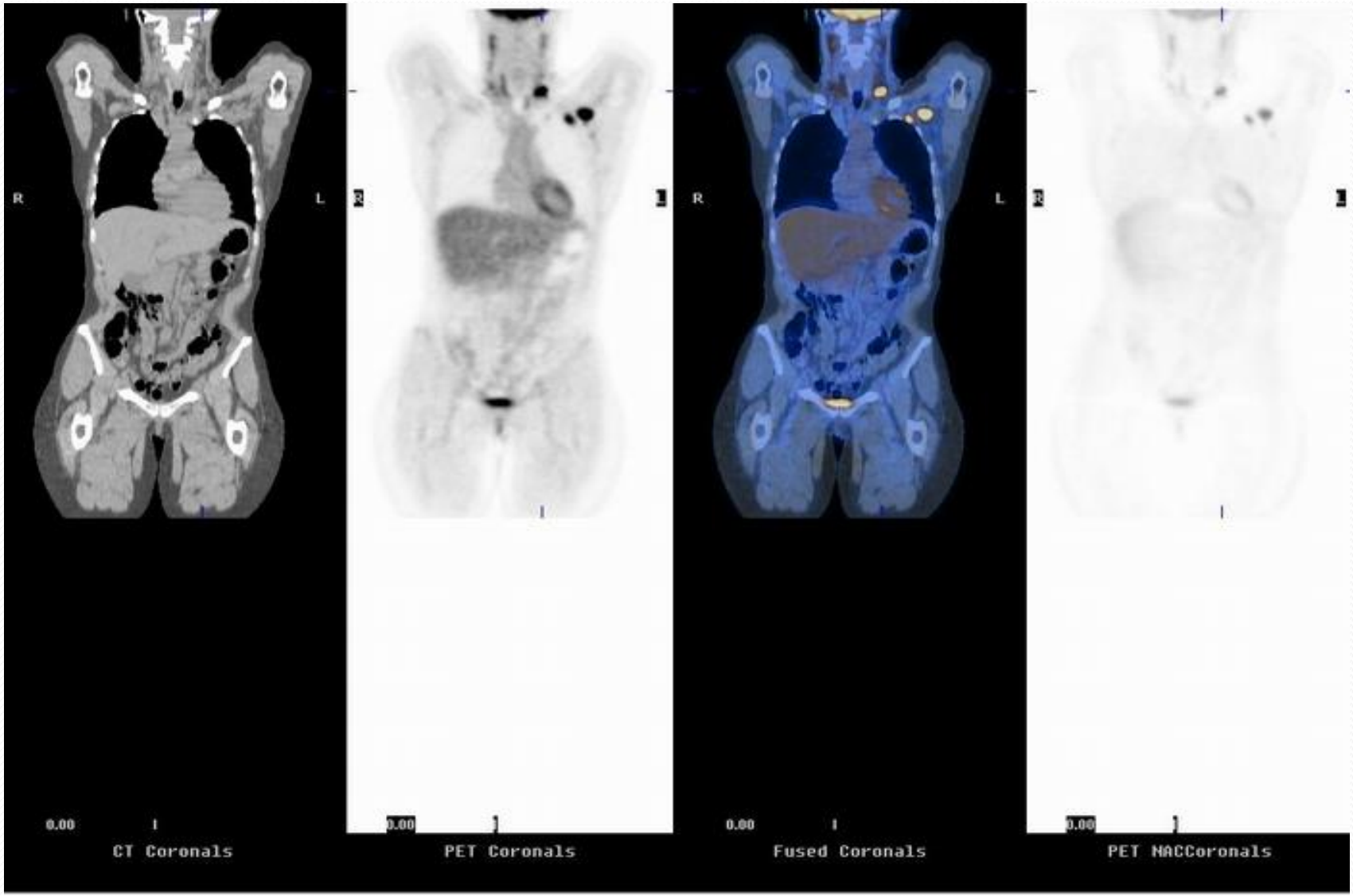
Brown Fat



Brown Fat

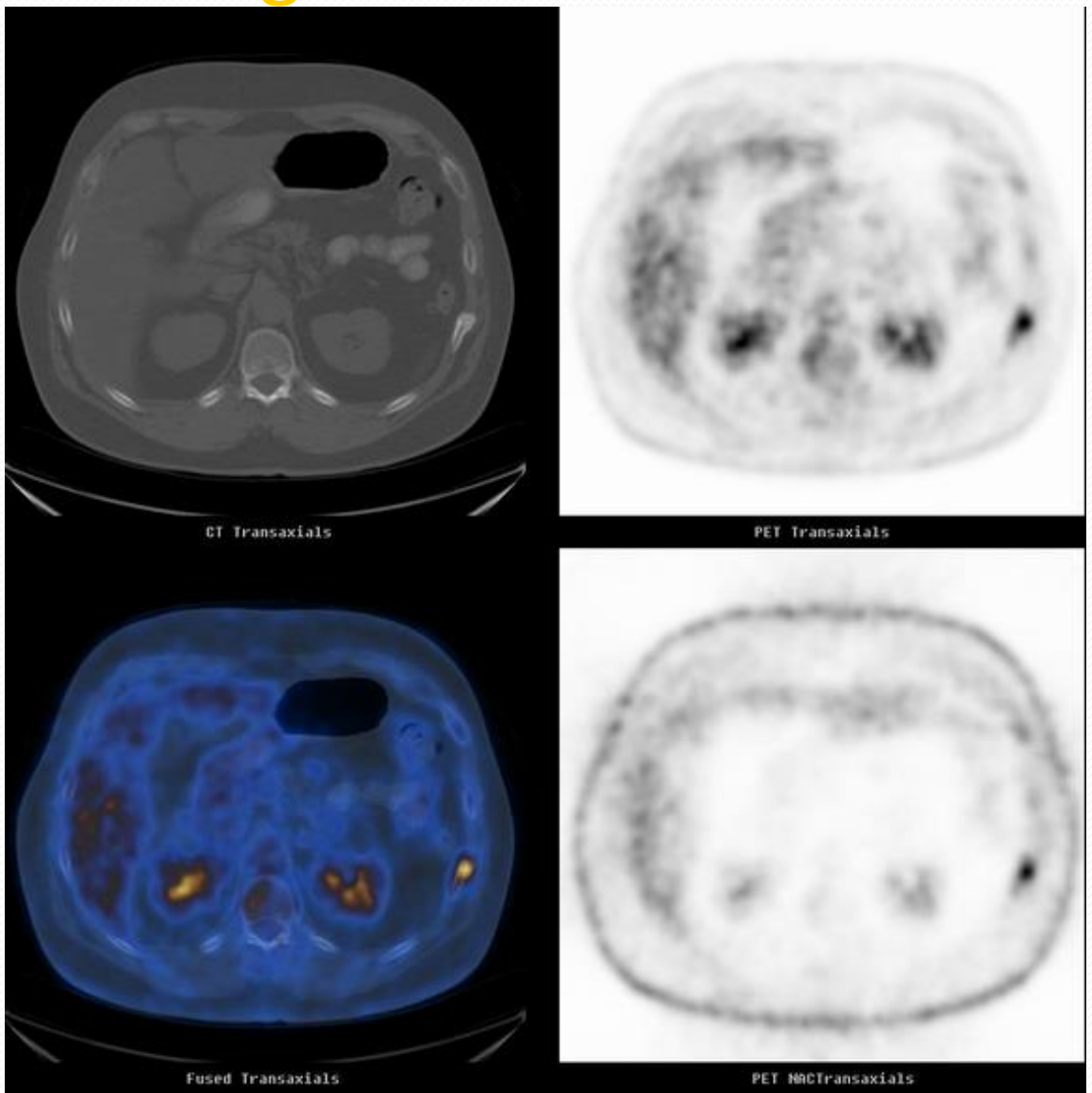


Brown Fat

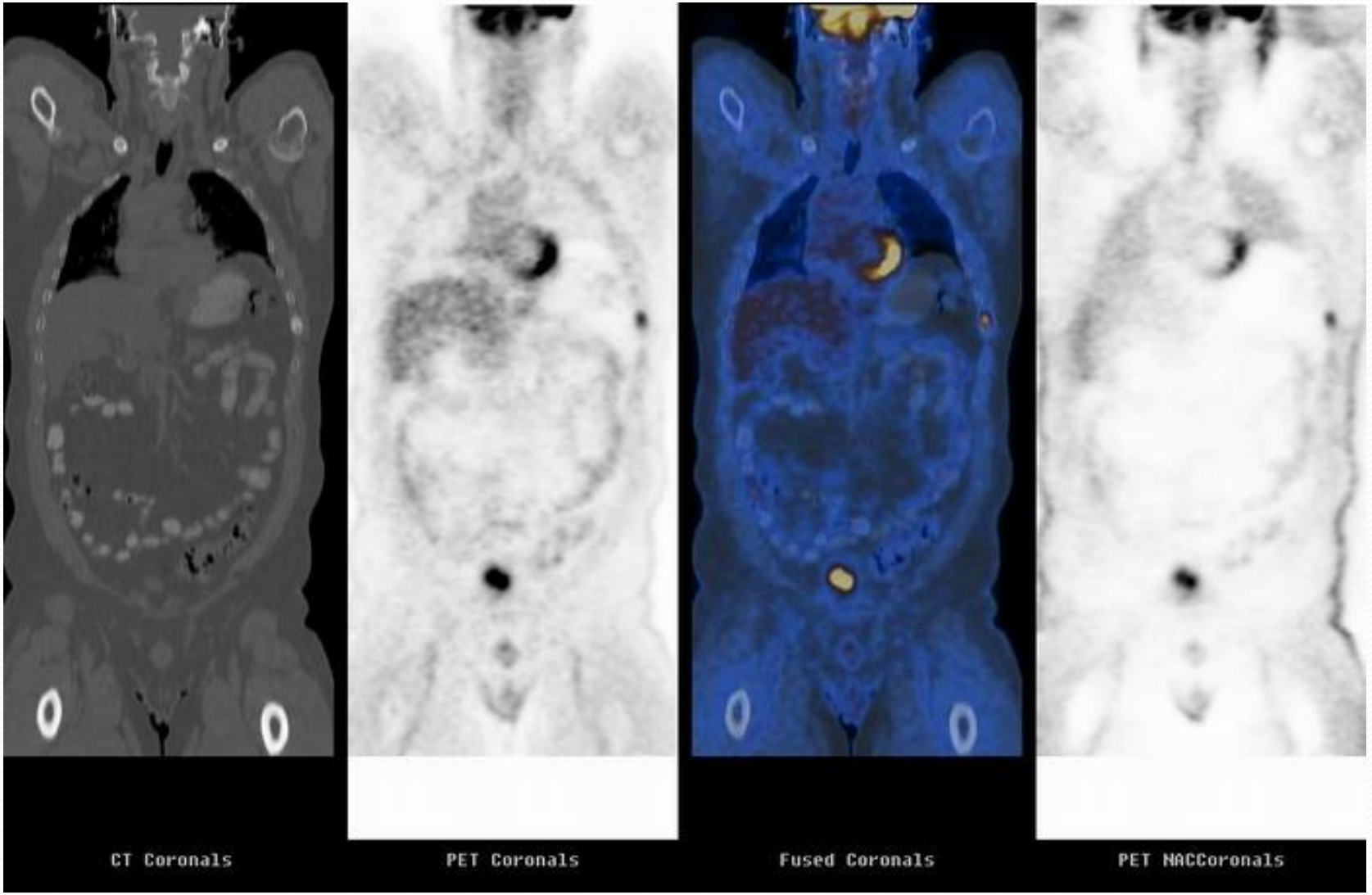

