A novel Standardized Uptake Value (SUV) calculation of PET DICOM files using MATLAB.

PAWITRA MASA-AH and SOMPHOB SOONGSATHITANON*
Nuclear Medicine Division, Department of Radiology,
Faculty of Medicine Siriraj Hospital, Mahidol University,
2 Prannok Rd., Bangkoknoi, Bangkok, 10700
THAILAND
*Corresponding author: sissst@mahidol.ac.th

Abstract: - This paper presents a novel SUV calculation scheme for PET DICOM files using MATLAB and 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 results show that the SUV calculation scheme for PET DICOM file using MATLAB is comparable with the SUV taken from the GE healthcare application software. 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.

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

1 Introduction

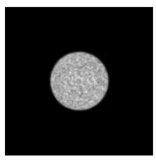
In Nuclear medicine, Positron Emission Tomography (PET) scanner plays an important role in both diagnosis and staging of cancers. The hybrid system of a PET scanner combined with CT scanner (PET/CT) has gained popularity in the oncological community since its commercial introduction to the market in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

For the F18-FDG uptake evaluation of the tumor metabolism quantitatively. SUV (Standardized Uptake Value) is the one 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.

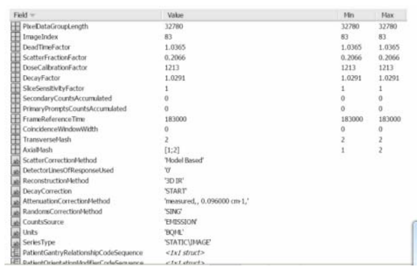
DICOM file was a file format that developed by the DICOM Standards Committee whose members are also partly members of NEMA. The Strength of DICOM files is the exchangeability between two entities that are capable of receiving image and patient data. DICOM also enables the integration of scanners, servers, workstations, printers, and network hardware from multiple manufacturers into a picture archiving and communication system (PACS).

A DICOM file is divided into two major sections. there are part of the DICOM image and the data header (DICOM elements or Metadata). DICOM image (Fig 1) shows a more detailed list of the DICOM header as displayed by the software. The data header or DICOM elements (Fig 1) required depends on the image type.

In this research we use MATLAB as a DICOM viewer and also for analysis. These are the reviewed DICOM file by MATLAB.



(a)



(b)

Fig. 1. The DICOM file is reviewed by MATLAB (a.) Image part (b.) Metadata part

2 Study Framework

This is a block diagram in our study that show the process, After a set of DICOM files throughout our created scheme, the scheme yielded the SUVmaximum and SUVmean

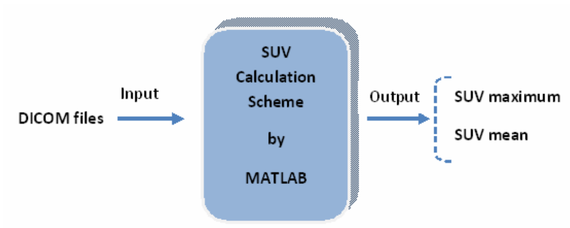


Fig. 2. The Study Framework

3 Calculation of Standardized Uptake Value (SUV).

SUV (Standardized Uptake Value) is the one 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 have 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 keep 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 bit 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 varies for every image slice. So the tissue activity is calculated using formula 1.

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

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 the fundamental 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 [8]

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

$$SUV_{body\ weight(kg/ml)} = \frac{\left(\frac{Pixel\ Value}{Image\ Scale\ Factor}\right)}{\left(\frac{actual\ activity}{body\ weight}\right) \times \left(dose\ calibration\ factor \times 10^{6}\right)} \qquad (3)$$

Where *Pixel Value* is Pixel Intensity Value in Region of Interest (ROI), $Image\ Scale\ factor = Rescale\ Slope \times 10^{-6}$, *Actual activity* is Injected activity at the time of scan, *Body Weight* is Patient Body Weight *(kg)* and *Dose Calibration factor* must be multiplied by 10^{-6} for *MBq/ml* to *Bq/ml* conversion.

For SUV is practically in the defined Volume Of Interest (VOI). We used MATLAB as a tool in the process. The SUV formula(2) have shown the requirement of data which are from image part including metadata part. Here we used MATLAB to extract these data.

