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Nuclear Medicine PACS and DICOM Application

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A Nuclear Medicine Study





A Nuclear Medicine Study





A Nuclear Medicine Study





Scanner for Nuclear Medicine





Nuclear Medicine Images











LT ANT LUNG(%) = 45.03 LT POST LUNG(%) = 46.08 LEFT GEOMETRIC MEAN(%) = 45.55

26.67 / 18.88

58.56 / 41.44



RT ANT LUNG(%) = 54.97 RT POST LUNG(%) = 53.92 RT GEOMETRIC MEAN(%) =54.45



UP/MID/LOW Lobe(%) = 18.90/6.14/29.41 Abs U/M/L Lobe(%) = 34.72/11.27/54.01





LÃO



LPO

UP/LOW (%) =

Abs Up/Lo(%) =

Nuclear Medicine Images





Image flow: before PACS





Image flow: PACS era





Primary images vs Screen Capture







Primary images of cardiac blood pool



Primary Image vs. Screen Capture





Primary images vs Screen Capture







Old storage for NM images













Interfile



A file format for NM image 1982 COST-B2 project of European community Need to design quality assurance programs Define a file format for data sharing Contains information about study and images

Ď 제목 없음 - 메모장 📃	Ď 제목 없음 - 메모장	Ď 제목 없음 - 메모장 📃 🗆 🗙
파일(E) 편집(E) 서식(<u>O</u>) 보기(<u>V</u>) 도움말(<u>H</u>)	파일(E) 편집(E) 서식(<u>O</u>) 보기(⊻) 도움말(<u>H</u>)	파일(E) 편집(E) 서식(<u>O</u>) 보기(<u>V</u>) 도움말(<u>H</u>)
data compression :=none data encode :=none !GENERAL IMAGE DATA := !type of data :=Static !total number of images :=2 study date :=1991:08:21 study time :=10:00:00 !imagedata byte order :=BIGENDIAN !number of energy windows :=1 energy window [1] := Tc99m energy window lower level [1] := 123 energy window upper level [1] := 123	decay corrected :=N *STATIC STUDY (General) := number of images/energy window :=2 *Static Study (each frame) := *image number :=1 *matrix size [1] :=64 *matrix size [2] :=64 *number format :=signed integer *number of bytes per pixel :=2 *image duration (sec) :=100 image start time :=10:20: 0 *maximum pixel coupt :=22	<pre>imacion la la</pre>
flood corrected :=N	total counts :=7781	PEND OF INTERFILE :=

Interfile: file format for NM image





Old scanner's workstation produce 'nice' interfile but 'awful' DICOM formatted file. Old scanner's workstation can export/import interfile, can export DICOM-file, canNOT import DICOM-file.

Limitations of `Interfile`

Lacks many information fields such as image position, orientation, ... Only for images from nuclear medicine

A file format specification, not a transfer protocol

Old scanner's images at New workstation



Incompatible DICOM header

DICOM elements to calculate SUV, 3D positioning/orientation Problems manipulating old PET machines images (Gemini, Advances, ...) at workstations from other vendor



Quantitation using PET scanner









Quantitation using PET scanner





Application of SUV





Application of SUV



Treatment response evaluation (Chemotherapy+Radiotherapy)





After therapy



Partial Metabolic Response: Decrease in MaxSUV > 25% (20.9→9.5)