R
L
0.00
CT Coronals
PET Coronals
Fused Coronals
PET NACCoronals

Fracture

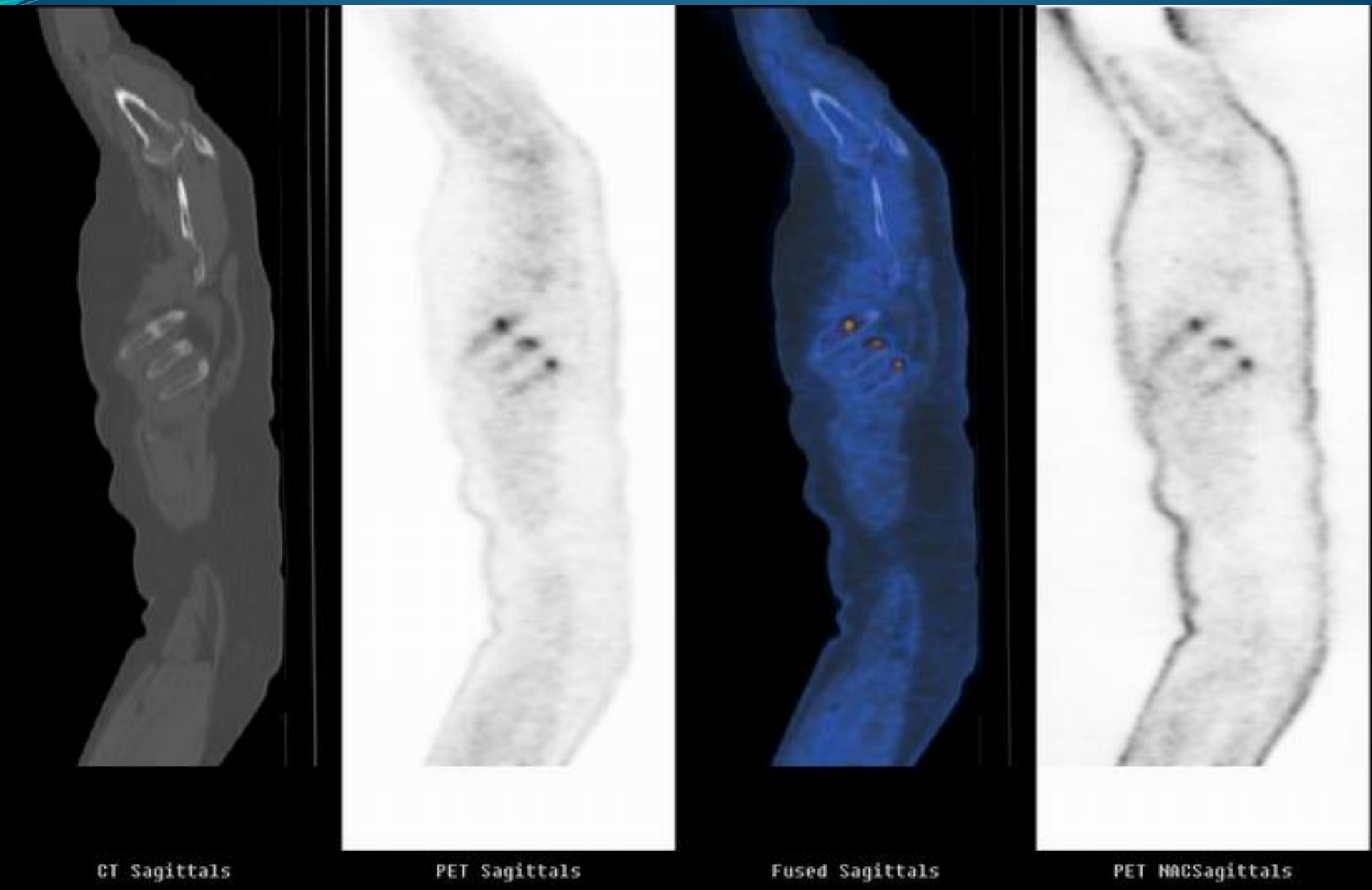
