

A novel scheme for Standardized Uptake Value (SUV) calculation in PET scans

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Abstract— This paper presents a novel scheme for Standardized Uptake Value (SUV) calculation in PET scans. The results are compared with the SUV taken from the well-known application software from GE healthcare. The performance of the scheme is evaluated by using the DICOM files taken from the widely used standard PET phantom scan. The comparison was performed with 2 different ROI sizes in 45 image slices and the Pearson's correlation is used. The results show that both systems are correlated significantly with 95% confidence. So the results ensure that his novel scheme for Standardized Uptake Value (SUV) calculation provides the correct SUV value. The strength of this scheme is that the interchangeability of the DICOM files can be done conveniently without the special application software from any vendors.

Keywords— Positron Emission Tomography combined Computed tomography (PET/CT), Standardized Uptake Value (SUV), The Digital Imaging and Communications in Medicine (DICOM)

I. INTRODUCTION

In Nuclear medicine, Positron Emission Tomography (PET) scanner plays an important role in both diagnosis and staging of cancers. The hybrid system of a PET scanner combined with CT scanner (PET/CT) has gained popularity in the oncological community since its commercial introduction to the market in early 2001.

PET/CT is the fusion of The Best of Both Worlds, it was combined by functional data and the structural anatomic information that lets us see the disease in a way that is diagnostically very powerful.

In addition to providing anatomic data, the CT transmission scan can be used to generate an attenuation map that can be used to correct this attenuation effect. This correction process is essential for quantitative assessment (SUV standardized uptake values). The Images of PET/CT are normally presented and viewed in 3 planes (coronal, transaxial, and sagittal) as well as a 3D maximum intensity projection (M.I.P.), which can be rotated while viewing. The CT, corrected and uncorrected PET scans, as well as the fusion image can be viewed on a single page. So in this research we used the DICOM file that has been through the attenuation correction in transaxial plane.

PET/CT is classified as medical device that measures radioactive traces injected into the body. The PET tracer (F18-

FDG) has two parts: glucose, and a mildly radioactive component. As the tracer moves through the body the cells that are active take up the glucose along with the radioactive part of tracer.

In fact, FDG is not cancer specific and will accumulate in areas with high levels of metabolism and glycolysis. Therefore the increased uptake can be expected in sites of hyperactivity (muscular, nervous), active inflammation (infection, sarcoid, arthritis, etc.), tissue repair, etc.

PET shows a metabolism of cell or tissue by displaying the image with the semi-quantitative value called Standardized Uptake Value (SUV).

In PET studies some case or some applications the PET image alone may be sufficient (brain scan for diagnosis Alzheimer's dementia) for clinical diagnosis. However Qualitative approaches are often used for practical reason.

It is some time the cases that need estimating the concentration of tracer, but not a full kinetic analysis, Semi-quantitative is often used.

The simplest semi-quantitative approach is to estimate the concentration of tracer in a given region from PET images by using an ROI analysis. The semi-quantitative measure of local

FDG uptake has been developed and utilized in differentiating benign from malignant lesion (malignant lesions in general having greater uptake).

SUV (Standardized Uptake Value) is the value that quite often used in PET scan. It is most commonly used semi-quantitative parameter utilized for analyzing FDG-PET images in routine clinical practice. It came to be used as a tool to supplement visual interpretation. [1]

Standardized uptake values (SUVs) are a measure of the concentration of a radiotracer in a defined region of interest (ROI) divided by the injected dose normalized for the patient's body weight at a fixed time after tracer injection.

SUV is also referred to as Standardized Uptake Ratio (SUR). As being a ratio, it is unit less and is calculated by formula:

$$SUV_{bw} = \frac{\text{Measure Activity in Region of interest (ROI)}_{(mCi/ml)}}{\frac{\text{Injected Dose}_{(mCi)}}{\text{Body Weight}_{(g)}}}$$

SUV is affected by several factors. It has a strong positive correlation with weight if calculated the SUV in body weight term. The time of measurement is also effected, the earlier

imaging provides low results, and conversely delayed scans provide high SUV. Also the other factors such as dose extravasations, attenuation parameters, reconstruction parameters, partial volume effect and plasma glucose level in patient blood affect the value of SUV.

The cut-off value for malignant lesion is 2.5 and it has largely been proven to be an oversimplification. SUV is the one of many criteria used for interpretation, including visual uptake, lesion size relative to uptake, and also clinical history. Some routine clinical purpose, visual analysis of PET images is sufficient for clinical interpretation. SUV does provide an objective parameter for image analysis and is useful for research purpose. For patients with cancer, it is important to report SUV of chosen index lesions.