Complete Metabolic Response: MaxSUV 11.6→background

Quantifying metabolism using DICOM formatted PET image





≡ (0010,0030)	DA	8	Patient's Birth Date		19620307			
≡ (0010,0040)	CS	2	Patient's Sex		F			
≡ (0010,1010)	AS	4	Patient's Age		053Y			
≡ (0010,1020)	DS	4	Patient's Size		1.52			
≡ (0010,1030)	DS	2	Patient				139	
🗏 (0010,21B0)	LT	0	Additio	👖 Paste Ob	ject	Ctrl+V		
≡ (0017,0010)	LO	12	<u> </u>	a			-07	
🔳 (0017,1004)	DT	18		Arrange I	mage	I		
🔳 (0018,0050)	DS	6	Slice T	Souo Mo	dified Images	Ctrl+E		
≡ (0018,0071)	CS	4	Acquisi	Jave Mu	ullieu illiages	Curt		
≡ (0018,0073)	CS	4	Acquisi	DICOM H	eader View			
🔳 (0018,0074)	IS	2	Acquisi	DIGOINI	04401 110 11,11			
≡ (0018,0075)	IS	2	Acquisi	Create &	mansier			
≡ (0018,1020)	LO	6	Softwar					
'≝ (0018,1030)	LO	14	Protoco	Print				
🔳 (0018,1060)	DS	2	Trigger	Dueferree	-			
≡ (0018,1063)	DS	2	Frame	Preferenc	;e			
'≝ (0018,1083)	IS	2	Interva	Minimize		₩IN+7		
🔳 (0018,1084)	IS	2	Interva 👘	191111120		WINT Z		
≡ (0018,1100)	DS	4	Recons	L Evit		Alt+F4		
🗏 (0018,1120)	DS	2	Gantry/Detector Tilt		0			
'≡ (0018,1147)	CS	16	Field of View Shape		CYLINDRICAL RING			
🔳 (0018,1149)	IS	8	Field of View Dimension(s)		700#153			
🗏 (0018,1181)	CS	4	Collimator Type		NONE			
≡ (0018,1242)	IS	6	Actual Frame Duration		150000			
≡ (0018,5100)	CS	4	Patient Position		HFS			
·Ⅲ (0019,0010)	LO	12	SIEMENS CM VA0 CMS - N	et Frequency	GEMS_PETD_01			



Tag	Name	VR	VM	Length	Value 🗠
(0028,0011)	Columns	US	1	2	144
(0028,0030)	Pixel Spacing	DS	2	1	4#4
(0028,0051)	Corrected Image	CS	7	4	DECYWRADLWATTNWSCA
(0028,0100)	Bits Allocated	US	1	2	16
(0028,0101)	Bits Stored	US	1	2	16
(0028,0102)	High Bit	US	1	2	15
(0028,0103)	Pixel Representation	US	1	2	1
(0028,0106)	Smallest Image Pixel Value	US	1	2	0
(0028,0107)	Largest Image Pixel Value	US	1	2	6335
(0028,1050)	Window Center	DS	1	11	2063.187184
(0028,1051)	Window Width	DS	1	11	4126.374368
(0028,1052)	Rescale Intercept	DS	1	1	0
(0028,1053)	Rescale Slope	DS	1	1	1
1 40010 00001	Croup BBkB Lopath	ш	4	h	700
	II				>

Quantifying metabolism using DICOM formatted PET image



é	AT I	6	Min 13191 Max 22147		SUV(t) =	inj	ecte	$\frac{c(t)}{d \ activity(t)}$	/ body	weight
		.	SD 3200.7 Mean 17214 Area 76.29	72 4.00 mm^2	≝ (0054,1000)	CS	12	Series Type		STATIC#IMAGE
					🗐 (0054,1001)	CS	4	Units		BQML
					──────────────────────────────	CS	8	Counts Source		EMISSION
		5.0	2					22	22147 B	sq/ml
	0010,1030j	DS	2	Patient's	Weight			62		
P 🔁 (0054,0016)	SQ	-1	Radiopha	rmaceutical Informat	tion Se	quence			
	3 (FFFE,E000)	0B	-1	ltem						
	🗐 (0018,0031)	LO	26	Radiopha	rmaceutical			FDG – fluorodeoxygluco	ise	
	- 🗐 (0018,1071)	DS	2	Radiopha	rmaceutical Volume			0		
	- 🗐 (0018,1072)	ТМ	10	Radiopha	rmaceutical Start Tin	ne		092300.00		
	- 🗐 (0018,1073)	ТМ	10	Radiopha	rmaceutical Stop Tin	ne		092400.00		
	🗐 (0018,1074)	DS	14	Radionuc	lide Total Dose			459589504		
	E (0018,1075)	DS	4	Radion						
E (0008,0020)	DA	8	Study [injected dos	se 4:	5958	9504 BQ		
-E (0008,0021)	DA	8	Series	Time 10:20:4	48 -	9:23	8:00 = 3420 s€)C	
-E (0008,0022)	DA	8	Acquisi	Half life of E	_1 Q	- 65	88 500		
E (0008,0023)	DA	8	Conten		-10	- 00			
E (0008,0030)	ТМ	6	Study T						
E (0008,0031)	ТМ	6	Series ⁻	Decay corre	ecte	d inje	ected dose = 3	320.7MBq	
E (0008,0032)	ТМ	6	Acquisitio	n Time			103057		