Benign Pathological Variants: Fractures



Benign Pathological Variants: Fractures

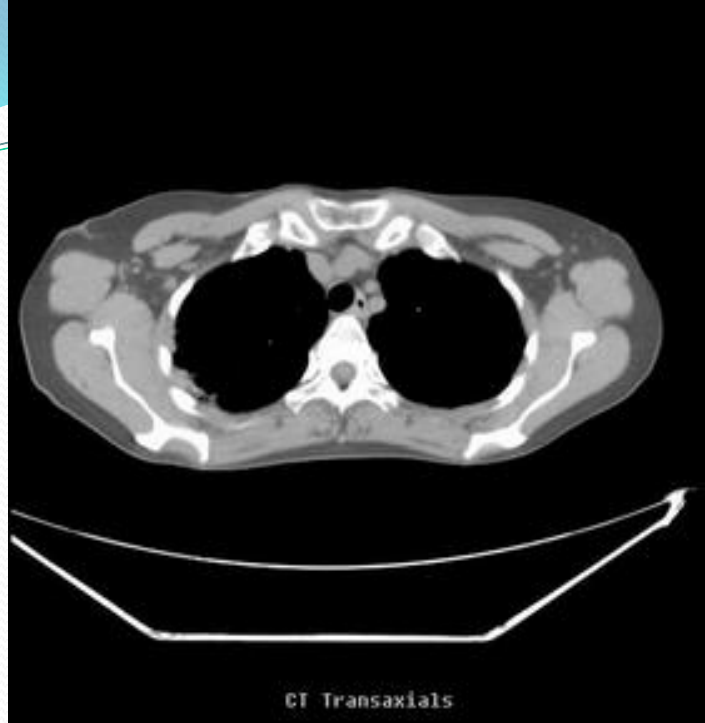


Benign Pathological Variants: Fractures

