Establishment of the Standardized Uptake Values of 99mTc-MDP in Normal Vertebrae for SPECT/CT Quantification

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Abstract

Purpose

To establish the standardized uptake value (SUV) of Tc-99m-methylene diphosphonate (MDP) for normal vertebra in both Chinese male and female by using a SPECT/CT scanner.

Methods

A retrospective study was carried out involving 116 men and 105 women who underwent SPECT/CT scan using ^{99m}Tc-MDP. We acquired the SUV, CT value of 2416 normal vertebra in total and analyzed the difference of SUV between men and women. We analyzed the vertebra data with no significant difference of SUVmax in male and female group. The correlations between SUVmax value and CT value, age, height, weight in each group were also analyzed.

Results

The SUVmax, SUVmean of vertebra in men were markedly higher than those in women($P < 0.0009$). Specifically, for males, the SUVmax of C1, C2-4 and C5-L5 vertebra appeared to have significant differences($P < 0.05$), while no significant difference of the SUVmax of C1-L5 vertebra were observed in females($P < 0.05$). The SUVmax of each vertebral segment showed a strong negative correlation with CT values in both men and women(r=-0.89,-0.92;$P < 0.0009$). The SUVmax of vertebra showed weak significant correlation with weight and height in male (r = 0.4,$P < 0.0009$;r = 0.28,$P = 0.005$),and weak significant correlation with weight in females(r = 0.32,P = 0.009).

Conclusion

This article study initially established SUVmax, SUVavgmean of normal vertebra in both Chinese men and women with a large sample population,and summarized the SUVmax of vertebra with no significant difference. The results could provide a quantitative reference for clinical diagnosis and the evaluation of therapeutic response in vertebral lesions.

Introduction

Radionuclide bone imaging is the most frequently used imaging technology in nuclear medicine, accounting for about 60.3% in SPECT/CT examination per year in China [1]. Up to now, the differentiation between lesions and normal bone tissue was mainly based on visual diagnosis, while quantitative analysis has not been well applied due to the lack of appropriate reconstruction algorism. Quantitative PET bone imaging based on ^{18}F-NaF is considered to have potential clinical value. However, ^{18}F-NaF PET/CT is quite expensive with limited availability, especially in China [2]. The development of SPECT/CT technology has enabled quantitative assessments of bone imaging using Tc-99m-diphosphonate methylene (MDP), a prevailing used SPECT tracer for bone imaging, which costs less and Tc-99m has a longer half-life compared to ^{18}F-NaF, making it more suitable for the clinical use in a large scale [3].

Michael Beck et al. [4] conducted a longitudinal follow-up of 52 bone metastases in 19 patients using SPECT/CT with visual analysis and quantitative analysis.They found that there was a high agreement among the observers in quantitative analysis, while visual analysis was was 42% inconsistent with quantitative analysis.Samul et al. [5] proved that standardized uptake value(SUV) obtained from SPECT images of bone metastases of breast and prostate cancer were significantly correlated with SUV obtained from PET images. These findings indicated the feasibility of SPECT quantification using SUV in the clinic.

Bone tissue uptake of ^{99m}Tc-MDP is proportional to blood flow and mineral metabolism [6]. Hence, bones at different sites can have different normal SUV values. Due to the larger bone conversion in the spine than other sites of bone, the spine is the most suitable place to quantitatively assess bone metabolism [7][8]. Bone metastasis is a common complication of cancer,and bone is the third most common site of metastasis after lung and liver [9]. For bone metastatic malignant lesions, spine is the most commonly invaded site [10]. Therefore, establishing the SUVmax range of normal vertebra is of great value in clinical practice. Tomohiro et al. [11] performed a quantitative study of SPECT/CT in 29 patients, and measured the MDP of normal vertebra with different SUV values. The results demonstrated that SUVmax had the lowest variance coefficient, indicating that SUVmax was a suitable quantitative indicator in bone imaging.

So far, only few quantitative studies with small sample sizes reported SUV of partial normal vertebra, and quantitative studies with large samples size investigating all the segments of normal cervical, thoracic and lumbar vertebrae are rare[11][12][13].The aim of this study was to establish the SUVmax for ^{99m}Tc-MDP in normal vertebra of both Chinese men and women using SPECT/CT imaging.