Either $SUV_{maximum}$ or SUV_{mean} in a region of interest (ROI) can be used. Nevertheless physician prefers to report the case by the Maximum SUV. Because the maximum SUV is least affect by partial volume effect, [2] so in this research we calculate the SUV_{max} which is obtained from the Maximum Pixel Value in the image slice.

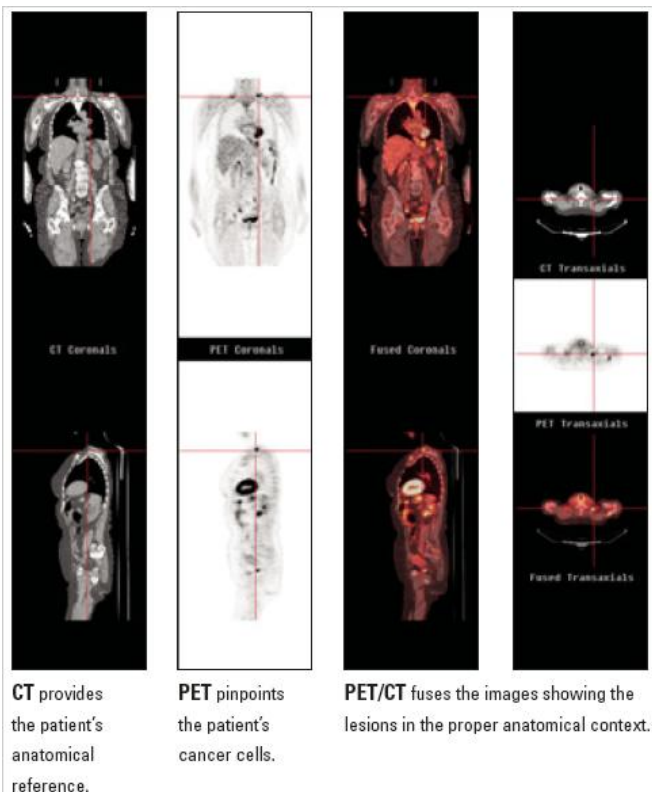


Fig 1. the example of all image planes from PET/CT : coronal plane(above), sagittal plane(below), transaxial plane(right) (<http://www.westcoastradiology.net/images/pic-pet-ct-1.jpg>)

The Data and parameter for SUV calculation are stored in the DICOM file format. DICOM file is a file format developed by the DICOM Standards Committee whose members are also partly members of NEMA. The strength of DICOM files is the exchangeability between two entities that are capable of receiving image and patient data. DICOM also enables the integration of scanners, servers, workstations, printers, and

network hardware from multiple manufacturers into a picture archiving and communication system (PACS).

Picture Archiving and Communication System (PACS) is an electronic system dedicated to medical image management. It enables the following image cycle: production on imaging devices, archiving, transfer via network and consultation, processing and softcopy reading on stations. It is a standard for file formats and inter-system communication used in hospitals and clinical labs for storing radiology images (X-rays, MRIs, CTs, PET/CT, etc). PACS relies on the DICOM standard for image representation and communication services. PET/CT is the modality which also stores images using DICOM in PACS.[3]-[6]

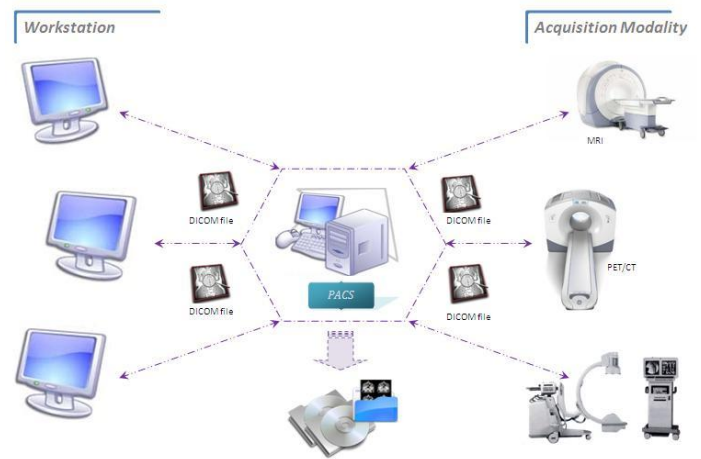


Fig 2. The work flow diagram of PACS and DICOM in the system.

A DICOM file is mostly divided into two main parts which are the DICOM image and the data header (DICOM elements or Metadata). All information about the image, patient, study, etc. are stored in the header.

Preamble	First 127 bytes contain blank area called preamble. This is a comment area.
Prefix	DICM is the prefix that identifies that this file is a DICOM image file. Strictly speaking, all the DICOM files must possess this preamble & prefix.
DATA ELEMENTS (Tag,VR, VL,Values)	A Data Element.
DATA ELEMENTS (Tag,VR, VL, Values)	It is the Data elements all the way down...
Pixel Data	And then comes the pixel data. Pixel data is nothing but the image. The image's pixel values are stored here. This pixel data array is followed by the a unique tag '7FE0 0010'. which tells you that it is Pixel data values.