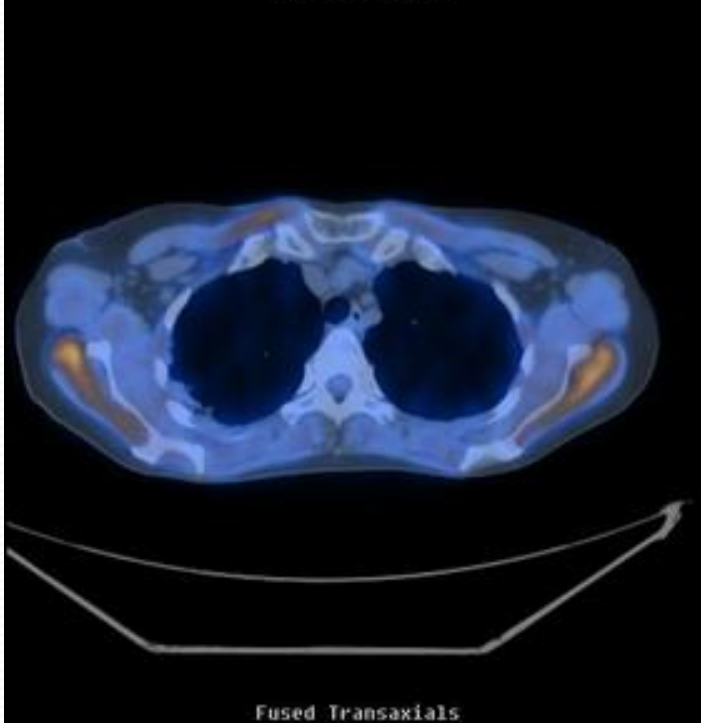


Common sites of skeletal muscular uptake:

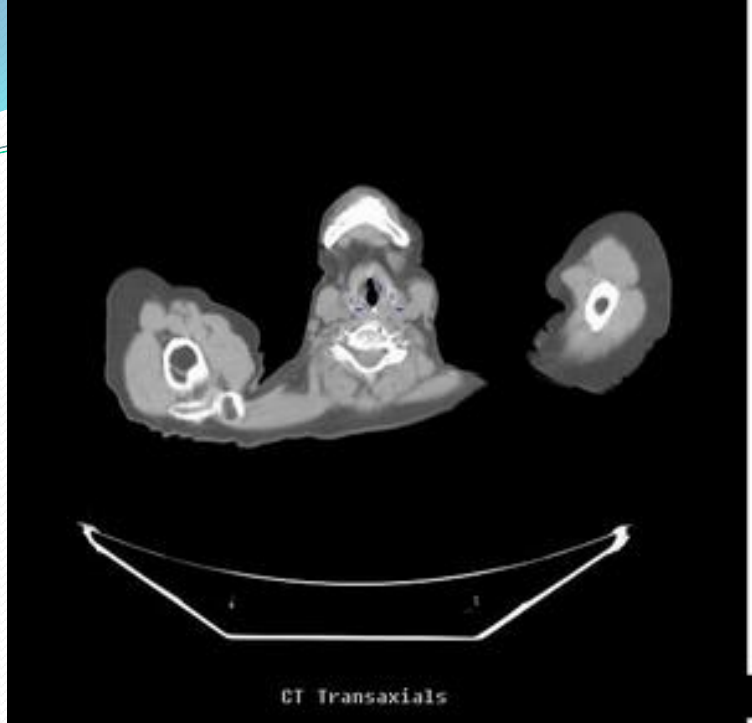
1. Ocular muscles
2. Muscles of mastication
3. Neck strap muscles
4. Tongue - especially the base
5. Larynx
6. Forearms
7. Hands
8. Large muscles of the legs