Quantifying metabolism using DICOM formatted PET image





$$SUV(t) = \frac{c(t)}{injected \ activity(t) \ / \ body \ weight}$$

c(t) = 0.022147 MBq/mIcorrected injected activity(t) = 320.7MBq body weight = 62 kg = 62000 g

SUV(t) = 4.28 g/ml

Required data elements for calculating SUV (0054,1001) Units (0010,1030) Patient's Weight (0054,0016) > (0018,1072) Radiopharmaceutical Start Time > (0018,1074) Radionuclide Total Dose > (0018,1075) Radionuclide Half Life (0008,0031) Series Time

Problems in Calculating SUVs



	(0008,0021) DA '20131204' # Series Date (0008,0031) TM '083220' # Series Time					
	(0018,1072) TM '120000.00' # Radiopharmaceutical Start Time (0018,1074) DS '2996089088' # Radionuclide Total Dose (0018,1075) DS '230400' # Radionuclide Half Life					
1	Y-90 Half-life ~ 2.67 days					
	(0018,1078) DT '20131203120000.00' # Radiopharmaceutical Start Datetime					
	CP-530 Clarifications to PET IOD	Date 2005/08/22 Status: Final Text				
	DICOM Correction Item					
	Correction Number CP	-530				
	Log Summary: Clarifications to PET IOD					
	Type of Modification	Name of Standard				
	Enhancement	PS 3.3 2004				
	Rationale for Correction					
	Working Group 3 has determined that there are ambiguities in the PET IOD that have lead to compatibility issues between various real world implementations. This CP is intended to rectify these problems.					
	1) In the existing PET IOD there is a radiopharm	naceutical start time, but no corresponding start				

Problems in Calculating SUVs





	(0054,1000)	Seri	pe		CS	2	5	WHOLE BO	DY₩IMAGE		
•	(0054,1001)	Unit	Units Counts Source				1	4	CNTS		
	(0054,1002)	Cour					1	8	EMISSION		
	(7053,0000)	UL	1	4	115	08					
	(7053,0010)	LO	1	25	Phi	lips	PET Pr	ivate G	roup		
	(7053,1000)	DS	1	8	0.0	01212					
	(7053,1001)	OB	1	8704							
	(7053,1002)			Table 104: Private Elements for PET Images							
	(7053.1003)	Tag	VR				Mean	ing		VM	
	(7050,4005)	7053,0010	LO	Private Creat	tor Data e	lement				1	1
	(7053,1005)	7053,1000	DS	SUV Scale Factor. This value only applies when Units (0054,1001) is equal to						al to 1	1
	(7053,1006)			CNTS. The SUV Scale Factor is used to convert the pixel data from counts to an SUV value. This is done by using the following formula:					ts to		
	(7053,1009)			SUV Value =	((SV * m)) + b) * f		ionio ini igrici ini			
ð				If the SUV So counts to an	n = Resca b = Resca f = SUV S cale Facto SUV valu	ale Slope de Interc Scale Fa or is 0.0, e.	(0028,105) ept (0028, ctor (7053) then the p	53) 1052) , 1000) ixel data cann	ot be converted fro	m	
		7053,1001	OB	Private						1	
ohy (PET)	Technical Information	7053,1002	OB	Private						1	
		7053,1003	ST	Original imag	je file nam	ne				1	
Conform Allegro [™] and C	M ance Statement _{Gemini[™] Systems}	7053,1009	DS	Activity Conc (0054,1001) to convert the done by usin Activity Conc where S n	entration is equal to e pixel dat g the follo centration SV = origir n = Resca b = Resca f = Activit	Scale Fa o CNTS. ta from c wing form Value = nal stored le Slope le Interc y Conce	actor. This The Activi ounts to A mula: ((SV * m) - d pixel valu (0028,105 ept (0028, ntration Sc	value only apj ty Concentrati ctivity Concen + b) * f Je 53) 1052) cale Factor (70	plies when Units ion Scale Factor is ttration (in Bq/ml). 053, 1009)	1 used This is	
				If the Activity converted fro	Concentr m counts	ation Sc to Activi	ale Factor ty Concen	is 0.0, then th tration.	ne pixel data canno	it be	

Problems in Quantification







Lossy image compression



I wanted to compare a study with an older study. Just after opening the case, I found that images of old study were spoiled.