A DICOM file contains binary *attribute* or data elements. Each element consists of

1. A tag, in the format of group, element (XXXX,XXXX) that identifies the element.
 - A Group No. Tells you about an entity.
 - An Element No. Identifies the exact information in the group

For Example, In the tag (0010,0020): Group No. is 0010 and Element No. is 0020. The Group no. 0010 tells you that the information is about PATIENT and the Element No. 0020 tells you that the information is about the PATIENT NAME.

Some Groups: (Group numbers are in Hexadecimal)

- Group 2: Contains File Meta information
 - Group 8: General series info.
 - Group 10: Patient info.
 - Group 20: General Study info.
 - Group 28: Image info.
 - Etc.
2. A Value Representation (VR) that describes the data type and format of the attribute's value. It is an optional field.
 3. A value length (VL) that defines the length of the attribute's value.
 4. A value field containing the attribute's data.

Each data element must be read in order to march through the file and find the data of interest.

The current DICOM standard specifies that the file contains the string "DICM" starting at byte position 128.

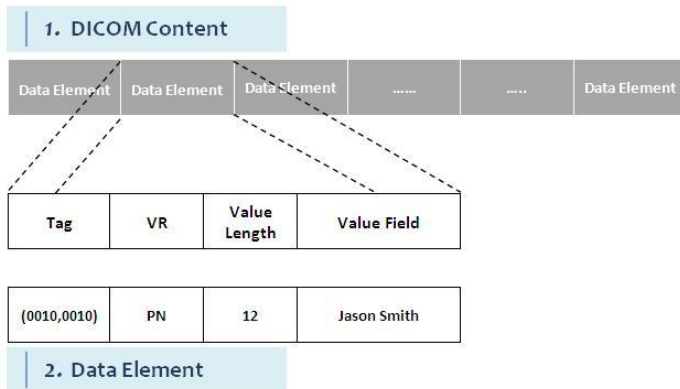
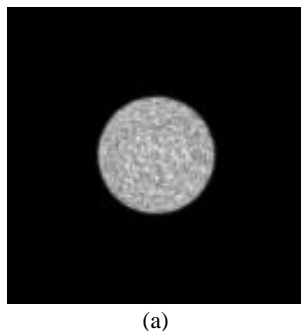


Fig 3. The data elements consisting of TAG, VR, Value Length and Value field.



Field	Value	Min	Max
PixelDataGroupLength	32780	32780	32780
ImageIndex	83	83	83
DeadTimeFactor	1.0365	1.0365	1.0365
ScatterFractionFactor	0.2066	0.2066	0.2066
DoseCalibrationFactor	1213	1213	1213
DecayFactor	1.0291	1.0291	1.0291
SliceSensitivityFactor	1	1	1
SecondaryCountsAccumulated	0	0	0
PrimaryPromptsCountsAccumulated	0	0	0
FrameReferenceTime	183000	183000	183000
CoincidenceWindowWidth	0	0	0
TransverseFlash	2	2	2
AcqFlash	[1;2]	1	2
ScatterCorrectionMethod	Model Based		
DetectorLinesOfResponseUsed	Y		
ReconstructionMethod	3D IR		
DecayCorrection	START		
AttenuationCorrectionMethod	measured, 0.096000 cm-1		
RandomCorrectionMethod	SRRF		
CountsSource	EBSSON		
Units	BQ#L		
SeriesType	STATIC IMAGE		
PatientGantryRelationshipCodeSequence	<1x1 struct>		
RelevantOrientationAndPatientCodeSequence	<1x1 struct>		

(b)

Fig. 4. The DICOM file is reviewed by MATLAB (a.) Image part (b.) Header (Metadata) part.

However, the way of reading and analyzing all these data and parameters is needed a specific application program. Each manufacture (vendor) will have their own application mostly just for their equipment.

Gustavo and team [7] have studied the comparison of the SUV by compare the SUV from the files that get through PACS (Picture archiving and communication system) and the files that view by the workstation at the scan site. The application program was used in their research is from the well known vendor.

From the literature review and the study of the feature of DICOM format, we're interested in widening the limited condition by using MATLAB. It means that if we can use the widely used program such as MATLAB in PET DICOM analyzing process. It might be much useful for user.

DICOM file type is quite limited on viewing. There is seldom meet the application program supporting this type of file. The general photo viewing program in the market mostly not supports the DICOM file format.

Some application program has a feature supporting the DICOM file but only for displaying the image and the metadata, still unable to extract them to further process.