CT Transaxials


PET Transaxials

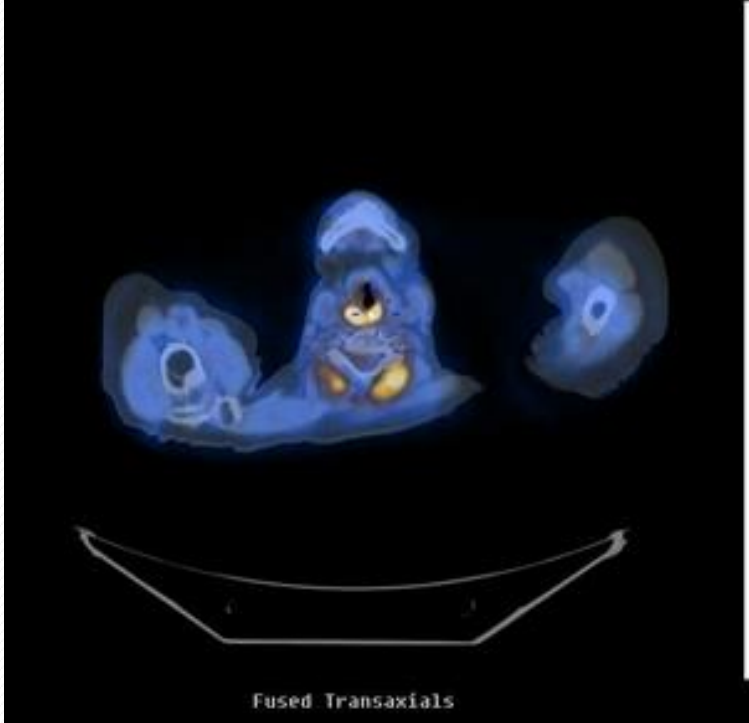

Fused Transaxials


PET NACTransaxials



CT Transaxials

PET Transaxials



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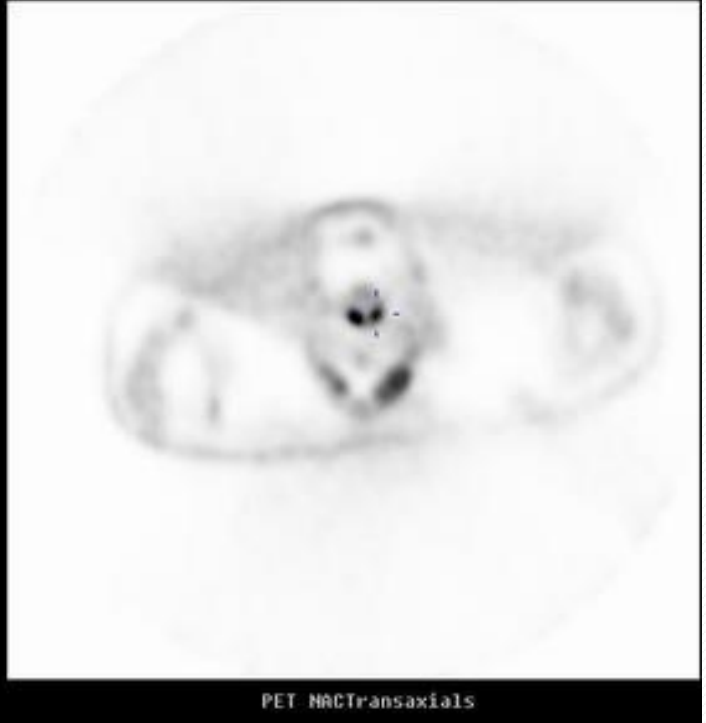