Methods

Patients

Retrospective analysis was performed on patients who underwent SPECT/CT scan in Shanghai East Hospital from August 2016 to October 2019, and all patients or family members signed informed consent for examination. This retrospective study was approved by institutional review board of Shanghai East Hospital.

The following are the patient’s exclusion criteria history of primary bone tumor or metastatic bone tumor; history of bone metabolic diseases such as rickets and osteoporosis; history of vertebral fractures;ankylosing spondylitis, sclerosing osteitis, vertebral tuberculosis and other inflammatory lesions history of renal insufficiency.

Height, weight, full needle dose and empty needle dose before and after bone imaging agent injection, and injection time were recorded. All subjects were injected with 25-30 mCi (9.24×10^8-1.11×10^9 Bq) ^{99m}Tc-MDP and received whole-body planar imaging and tomographic imaging for examination purposes within 4-5 hours. Each test took approximently 40 minutes.

Data acquisition

We used Siemens Symbia Intevo T16 (CT Max. 16 pieces per rotation acquisition), a low energy high resolution collimator with a single probe rotation 30 projections over 180° with 20s acquisition time per view, 256×256 matrix, pixel size 2.4×2.4 mm^2, 2.4 mm thickness. Low-dose CT scan was performed at 130 kV and 10 valid mAs. CT data were reconstructed using a smooth attenuation-correction kernel B31s with 3 mm slice thickness and a sharp bone kernel B50s with 5mm slice thickness. SPECT reconstruction was performed based on the B31s CT attenuation map of ordered subsets conjugate gradient enhanced OSCGwith two subsets and twenty-eight iterations without post-smoothing,which gave SUV results comparable to PET.

Two experienced nuclear medicine physicians screened out the normal vertebrae by the exclusion criteria mentioned above and also referred to the other imaging tests such as CT or MRI. Vertebra that were considered normal by both physicians were eventually included in the study. They drew volum of interest (VOI) including cortical bone and sponges tissue (using Siemens 3D Isocontour) on its sagittal position. SUVmax, SUVmean and CT values were recorded. Figure 1 shows the representative coronal, sagittal, and transversal images with VOIs of a patient.

Statistical analysis

The age of the male and female group was tested by independent sample T test.The SUVmax values of 24 vertebras in each group were analyzed using ANOVA variance homogeneity test and LSD multiple comparison test. Pearson correlation analysis was performed between SUVmax and CT value, height, weight and age. Statistical analysis was performed using SPSS 23.0 statistical software. All data was expressed as mean ± standard deviation (SD). *P*0.05 was considered statistically significant.

Results

Patient data

A total of 221 patients were included in this study. The collected data and statistical analysis of male and female patients are listed in Table 1. For male patients, the mean±SD of SUVmax and SUVmean of all the included vertebrae sre 7.86±1.57 and 4.97±1.01. The CoV of SUVmax and SUVmean are 0.19 and 0.20 respectivily. For female patients, the mean±SD of SUVmax and SUVmean are 6.07±1.63 and 4.59±1.02. The CoV of SUVmax and SUVmean are 0.23 and 0.22. The detailed inclusion number, CT value, SUVmax and SUVmean of 24 vertebrae in the two groups are shown in Table 2 and Table 3 respectivelyat the end of the article. Specifically, the SUVmax and SUVmean of each vertebra are analyzed using Box-and-whisker plots (Fig 2 & 3). Table 4 separately shows the SUVmax of cervical, thoracic, lumbar in male participants (7.66±1.74, 8.01±1.52, 7.75±1.46) and female participants (6.85±1.64, 7.01±1.68, 7.04±1.47).

SUV data comparison between male and female patients

Paired t-test was performed to compare the differences of SUV in each vertebra between male and female patients (Table 5). Significant statistical differences were observed in SUVmax of almost all the vertebra (91.6%) except C1 and L4 vertebra ($P < 0.05$). For SUVmean, more than half of the vertebra (62.5%) showed significant differences between male and female patients. For each vertebral segment, both SUVmax and SUVmean was found to have significant differences in C6-C7, T1-T11 between male and female participants. Table 4 demonstrated that the SUVmax of cervical, thoracic, lumbar in male participants were higher than that in female participants（P＜0.0009).