By the nature of the DICOM format, which contain by 2 parts, there are the part of image and metadata (Header) and MATLAB has a command that supports the DICOM file. Therefore in our research we choose MATLAB as a tool for calculation and analysis.

We have studied structure of PET/CT DICOM file and studied the various involved parameter in the method of SUV calculation. We found that DICOM file from different vendor is containing in different way. So in our research we used the DICOM file that process through the PET/CT Discovery STE from the GE healthcare. [8]

For much understanding the meaning of DICOM file, the study of general meaning of the DICOM format from NEMA statement is needed [9]. Also combination study with the conformance statement from the vendor (GE healthcare) [10] has been studied. It provides the information about the way of storing parameter and the meaning of involved parameter.

After we reviewed the literature, we found that the SUV calculation from DICOM file was still not much prevalent.

Aparna and team [11] studied about the image of PET. They created the segmentation scheme to detect the tumor in the PET image. In their research they also use the SUV.

So our objective of this research is to study the SUV calculation from PET DICOM file by using MATLAB.

II. STUDY PROCEDURE

The study of SUV calculation from DICOM file is quite new and not much found the common study. So we need to understand the meaning of the SUV, the DICOM, as well as the linking of two of them and the processing them by using MATLAB. We summarize the Study Procedure of our Research as following

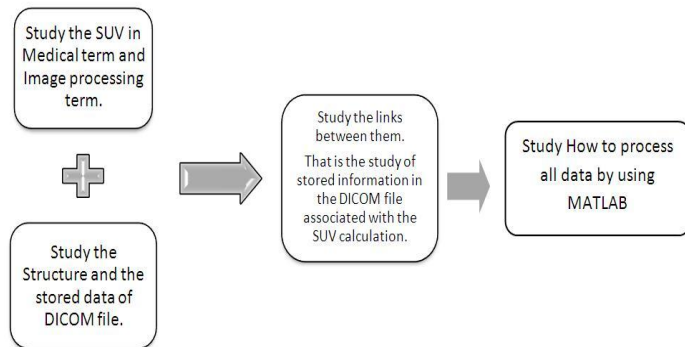


Fig. 5. The Study Procedure.

III. STUDY FRAMEWORK

A block diagram shown in (Fig 6) is the entire process of our scheme. After a set of DICOM files passed through our created scheme, the SUV are yielded.

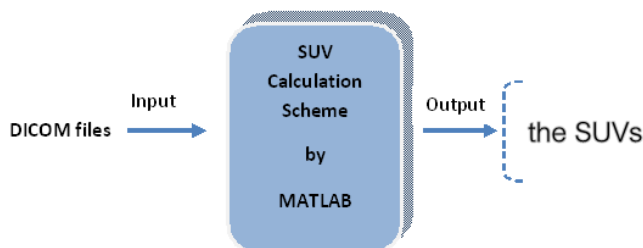


Fig. 6. The Study Framework

IV. PHANTOM PREPARING

In this study, we used DICOM files from Phantom scan. It must be prepared, and we use the WCC phantom or Well Counter Correction Phantom and do the scan according to the Phantom preparing for Quarterly QC. [12]

Preparing & Scanning WCC phantom

- 1) Adjust a holder with columnar WCC phantom before putting Activity into here.
- 2) After this, work will be done in the Laboratory or else like
- 3) Remove water inside phantom a little and put in 18F-FDG of well known amount of radioactivity. Put the time of Dose calibrator which measures the amount of radioactivity at this time, and the PET/CT scanner itself together
- 4) Stir the water in side phantom quietly with being careful that a bubble doing not appear. (be careful not to spill a liquid as much as possible)
- 5) Fill phantom with the water and being careful that a bubble becoming a minimum.
- 6) Carry out it from the room, and set on a holder of the scanner with being careful of the pollution.
- 7) Scan WCC phantom with the same protocol as with patient.

After the scan, we get a set of DICOM files. We used files that have already been corrected by the attenuation correction.

V. CALCULATION OF STANDARDIZED UPTAKE VALUE (SUV)

SUV (Standardized Uptake Value) is the value that quite often used. It is most commonly used semi-quantitative parameter utilized for analyzing FDG-PET images in routine clinical practice. It came to be used as a tool to supplement visual interpretation. The SUV is also used to distinguish between malignant and benign tumor. The cut-off value for malignant lesion is 2.5 and it has largely been proven to be an oversimplification.

In this study, the DICOM files are the main source to analyze and calculate SUV. The Component of the DICOM file can be divided into 2 main parts which are the image and metadata. The image is the part that displays the information by image and the metadata is the part that keeps the detail of the data such as dose of injection, type of scan, patient weight, patient name, etc.

We calculate the Standardized Uptake Value (SUV) and the brief meaning of SUV is the Differential Uptake Value, Dose Uptake Ratio, or Dose Absorption Ratio. For this study we used PET DICOM file that has been through the attenuation correction.