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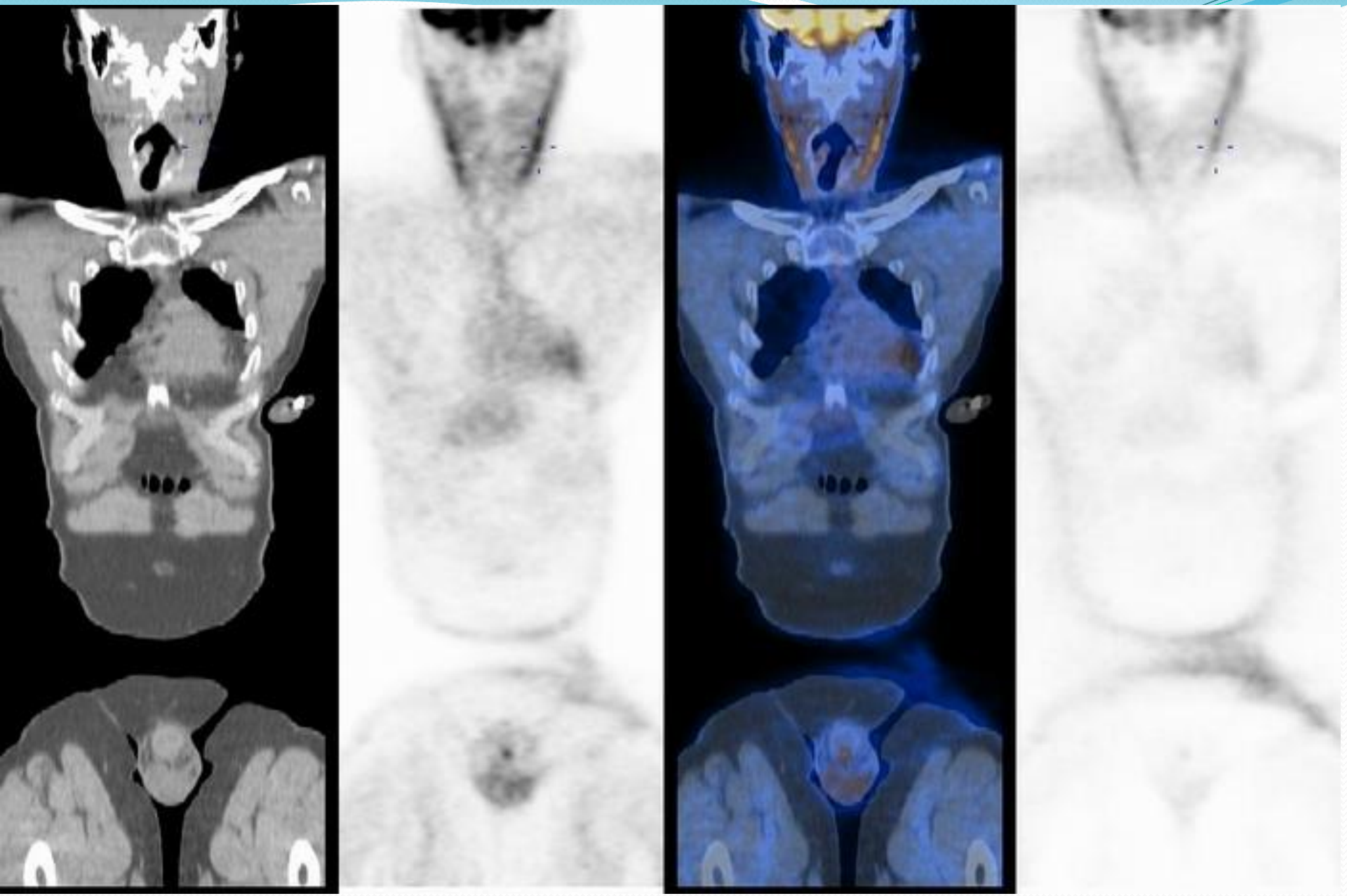

Q&A

感謝凝聽