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

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 Mean and Maximum pixel intensity because we need them to calculate the SUVmean and SUVmax

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

$$\text{Activity Concentration in ROI} = \frac{\text{Pixel Value}}{\text{Image Scale factor}}$$

Where $\text{Image Scale factor} = \text{Rescale Slope} \times 10^{[illegible]}$

The related tag 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), Radiophamaceutical Start Time (0018,1072), Radiophamaceutical Half Life (0018,1075) and Patient Weight (0010,1010)

Step 4: Integral SUV of ROI to VOI

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

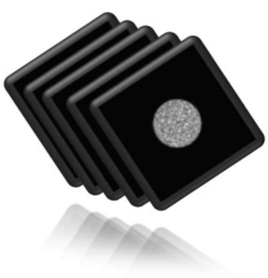


Fig. 2. Integral ROIs to VOI

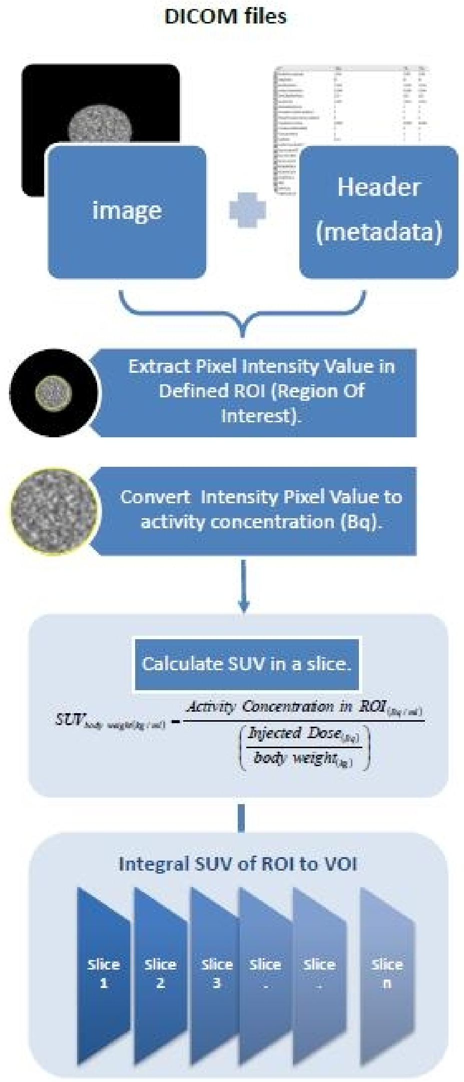


Fig. 3. The SUV calculation Scheme

3 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)

Xeleris and MATLAB all allow interpretation of ROI analysis. Three circular ROIs were drawn surrounding the region of FDG uptake. see the demonstration in the fig. 4.

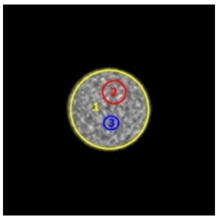


Fig. 4. Example of the 3 sizes ROI drawn on Phantom transaxial images

The maximum SUV was recorded and mean SUVs of the malignant lesion were calculated and recorded by the Xeleris® workstation and MATLAB. And the Xeleris and MATLAB were analyzed together for further studying the correlation of both system.

Data were analyzed using SPSS software. Correlation of the SUV measurement between the dedicated Xeleris workstations and MATLAB was measured with Pearson correlation coefficient. The comparison was perform with 3 sized-ROI in 45 phantom slice.

4 Results

The result shown that the Correlation between Xeleris Workstation and MATLAB was very good for the $SUV_{maximum}$ and SUV_{mean}. This is reassuring, Because it mean that the proposed of the SUV calculation scheme can interpret PET/CT images even though the worker is not on the workstation site.

5 Conclusion

These Result indicate that the SUVs from MATLAB analysis could be used interchange 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] 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

[3] S.Chicklore, P.Jaye, S.Vijayanatham, D.Gallacher, *"Comparing diagnostic accuracy of digital images viewed on a Picture Archiving and Communication System(PACS) diagnostic workstation and on a Personal Computer(PC)-Based imaging system"* St Thomas' Hospital, London, UK

[4] ACR-NEMA, *"Digital Imaging and Communication in Medicine (DICOM) Positron emission tomography image objects Supplement 12 "*

[5] 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

[6] 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 Imaging (2007)34, p.1683-1692

[7] Mark. T Madsen, *"Selecting New PET/CT System"*, Technology talk, 2004 American College of Ragiology, p.356-358

[8] GE Medical System, *"Technical Publication Advance TM 5.1 Conformance Statement for DICOM V3.0"*, GE Healthcare, p. 3_17 – 3_21

[9] http://qibawiki.rsna.org/

[10] GE Medical System, "DiscoverySTE Quick Manual" , GE Healthcare MISM Tip application, p. 28-38