The Uptake Value is represented by Pixel intensity value in the image and the GE DICOM file. It collects the data in 16 bits so that the pixel intensity value is between 0-32767.

Therefore, the first process of the SUV calculation is the conversion of the pixel intensity value to the activity concentration.

The related attributed tag for the conversion is Rescale Slope tag, and Rescale Intercept tag (there are from metadata part). These tags vary for every image slice. So the tissue activity is calculated using formula 1.

$$U = m \cdot SV + b \quad (1)$$

Where m is rescale Slope (which is different in each image slice), SV is the stored value (Pixel intensity Value), b is rescale intercept (for PET scan is always Zero) and U is units of value after conversion (for our study is Bq/ml , Shown in Unit tag)

The conversion formula above is fundamentally defined by NEMA, however the formula maybe slightly different for each vendor. In this study we used GE DICOM file. So the method of calculation is based on GE conformance statement [9]

$$SUV_{body\ weight(kg/ml)} = \frac{Activity\ Concentration\ in\ ROI_{(Bq/ml)}}{\left(\frac{Injected\ Dose_{(Bq)}}{body\ weight_{(kg)}}\right)} \quad (2)$$

$$SUV_{body\ weight(kg/ml)} = \frac{(Pixel\ Value \times Image\ Rescale\ factor \times dose\ calibration)}{\left(\frac{actual\ activity}{body\ weight}\right)} \quad (3)$$

Where *Pixel Value* is Pixel Intensity Value in Region of Interest (ROI), *Image ScaleFactor* = Rescale Slope, *Actual activity* is Injected activity at the time of scan, *Body Weight* is Patient Body Weight (kg) and *Dose Calibration factor* must be corrected for MBq/ml to Bq/ml conversion.

For SUV is practically in the defined Volume Of Interest (VOI). We used MATLAB as a tool for this process. The SUV formula (2) requires data from both image part and metadata part so we used MATLAB to extract these data.

The steps of the SUV calculation scheme are summarized as follows:

Step 1: Extract Pixel Intensity Value in Defined ROI (region of interest).

The purpose of extraction is to note the obtained pixel intensity value for the next step of calculation, so we extract Maximum pixel intensity because we need them to calculate the SUV_{max}

Step 2: Convert Intensity Pixel Value to activity concentration (Bq).

After we extracted the desired value, the conversion of Intensity Pixel Value to Activity Concentration (Bq) is the next step. The data in this conversion based on some of the detail part (metadata). See formula (2) then become

$$Activity\ Concentration\ in\ ROI_{(Bq/ml)} = \frac{Pixel\ Value}{Image\ Scalefactor}$$

Where *Image Scale Factor* = Rescale Slope

The related tags in this part are Rescale Slope, Rescale Intercept and Units. Only Rescale slope is individual in each slice.

Step 3: Calculate SUV in each slice.

Calculate SUV by formula (3) which the related tag in this part are Total Dose (0018,1074), Series Date (0008,0021), Series Time (0008,0031), Radiopharmaceutical Start Time (0018,1072), Radiopharmaceutical Half Life (0018,1075) and Patient Weight (0010,1010)

Step 4: Integral SUV of ROI to VOI

In practical, SUV calculation is analyzed in the Volume of Interest (VOI). So In this study we calculated SUV in each slice and then summarized them which is depending on number of slices and projected the region of interest into every slice in the volume. Mean that every slice under the volume has the same size and position.



Fig.7. Integral ROIs to VOI

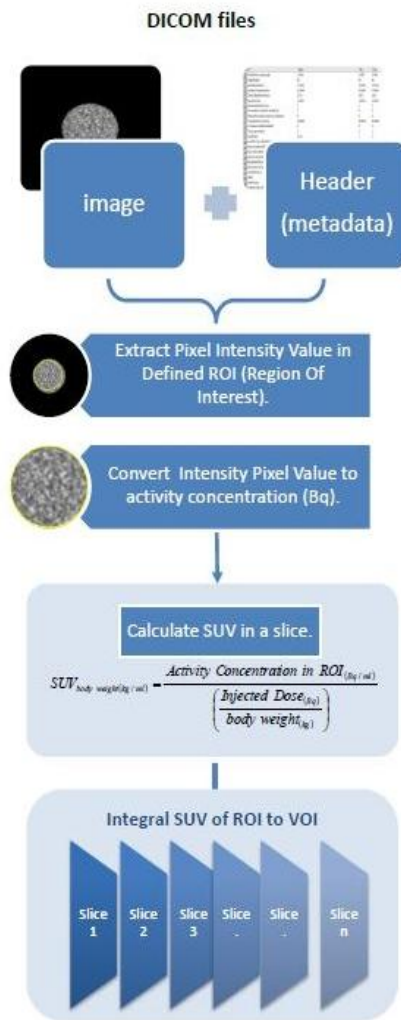


Fig. 8. The SUV calculation Scheme

VI. SCHEME TESTING

This SUV calculation Scheme is operated on the PC with installing MATLAB. In order to evaluate the performance of the scheme, it is compared to the SUV that obtained from the Well-known application software from GE healthcare (Xeleris workstation)