ANOVA variance homogeneity test and LSD multiple comparison test were performed to compare the differences of SUVmax between each vertebra in male and female, respectively. Table 6 summarized the vertebral segments that show no statistical difference in SUVmax of male and female participants.

Correlation analysis

Correlations of vertebral SUVmax with CT value, age, weight, height were analyzed separately. A strong negative correlation was found between SUVmax and CT value in both male ($r = -0.89$; P＜0.0009) and female ($r = -0.91$; P＜0.0009) group (Table 7). For male participants, there was no significant correlation between vertebral SUVmax and age. But the correlation of vertebral SUVmax with height and weight was found to be weak ($r=0.28$, $P=0.005$; $r = 0.4$, $P < 0.0009$) (Table 7）. For female participants, Table 7 also demonstrated that vertebral SUVmax had no significant correlation with age and height but had a weak correlation with body weight ($r=0.32$ $P=0.009$).

Discussion

Advances in SPECT reconstruction techniques have allowed for the use of quantitative image metrics such as SUV to be used in ^{99m}Tc-MDP bone imaging studies. Israel et al. [14] was the first to calculate the ^{99m}Tc-MDP in vertebra without attenuation correction,and the error was about 30–40%. Recently,with the introduction of CT-based attenuation correction,the error of calculating SUV in SPECT/CT images was less than 10% [15],leading to the widespread use of SPECT/CT bone quantification in clinical studies. SPECT/CT quantification has been demonstrated as an efficient tool for evaluating the efficacy of disease [16][17] and identifying the benign and malignant bone diseases [18].To the best of our knowledge, this is the first large sample study to obtain SUV measurements of all 24 vertebrae based on OSCG-enhanced reconstruction algorithm of CT attenuation correction.

Cachovan et al.[12] used SPECT/CT bone quantification to obtain the mean SUVmax of ^{99m}Tc - diphosphono - sponge propanedi - carboxylic acid (DPD) of L3-5 vertebral spongy bone in 50 females (mean ± SD = 5.91 ± 1.54). In our study, the mean SUVmax of lumbar in female participants was 7.04 ± 1.47, which was slightly higher than the reference value,because the tracer kinetics were not same，this might lead the different results.On the other hand,in our study, the VOI contained the cortical part of the bone that high bone salt metabolism leading to the increased SUVmax. The results remind us that when comparing SUV of bones, it is important to determine whether bone cortex is included in VOI. The

SUVmax of normal vertebra in our study was similar to the previously reported studies which also included bone cortex in their VOIs[19] [20]. And the VOI of both studies also included bone cortex. It is well known that bone lesions including tumors, inflammation and other diseases often end up with cortical hyperplasia[21][22].Thereafter,we highly recommend that to establish the normal vertebral SUVmax, cortical bone should be included when outlining the VOI.

Hounsfield Unit(HU) is a commonly used measurement index in CT images that indicates the X-ray attenuation degree in tissue (also known as bone density). Bone mineral density (BMD) obtained through dual X-ray absorptiometry (DEXA) is the gold standard and previous studies showed a significant positive correlation between HU and BMD[23][24]. By analyzing the correlation between CT value and SUV, we found that SUVmax of each vertebral segment had a negatively strong correlation with the CT value (HU), which is contrary to the results of previous studies [20][25][26],those only analyzed the relationship between SUVmax and CT value of lumbar vertebrae while the gravity and blood supply of vertebral bodies were consistent. Different from previous studies, we analyzed the relationship between SUVmax and CT value of all vertebral body segments.SUVmax of 99mTc-MDP in bone is often associated with blood supply and bone mineral density [27]. Maybe due to the influence of gravity and calcium loss in elderly,the bone mineral density of lumbar vertebra was lower than the cervical vertebra in our study. The blood supply of the lumbar artery from the abdominal aorta is richer than that from the vertebral artery [28] and increased pressure of lumbar leads richer blood supply[11]. So although the CT value of the lumbar spine was lower, it might have a high SUVmax. This might explain why we got the opposite resul, but the mechanism underlying this correlation need further investigation. And we separately compared the correlation of SUmax and CT in different vertebral segment (data not shown). The result was consistent with previous study in lumbar vertebrae.