Lossy image compression vs. Lossless compression











Lossy compression in NM image

- NM images have more noise than X-ray or CT or MR
- Severely degraded even in a low compression ratio
- Quantification using lossy compressed image alter study result.





Loss of Data elements

Digital Imaging and Communications in Medicine

HOL II TOP

I fetched an old study from PACS into my PET workstation. However, PET workstation didn't show SUV number!

A DICOM file	e of PET image			MI ANTIN ON IN
(0054,1105)	scarcer correction dethod	LO	SS-SIMUL	
(0054,1300)	Frame Reference Time	DS	97000	(() min)
(0054,1321)	Decay Factor	DS	1	W # #
(0054,1330)	Image Index	US	1	
· (7053,0000)	Group 7053 Length	UL	11460	
(7053,0010)		LO	Philips PET Private Group	
(7053,1000)		DS	0.00	
(7053,1001)		OB	Private Tags for cal	culating SUV
(7053,1002)		OB	(image from Philips®	PET scanner)
(7053,1003)		ST	р148 850_00_ссас.109	,
(7053,1005)		LO	p1488s0_wb.wls	
(7053,1006)		OB		
- (7053,1009)		DS	6.910539	
(7FE0,0000)	Group 7FE0 Length	UL	9088	

	/ 005.1	1102)	Decay Correction	CS	START
A DICOM file in long term sto	1103)	Reconstruction Method	LO	LOR-RAMLA	
, and the second s	(0054,	1105)	Scatter Correction Method	LO	SS-SIMUL
	(0054,1300)		Frame Reference Time	DS	102000
Private Tags is missingl	(0054,	,1321)	Decay Factor	DS	1
SUV cannot be calculated.	(995 h	1330)	Image Index	US	1
	- (7FE0,	0000)	Group 7FE0 Length	UL	10690

VR with UN (Unknown VR)?



I opened a study of out-hospital patient and I felt something wrong...

⊞ (0054,0022)	Detect	SQ	1		
⊞ (0054,0410)	Patien	SQ	1		
⊞ (0054,0414)	Patien	SQ	1		
(0055,0010)		LO	1	SIEMENS MED NM	
(0055,107E)		UNKNOWN_VR	1		
(0055,1000)		UNKNOWN_VR	1		

```
(0054,0414) SQ (Sequence with explicit length #=1)
                                                         # 54, 1 PatientGantryRelationship
                                                           # 46, 1 Item
  (fffe,e000) na (Item with explicit length #=3)
    (0008,0100) SH [G-5191]
                                                             # 6, 1 CodeValue
                                                                 6, 1 CodingSchemeDesignator
    (0008,0102) SH [99SDM]
    (0008,0104) LO [Feet-first]
                                                              10, 1 CodeMeaning
  (fffe,e00d) na (ItemDelimitationItem for re-encoding)
                                                              0, 0 ItemDelimitationItem
(fffe,e0dd) na (SequenceDelimitationItem for refenced.) #
                                                             0, 0 SequenceDelimitationItem
(0055,0010) LO [SIEMENS MED. MM]
                                                           14, 1 PrivateCreator
(0055,107e) UN 00\00\c8\41
                                                            4, 1 Unknown Tag & Data
(0055,10c0) UN 2f\00\11\00\d1\03\ef\00
                                                            8, 1 Unknown Tag & Data
```

VR is missing somewhere Private data elements became unreadable

Implicit VR Little Endian Transfer Syntax?

Risk of NM images in PACS



Saving storage by performing lossy-compression, removing data elements with private tag, storing in "Implicit VR Little Endian"



Image is displayed well anyway. But, Information for quantification is gone!





Quantification is crucial in Nuclear Medicine.

Do store "primary" nuclear medicine images if possible

Don't lossy-compress "Nuclear Medicine Image" and "Positron Emission Tomography Image" ("CT Image" and "Secondary Capture" are okay)

Don't discard "private" data elements

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Thank you for your attention!