The effect of digital PET/CT and reconstruction algorithms on semi-quantitative values and Deauville scoring in patients with lymphoma

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Abstract

Objective: Fluorine-18-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography/computed tomography (PET/CT) is widely used in lymphoma for diagnosis, interim evaluation, and treatment response assessment, utilizing both visual and semiquantitative analyses. However, factors such as image reconstruction algorithms may influence maximum standardized uptake value (SUVmax), mean SUV (SUVmean), and Deauville scores. This study aims to evaluate the impact of ordered subset expectation maximization (OSEM) and Q.Clear reconstruction methods on these parameters in lymphoma patients. **Materials and Methods:** This study included 48 patients diagnosed with lymphoma who underwent ^{18}F-FDG PET/CT imaging between January 1 and April 12, 2024, for interim evaluation, post-treatment assessment, or relapse investigation. Positron emission tomography data were reconstructed using OSEM and Q.Clear algorithms, routinely applied in our clinic. The lymph node with the highest SUVmax in each scan was selected as the target lesion. Additionally, subcentimetric lymph nodes (<1cm) were analyzed to assess the impact of reconstruction algorithms on detectability. Maximum SUV and SUVmean values of the liver and mediastinal blood pool were also recorded for Deauville scoring. Statistical analyses were conducted to evaluate significant differences between the two reconstruction methods. **Results:** This results refers to the comparative use of ^{18}F-FDG PET/CT imaging with different reconstruction algorithms in treatment response evaluation and restaging changes to the standardization and that caution should be exercised in the DS evaluation based on semiquantitative values. This leads to a challenge in single and multicenter comparative evaluations with PET/CT scanners using different reconstruction algorithms including digital systems. In this study, we have shown that the reconstruction algorithms used in digital PET/CT devices cause changes in Deauville scoring in patients diagnosed with lymphoma. Therefore, it is important to perform ^{18}F-FDG PET/CT imaging with the same reconstruction algorithms under standardized conditions or to take this into consideration if not done.

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Introduction

Fluorine-18-fluorodeoxyglucose (^{18}F-FDG) positron emission tomography/computed tomography (PET/CT) is one of the main imaging modalities used in staging, interim evaluation and evaluation of treatment response in patients with lymphoma [1-3]. While this evaluation is performed visually, semi-quantitative parameters such as standardized uptake value (SUV) are also used. Specific SUV values can also be measured by taking the maximum and mean counts in the region of interest (SUVmax and SUVmean, respectively) [4]. The most commonly used semi-quantitative parameter is the SUVmax value [5]. However, many factors may cause changes in SUVmax value [2]. These factors may be related to the patient as well as the reconstruction algorithms used in ^{18}F-FDG PET/CT imaging.

Ordered subsets expectation maximisation (OSEM) is one of the iterative reconstruction algorithms widely used in PET/CT for many years. However, with the increasing use of digital PET systems in recent years, the use of Bayesian penalized likelihood (BPL) algorithms such as Q.Clear, a new generation iterative reconstruction algorithm developed by General Electric Healthcare, is also increasing. This algorithm aims to provide more accuracy in PET quantification and increase the lesion-to-background ratio. It is also designed to obtain high quality images while reducing the amount of radioactivity.

Although there are studies defining new methods for treatment response assessment and staging, the Deauville scoring system is in use as the benchmark method in lymphoma. The Deauville scoring (DS) system is one of them and it is basically a scoring system consisting of 5 levels obtained by visually comparing the uptake of the lesion with the uptake of the liver and mediastinal blood pool. Generally, DS 1-3 is defined as respon-

sive to treatment, and DS 4-5 is defined as non-responsive [6]. However, the reconstruction algorithm may cause differences on these scores [7, 8]. There are many studies in the literature examining the effects of these algorithms on semi-quantitative values. Some studies have shown that the Q.Clear reconstruction algorithm improves lesion discriminability and provides better resolution especially in lesions smaller than 1cm [7-9]. However, there is no consensus on whether the effect of these algorithms on semi-quantitative values such as SUVmax and SUVmean is statistically significant in the evaluation of treatment response. In addition, with the widespread use of digital PET systems, the effect of different reconstruction algorithms on semi-quantitative values in digital devices is gaining importance. In this study, we aimed to investigate the effects of different reconstruction algorithms on SUVmax and SUVmean values and thus Deauville Scoring in digital PET/CT imaging.

Materials and Methods

Ethics

This study was conducted under the 1964 Declaration of Helsinki. The study was approved by the local medical ethics committee (2025/157); written informed consent was taken from all the individuals.

Study protocol and patient selection

This study was carried out retrospectively in the Department of Nuclear Medicine of Prof. Dr. Cemil Taşcıoğlu City Hospital. In this study, 48 patients who underwent ^{18}F-FDG PET/CT imaging between 01/01/2024-12/04/2024 for interim evaluation, treatment response evaluation after treatment completion and relapse investigation among male and female patients diagnosed with lymphoma from all age groups were included. The exclusion criteria of the patients are as follows:

- Patients with secondary malignancy other than lymphoma.
- Patients with a diagnosis of lymphoma but only had baseline ^{18}F-FDG PET/CT imaging were excluded from the study.