It has been reported that SUVmax of the vertebra and pelvis was independent of height, however, the results are controversial[29][30][11]. The opposite conclusions from these studies may due to the small sample size. With a large sample size, our results showed that SUVmax was positively correlated with the height,weight in men and with the weight in women which further validated the hypothesis proposed by Tomohiro et al. [11] that the increased pressure leads to more blood supply, thus resulting in the increasing SUVmax. In our study, the SUVmax and SUVmean were significant higher in men than those in women. This may also be due to the women’s height in our study was generally lower compared to men. In addition, the female participants were mostly postmenopausal,and it has been reported that decreased estrogen levelmay cause bone density decline[31]. Since the number of participants in each age group was not evenly distributed by height, we did not find a correlation between SUV value and age.

Our study found no difference in the coefficient of variation between SUVmax and SUVmean. The results suggested that both SUVmax and SUVmean could be used as reference value of normal physiology. And further studies of precise grouping will be conducted to verify our results. Different from a previous study [11], our results showed that the SUVmax variation coefficient of T8 vertebrae of men and L2 vertebrae of women was the smallest, suggesting that they could be used as an optimal reference in the future studies.To obtain the normal value of vertebrae in each segment of men and women, we summarized the

SUVmax value of the vertebrae with no significant statistical difference as reference for clinical validation.

Our study also has the following limitations. Although age distribution was wide, the uneven distribution of research object number of each age group could make it is hard to reflect the SUVmax of all ages. In addition, the SUVmax acquired in our study was all based on the weight. Since the ^{99m}Tc-MDP uptake mainly exists in bone, the standardization of bone volume can improve the accuracy of quantification[32]. This indicated that bone volume should be included in future studies. The quantitative accuracy of bone imaging is also affected by the reconstruction parameters. Previous studies have shown that quantitative values increase with higher number of iterations, 50–100 iterations reached a steady state [33]. Thus, in SPECT/CT, it is important to optimize the reconstruction parameters and improve the quantitative accuracy. Therefore, in future studies, we will further stratify experimental subjects according to age and height, BMI and further optimize reconstruction parameters to obtain more accurate bone quantitative standard values.

Conclusion

This study has established the SUVmax, SUVmean of normal vertebrae in both Chinese men and women with a large sample population. SUVmax of the normal vertebrae which showed no significant difference between male and female participants were summarized. as a reference for clinical diagnosis and therapeutic evaluation of bone lesions.

Declarations

Ethical Approval and Consent to participate: Ethical approval was waived by the local Ethics Committee of Shanghai East Hospital in view of the retrospective nature of the study and all the procedures being performed were part of the imaging examination.

Consent for publication: Not applicable.

Availability of supporting data: The datasets used or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Tables

Table 1. Patient Demographics

Parameters	Male	Female
Included number	116	105
Age (range, mean±SD)	29-89, 66.28±10.765	29-89, 62. 84±11.486
Weight (range, mean±SD)	35-85, 62.8±11.0	37-90, 58.5±10.2
Height (range, mean±SD)	150-181, 168.4±6.3	145-173, 148.9±5.4
CT values (HU) (range, mean±SD, CoV)	46.6-737.3, 224.9±100.0, 0.44	53.1-646.1, 224.2±93.2,0.42
SUVmax (range, mean±SD, CoV)	3.29-12.69, 7.87±1.57, 0.19	2.47-11.69, 6.97±1.63, 0.23
SUVmean (range, mean±SD, CoV)	2.34-9.03▯4.97±1.02, 0.20	2.47-7.62,4.59±1.02, 0.22

Table 2. Inclusion number, CT value, SUVmax and SUVmean of each vertebrae of male participants