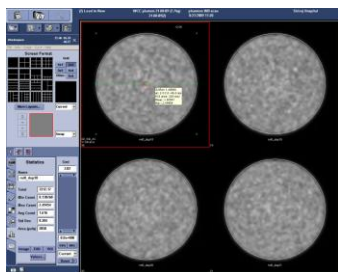


Fig 9. The screen of Xeleris Workstation from GE healthcare.

Both Xeleris and MATLAB allow interpretation of ROI analysis. Two circular ROIs were drawn surrounding the region of FDG uptake as seen in (Fig 9).

The SUV in the defined region was recorded by the Xeleris® workstation and MATLAB. Then both Xeleris and MATLAB were analyzed together for further studying the correlation of both systems.

Data were analyzed using SPSS version 11.5 and Microsoft Excel. The Normal Distribution of SUV measurement is tested on both Xeleris workstations and our scheme. The correlation of both systems is analyzed with Pearson correlation coefficient. The comparison was performed with 2 sized-ROI in 45 phantom slices.

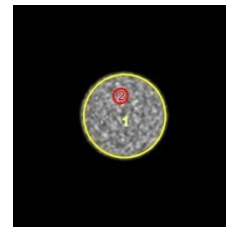


Fig. 10. Example of the 2 sizes ROI drawn on Phantom transaxial images.

VII. RESULT

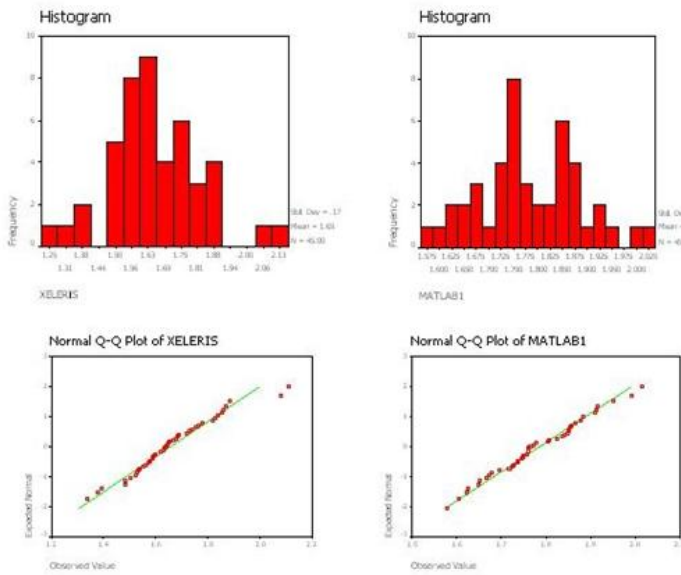
SPSS version 11.5 and Excel were used as a tool for the statistical analysis. The SUV from Xeleris and MATLAB were compared by the Pearson correlation Test. The basic descriptive statistic was shown as the mean, the standard deviation, and the histogram of the set of data that computed from both systems.

Paired Samples Statistics

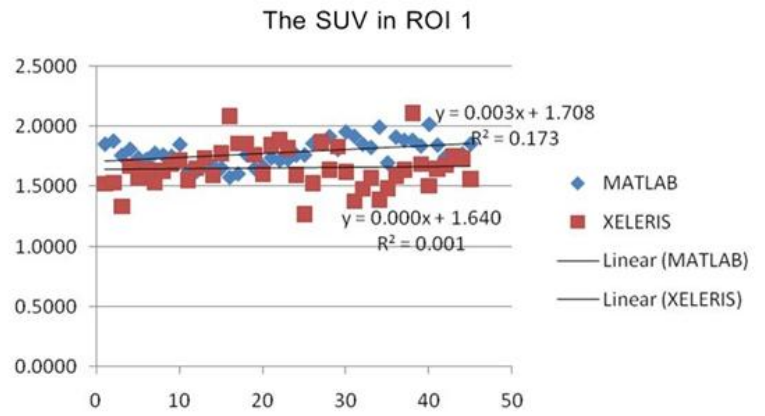
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	MATLAB1	1.783689	45	.1034177	.0154166
	XELERIS1	1.653513	45	.1718357	.0256158
Pair 2	MATLAB2	1.477956	45	.1298382	.0193551
	XELERIS2	1.640898	45	.1682660	.0250836