vertebrae	Included number	CT values (HU，mean±SD，CoV	SUVmax			SUVmean		
			(mean±SD)	Range	CoV	(mean±SD)	Range	CoV
C1	36	466±98，0.21	6.46±1.33	3.53-9.66	0.21	3.89±0.59	2.34-5.26	0.15
C2	41	387±77，0.20	7.16±1.88	3.29-11.14	0.26	4.41±1.01	2.78-8.24	0.23
C3	42	360±74，0.21	7.38±1.51	4.20-10.87	0.20	4.69±0.79	3.34-7.13	0.17
C4	43	364±61，0.17	7.79±1.36	5.55-10.55	0.17	4.98±1.00	3.31-8.04	0.20
C5	41	375±94，0.25	8.04±1.71	4.65-12.14	0.21	5.01±1.01	3.21-7.20	0.20
C6	42	319±89，0.28	8.16±1.50	5.35-10.81	0.18	5.37±1.09	3.65-8.55	0.20
C7	52	272±62，0.23	8.29±2.0	4.07-12.69	0.24	5.32±1.17	3.07-8.20	0.22
T1	56	233±38，0.16	8.41±1.87	5.16-12.61	0.22	5.33±1.13	3.35-8.86	0.21
T2	59	215±46，0.22	7.92±1.77	4.61-11.90	0.22	5.02±1.06	3.32-7.80	0.21
T3	43	213±47，0.22	7.96±1.24	3.61-10.31	0.16	5.19±0.98	3.05-7.39	0.19
T4	50	211±38，0.18	7.72±1.71	4.23-11.83	0.22	4.86±0.98	3.27-7.16	0.20
T5	50	201±36，0.18	8.06±1.51	4.70-11.84	0.19	5.09±0.97	3.11-7.37	0.19
T6	52	190±39，0.21	7.84±1.48	4.47-10.88	0.19	5.00±1.02	2.93-7.18	0.20
T7	55	180±35，0.19	8.02±1.61	4.20-11.13	0.20	5.14±1.15	2.98-8.21	0.22
T8	43	181±37，0.20	8.17±0.83	5.74-9.71	0.10	5.26±1.16	3.77-7.69	0.17
T9	56	175±40，0.23	8.16±1.60	4.81-11.69	0.20	5.24±1.16	3.44-7.86	0.22
T10	56	172±38，0.22	8.04±1.72	4.08-11.30	0.21	5.02±0.89	2.99-6.95	0.18
T11	55	160±37，0.23	7.82±1.32	5.23-10.96	0.17	5.00±0.87	3.33-7.10	0.17
T12	55	152±40，0.25	7.96±1.22	5.05-10.03	0.15	4.97±0.87	3.19-6.93	0.18
L1	52	151±46，0.30	7.98±1.76	4.09-11.83	0.22	4.94±1.13	3.48-9.03	0.23
L2	52	149±40，0.27	7.90±1.34	4.88-11.58	0.17	4.94±0.92	3.28-7.52	0.19
L3	49	149±35，0.23	7.57±1.66	3.91-11.77	0.22	4.69±0.93	3.01-8.38	0.20
L4	48	157±41，0.26	7.51±1.30	4.98-10.69	0.17	4.59±0.83	3.15-8.31	0.18
L5	48	164±45，0.27	8.26±1.82	5.34-16.98	0.22	5.03±0.81	3.61-7.13	0.16

Table 3. Inclusion number, CT value, SUVmax and SUVmean of each vertebrae of female participants

vertebrae	Included number	CT values (HU）	SUVmax			SUVmean		
			(mean±SD)	Range	CoV	(mean±SD)	Range	CoV
C1	39	407±90（0.22	6.32±1.75	2.72-9.88	0.28	3.80±0.64	2.65-4.99	0.17
C2	46	351±105（0.30	6.32±1.50	2.47-10.04	0.24	3.96±0.63	2.47-5.27	0.16
C3	50	323±77（0.24	6.65±1.57	2.97-10.29	0.24	4.33±0.91	2.69-7.32	0.21
C4	50	348±83（0.24	7.09±1.83	3.14-10.89	0.26	4.66±1.23	2.74-8.68	0.26
C5	52	337±72（0.21	7.11±1.51	3.60-10.20	0.21	4.71±1.17	2.93-8.90	0.25
C6	52	301±64（0.21	7.03±1.54	3.87-10.59	0.22	4.76±1.05	2.96-8.77	0.22
C7	61	272±57（0.21	7.17±1.62	3.64-10.42	0.23	4.85±1.09	2.89-6.62	0.23
T1	63	245±57（0.23	7.29±1.52	3.74-10.58	0.21	4.92±1.04	2.92-7.14	0.21
T2	65	230±43（0.19	6.99±1.53	3.07-9.96	0.22	4.64±0.93	2.95-7.18	0.20
T3	45	221±44（0.20	6.91±1.88	2.50-11.69	0.27	4.43±0.93	2.50-6.42	0.21
T4	46	215±44（0.20	6.77±1.69	3.20-10.11	0.25	4.46±1.12	2.83-8.35	0.25
T5	45	205±44（0.21	6.77±1.76	3.66-11.47	0.26	4.51±1.03	2.92-7.92	0.23
T6	49	195±39（0.20	7.03±1.84	2.64-10.74	0.26	4.55±1.00	2.55-7.28	0.22
T7	54	186±42（0.23	6.96±1.72	3.09-10.14	0.25	4.60±1.05	2.80-7.47	0.23
T8	53	182±42（0.23	7.06±1.69	3.44-9.82	0.24	4.59±1.03	3.01-7.18	0.22
T9	59	178±47（0.26	7.24±1.60	3.83-10.42	0.22	4.72±0.97	3.14-6.57	0.21
T10	55	179±44（0.25	6.98±1.71	3.40-11.42	0.24	4.61±0.93	2.93-6.37	0.20
T11	58	170±44（0.26	7.06±1.83	2.93-11.07	0.26	4.58±0.91	2.65-6.24	0.20
T12	55	155±41（0.26	6.98±1.73	2.77-12.50	0.25	4.70±1.07	2.77-8.97	0.23
L1	58	144±37（0.26	7.18±1.61	3.19-10.58	0.22	4.87±1.03	3.17-7.00	0.21
L2	48	146±40（0.27	6.81±1.15	4.15-9.53	0.17	4.70±0.87	3.28-6.70	0.19
L3	46	142±49（0.36	6.70±1.32	3.18-9.35	0.20	4.43±0.79	2.75-6.22	0.18
L4	50	155±49（0.32	7.21±1.75	3.37-11.27	0.24	4.54±1.11	2.55-9.94	0.24
L5	42	158±59（0.37	7.18±1.75	4.65-10.52	0.21	4.85±1.41	3.33-11.07	0.29

Table 4. SUVmax of cervical, thoracic, lumbar vertebrae in male and female participants

SUVmax (range,mean±SD)	Male	Female	T-test *P*
CERVICAL	3.29-12.69,7.66±1.74	2.47-10.89,6.85±1.64	<0.0009
THORACIC	4.08-12.61,8.01±1.52	2.50-11.69,7.01±1.68	<0.0009
LUMBAR	3.91-11.83,7.75±1.46	3.19-11.27,7.04±1.47	<0.0009

Table 5. Differences of SUVmax and SUVmean between male and female participants in each vertebra

	P1	*P2*
C1	0.442	0.468
C2	0.007*	0.005*
C3	0.038*	0.041*
C4	0.071*	0.192
C5	0.004*	0.144
C6	0.002*	0.011*
C7	0.004*	0.044*
T1	0.001*	0.021*
T2	0.006*	0.023*
T3	0.006*	0.000*
T4	0.003*	0.037*
T5	0.000*	0.003*
T6	0.008*	0.030*
T7	0.002*	0.024*
T8	0.000*	0.003*
T9	0.008*	0.024*
T10	0.001*	0.027*
T11	0.022*	0.019*
T12	0.001*	0.186*
L1	0.018*	0.988
L2	0.000*	0.267
L3	0.001*	0.163
L4	0.211	0.939
L5	0.013*	0.459

P1, P2 represent the paired sample T test results of SUVmax and SUVmean of each vertebra in the two groups, *$P<0.05$.

Table 6. The SUVmax of vertebral segment with no difference SUVmax in male and female participants

	male			female
	C1	C2-C4	C5-L5	C1-L5
SUVmax mean	6.46	7.45	7.97	6.97
SD	1.33	1.6	1.54	1.63
min	3.53	3.29	3.91	2.47
max	9.66	11.14	12.69	11.69

Table 7. Correlations between SUVmax and CT values, age, height, weight in male and female group

	Male		Female	
	r	*P*	r	*P*
CT value	-0.89	0.0009	-0.92	0.0009
Age	-0.45	0.656	0.23	0.069
Height	0.28	0.005	0.22	0.075
Weight	0.4	0.0009	0.32	0.009

r represent the the correlation coefficient of Pearson correlation analysis, *P* represents the significance, *P* 0.05.