Fig 11. the Display result from SPSS shows the mean and standard deviation of the SUV from MATLAB and Xeleris. (MATLAB1: the SUV from MATLAB in ROI-1, Xeleris1: the SUV from Xeleris in ROI-1, MATLAB2: the SUV from MATLAB in ROI-2, Xeleris1: the SUV from Xeleris in ROI-2)

The SUV in ROI 1

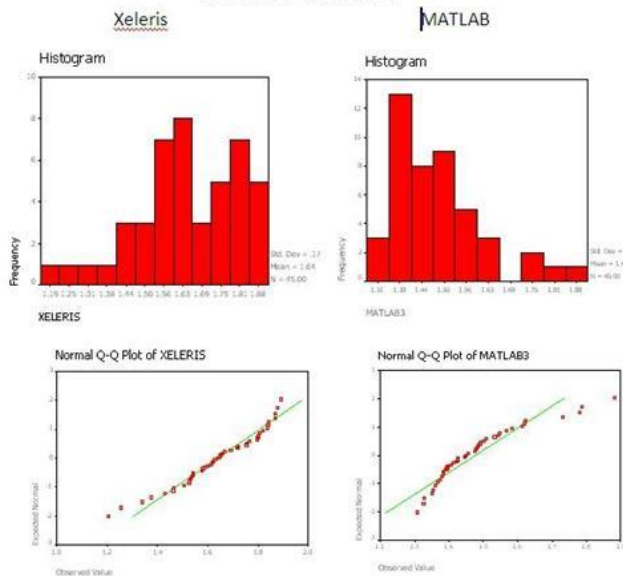


(a1)

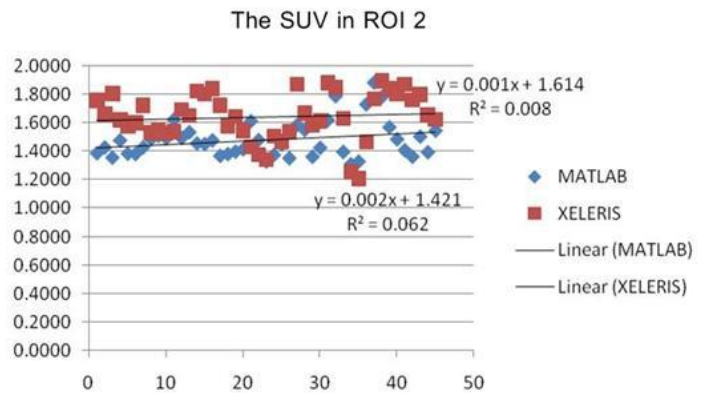


(b1)

The SUV in ROI 2



(a2)



(b2)

Fig 12 the Histogram and graph show the distribution of SUV from Xeleris workstation and MATLAB in ROI-1(a1) and ROI-2(a2), and the Scatter charts with trend line show The SUV comparison of 2 systems in ROI-1 (b1) and ROI-2 (b2).

Correlations

		XELERIS1	MATLAB1
XELERIS1	Pearson Correlation	1	-.333*
	Sig. (2-tailed)	.	.026
	N	45	45
MATLAB1	Pearson Correlation	-.333*	1
	Sig. (2-tailed)	.026	.
	N	45	45

*. Correlation is significant at the 0.05 level (2-tailed).

(a)

Correlations

		MATLAB2	XELERIS2
MATLAB2	Pearson Correlation	1	.349*
	Sig. (2-tailed)	.	.019
	N	45	45
XELERIS2	Pearson Correlation	.349*	1
	Sig. (2-tailed)	.019	.
	N	45	45

*. Correlation is significant at the 0.05 level (2-tailed).

Fig .13. the Display result from SPSS shows the Correlation of maximum SUV between 2 systems from the ROI-1 (a) and ROI-2(b).

The Result shows the Pearson's Correlation Coefficient between the two systems and also the significance which the correlation is significant at the 0.05 level (2-tailed).

The Result of Pearson Correlation tests of 2 systems in the two Region of Interests (ROIs) are following.

ROI 1 : The Pearson correlation coefficient of the SUVmax is -0.333 and the probability (2 tailed significant) is 0.26.

ROI 2 : The Pearson correlation coefficient of the SUVmax is 0.349 and the probability (2 tailed significant) is 0.019

On the above correlation tests table, the value of the significance of the SUV in ROI-1 and ROI 2 is 0.26 and 0.019, which less than 0.05, we can therefore confirm that the correlation between the two systems is statistically significant with 95% confidence.

VIII. DISCUSSION

The results show that both systems have normal distribution. The Correlation between both Xeleris Workstation and MATLAB is very good for the SUV.