Figures

Figure 1

Transaxial (A), saggital (B) and coronal (C) images of a patient’s SPECT/CT fused data sets including thoracic and lumbar regions.The ellipses depict the VOI of L2 using Siemens 3D Isocontour).

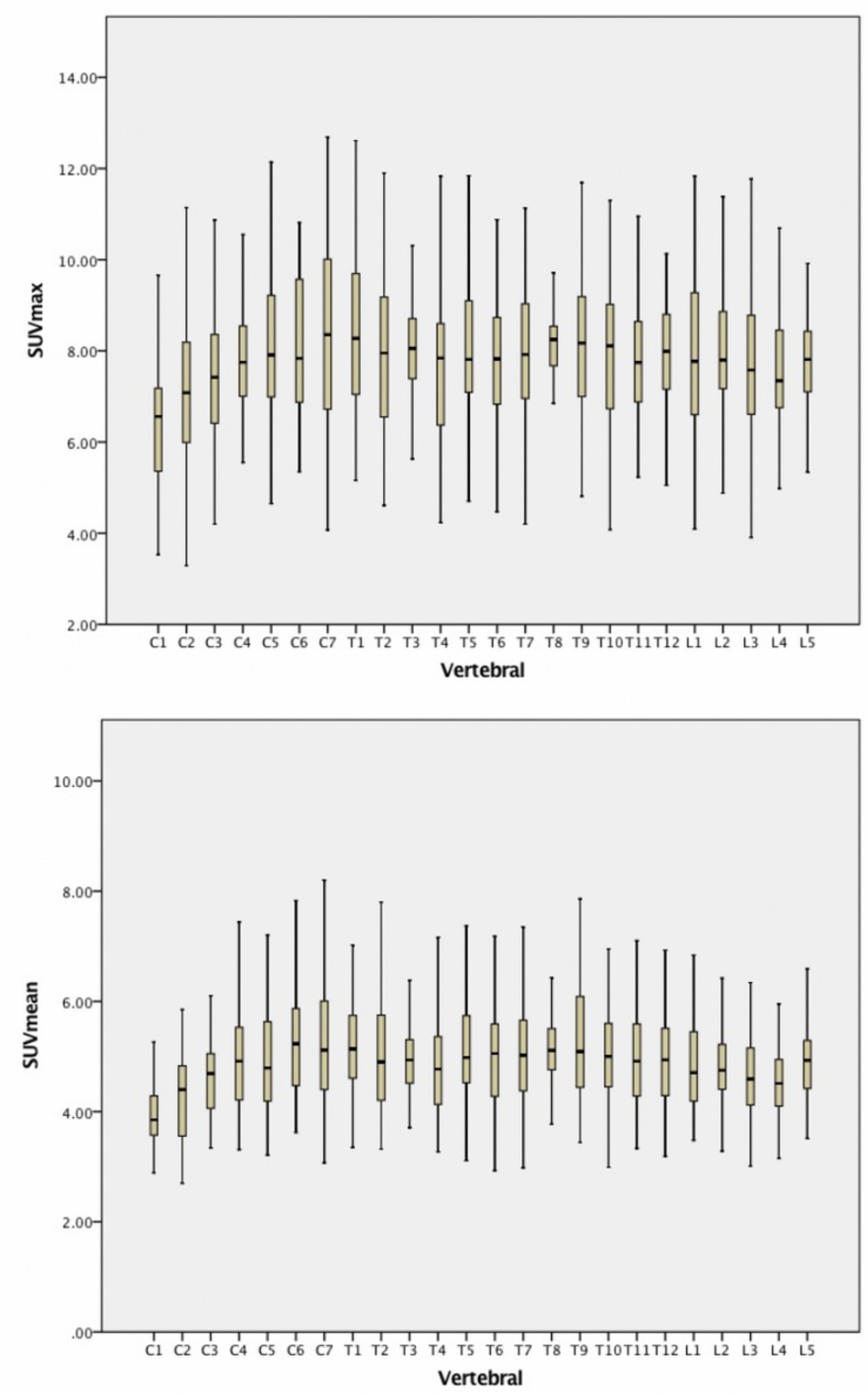

Figure 2

Box-and-whisker plots of SUVmax and SUVmean in each vertebrae of male patients, showing a quantitative distribution of 5 standard statistics: Smallest value, lower quartile, median, upper quartile, and largest value. SD: Standard deviation, CoV: Coefficient of variation.