The values obtained from MATLAB are a bit difference from Xeleris workstation. It might be because of some data lost in the transformation process. However, the correlation of both is very good. It allows us to apply the Regression Correction for adjustment.

This is reassuring that this novel SUV calculation scheme can interpret PET/CT images even though the worker is not on the workstation site. This research is beneficial for further study.

IX. CONCLUSION

These results indicate that the SUVs from MATLAB analysis could be used interchangeably with PET/CT Xeleris® workstation for interpretation of PET/CT image without losing the capacity to accurately measure the SUV.

REFERENCES

- [1] Joseph A. Thie, PhD, "Understanding the Standardized Uptake Value, Its Methods, And Implication for Usage" The journal of Nuclear Medicine, Vo. 45, No.9 p. 1431-1434
- [2] Soret M, Bacharach SL, Buvat I. "Partial-volume effect in PET tumor imaging". J Nucl Med. 2007;48:932-945
- [3] Francisco J.Novoa, Antonio F.Castro, Javier Pereira, Alejandro Pazos, "Development of a DICOM server for the reception and storage of medical images in digital format." Proceeding of the 4th WSEAS International Conference on Applied Informatica and communication, December 2004.
- [4] Somphob Soongsathitanon, PhD, "Wavelet-based Image Compression using a new patial search LBG Algorithm." WSEAS transactions an communications on communications, Issue 5, Volume 6, May 2007, p715-721
- [5] Somphob Soongsathitanon, PhD, "A Novel LBG algorithm for image compression in Wavelet transform Domain", Proceeding of the 11th WSEAS International Conference on Applied Mathematics, March 2007, p.153-157
- [6] Armando Jiménez-Herrera, Carlos Avilés-Cruz and Rene Arechiga-Martínez, "Minimum PACS system based on DICOM standard", Proceeding of the 11th WSEAS International Conference on Computers, July 2007.
- [7] Gustavo S.P. Meirelles, Peter kijewski, Timothy, "Correlation of PET/CT standardized Uptake Value measurements between Dedicated workstations and PACS-integrated workstation system" Journal of Digital Imaging, Vol 20, NO.3(September)2007, p.307-313
- [8] M.Teras, T.Tovanen, J.J.Johnasson, J.J.Williams, J.Knunti, "Performance of the new generation of whole-body PET/CT scanners: Discovery STE and Discovery VCT", Eur journal Nuclear Molecular
- [9] ACR-NEMA, "Digital Imaging and Communication in Medicine (DICOM) Positron emission tomography image objects Supplement 12 "
- [10] GE Medical System, "Technical Publication Advance TM 5.1 Conformance Statement for DICOM V3.0", GE Healthcare, p. 3_17 – 3_21
- [11] Aparna Kanakatte, Jayavardhana Gubbi, Nallasamy Mani, Tomas Kron, David Binns, "A Pilot Study of Automatic Lung Tumor Segmentation from Position Emission Tomography Images using Standard Uptake Values", Proceedings of the 2007 IEEE symposium on Computational Intelligence in Image and Signal Processing (CIISP 2007), p 363-368
- [12] GE Medical System, "DiscoverySTE Quick Manual", GE Healthcare MISM Tip application, p. 28-38
- [13] Imaging (2007)34, p.1683-1692
- [14] Mark. T Madsen, "Selecting New PET/CT System", Technology talk, 2004 American College of Ragiology, p.356-358
- [15] <http://qibawiki.rsna.org/>

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Malulee Tuntawiroon was born at Bangkok, on July 20, 1946. She received her B.Sc in Medical Physics and M.Sc in Nuclear Medicine from M.D. Anderson Hospital and Tumor Institute, University of Texas at Houston, USA in 1966. She is an Associate Professor and currently a lecturer of the Master of Science Programme (Radiological Science), Teaches principles of health physics for care and treatment of patients to resident physicians, provides health physics information, technical data and advices to ensure existing safety standards at Mahidol University, Bangkok, Thailand.

Her interest and Research Experiences (1955-2010) is the Radiation safety and dosimetric calculations.

Somphob Soongsathitanon*(Corresponding Author) was born at Ratchaburi in Thailand on 20 October 1973. He graduated in electrical engineering from the Sirindhorn International Institute of Technology (SIIT), Thammasat University, Thailand in 1996. Then he received Master of Science in Operational Telecommunications from Coventry University, United Kingdom in 1998. After two years work experience, he registered at Newcastle University, Newcastle upon Tyne, United Kingdom in 2000 for a Ph.D. in computer engineering. He completed the doctoral research in Digital Image Processing in 2004. He has had a long research career in Thailand and England. He has published a number of papers in the area of video block matching algorithms and digital image processing. Currently he works as a lecturer in Nuclear Medicine Division, Faculty of Medicine Siriraj Hospital, Mahidol University, Thailand.