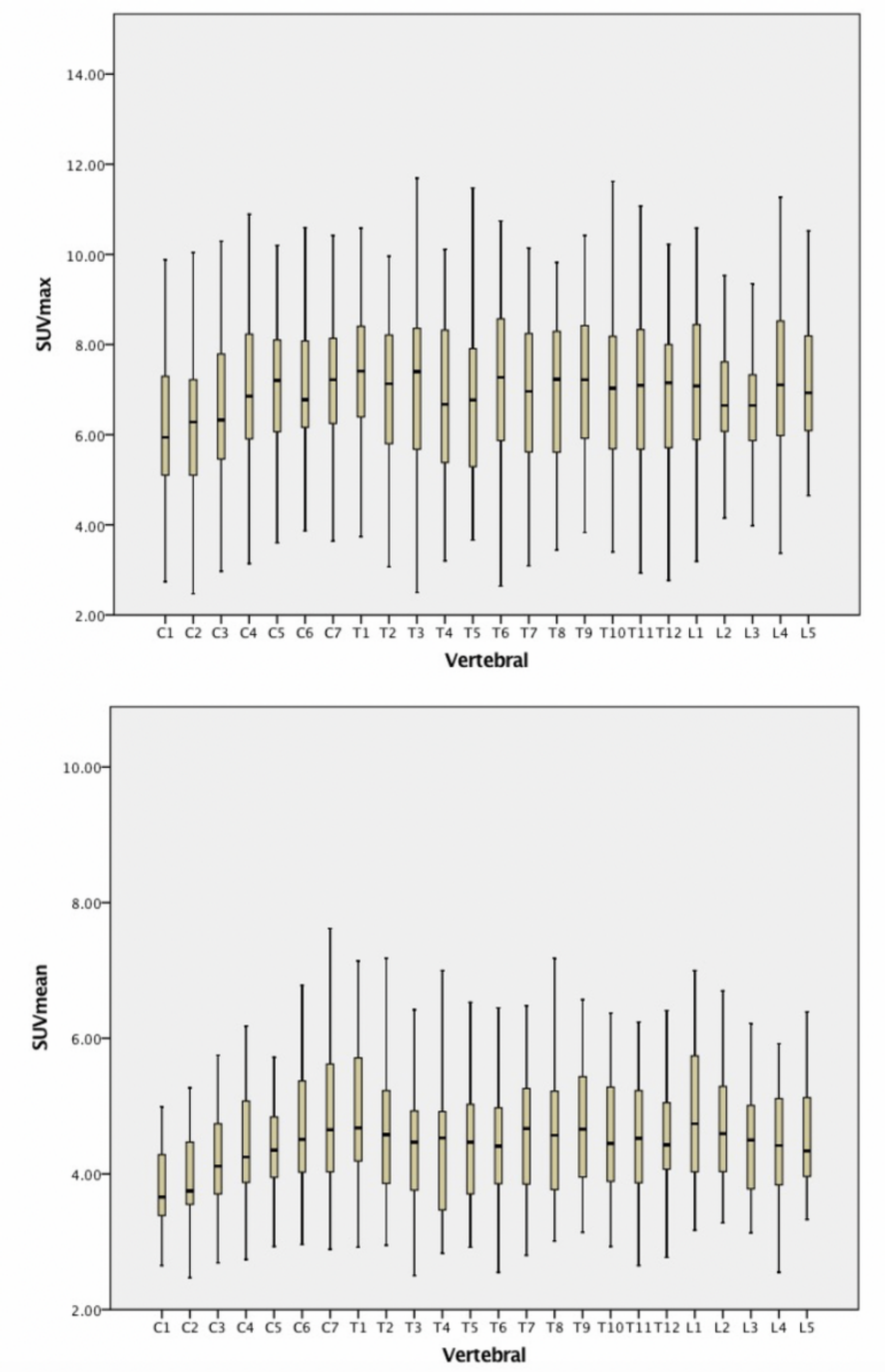

Figure 3

Box-and-whisker plots of SUVmax and SUVmean in each vertebrae of female patients, showing a quantitative distribution of 5 standard statistics: Smallest value, lower quartile, median, upper quartile, and largest value. SD: Standard deviation, CoV: Coefficient of variation