PET/CT acquisition and evaluation

Patients with a blood glucose level of 150mg/dL or less received intravenous injections of ^{18}F-FDG with an activity of 0.09-0.14mCi (3.33-5.18MBq) per kilogram. Fluorine-18-FDG PET/CT was performed after a fasting period of at least six hours. Non-diagnostic low-dose CT was used for anatomical correlation and attenuation correction.

Digital PET/CT: Imaging was performed with a General Electric Discovery MI 3 Ring PET/CT (GE Healthcare, Milwaukee, USA). Image reconstruction was performed using the OSEM, in addition to BPL (Beta factor) and point spread function (PSF) methods. Each bed was imaged for a duration of 90 seconds.

Reconstruction algorithms

Ordered subsets expectation maximisation is one of the iterative reconstruction algorithms that has been widely used in PET/CT for many years. Iterative reconstruction algorithms use an iterative process to reconstruct the image using projection data. These algorithms initially generate a prediction image and then iteratively update it to reduce the difference between this prediction and the measured projection data. The main objective is to maximise a likelihood function for the data (maximum likelihood expectation maximisation). Maximum likelihood expectation maximisation (MLEM) iteratively reconstructs the image using a poisson probability distribution. In each iteration, it tries to minimise the difference between the expected number of events and the actual number of events, which is called convergence. However, in the MLEM algorithm, a large number of iterations are required for convergence and therefore processing times are long. The OSEM algorithm is a derivative of the MLEM algorithm and aims to reduce the long times required for itera-tions. It operates by creating ordered subsets from the pro-jections, thus achieving a faster convergence in each ite-ration [10, 11]. As the number of iterations increases in these algorithms, the errors in the reconstruction time accumulate and the noise level increases while the details in the image increase. In this study, three iterations, 17 subsets were used for the OSEM algorithm.

Point spread function is the distribution of a point source over the image. In an ideal situation, the image of a point source should only be in one pixel, but in the real world, diffusion occurs due to optical and systemic effects. Point spread function describes this spread and shows how the image of a point source is spread around it. Point spread function reconstruction algorithms reconstruct the image taking this spread into account [11]. In this study, we evaluated images by using 5.0 PSF. By this, our method is designed as 3 iteration, 17 subset and 5.0 PSF (3iter17subset5PSF).

Time-of-flight (TOF) is not a direct reconstruction algorithm. Time-of-flight is a technique that improves imaging performance by utilising the difference between the arrival times of detected photon pairs. This information is used in the reconstruction process to provide more precise localisation and better image quality. Reconstruction algorithms using TOF information can more accurately reconstruct the image by taking this time difference into account. Therefore, TOF should not be considered as a reconstruction technique or algorithm used in PET/CT imaging systems, but as a source of information used in the reconstruction process. Reconstruction algorithms using TOF are generally iterative reconstruction methods [11].

In addition to PSF modelling, the Q.Clear algorithm uses a user-modifiable penalty factor BPL that aims to improve lesion discriminability and lesion to background activity ratio. This penalty factor is applied regularly between iterations and aims to reduce the noise level that increases with iterations by penalising it (block squencial regularized expectation maximization, BSREM) [12, 13]. It is also designed to obtain higher quality images in PET images taken at lower doses.

Digital PET/CT

Digital detectors used in digital PET/CT systems have a higher detection capacity compared to analogue detectors. In

analogue systems, each scintillation crystal is not directly connected to a detector. The image formed by multiple scintillation crystals is detected by one detector. In digital PET/CT, each scintillation crystal is directly connected to a detector. Thanks to this 1:1 connection, digital PET systems offer more sensitive data collection and processing. In addition, digital PET/CT has a lower dead time. This means that the waiting time of the detectors before taking the next measurement is reduced. In addition, silicon photomultipliers (SiPM) detectors used in digital PET/CT systems have a higher sensitivity than photomultipliers tubes (PMT) used in analogue systems. In this way, more photons and therefore more information are obtained. As a result, data is obtained faster and more accurately. As a result of all these, it provides higher spatial resolution in digital systems. This means that smaller lesions can be detected more clearly. In addition, whole body scans can be performed in a shorter time and high-quality images can be obtained [14-17].

Obtaining data from PET/CT images

Positron emission tomography data of 48 patients included in the study were obtained from images of OSEM (3iter 17subset5PSF), B700+TOF and B550+TOF reconstruction algorithms created as standard in our clinic. The lymph node with the highest SUVmax value in these images was selected as the target lesion. In addition, <1cm lymph nodes were selected to investigate the effect of different reconstruction algorithms on the selectability of <1cm lymph nodes. However, since one patient did not have a target lesion and <1cm lymph node with distinguishable ^{18}F-FDG uptake, a total of 48 target lesions and 48 <1cm lymph nodes were selected. All lesion diameter measurements were performed under CT images. Maximum SUV and SUVmean values of these selected lymph nodes were recorded. In addition, liver and mediastinal blood pool SUVmax and SUVmean values were recorded for Deauville scoring. Liver SUVmax and SUVmean values were obtained from a 3cm^2 elliptical region of interest (ROI) in the right lobe of the liver with no lesion. Mediastinal blood pool SUVmax and SUVmean values were obtained with a 1cm^2 elliptical ROI drawn from the thoracic aorta. Quantified Deauville scores were calculated based on these results.

Patients were divided into 3 groups; patients referred for interim evaluation after 2-4 cycles of chemotherapy (iPET), patients referred for response evaluation after completion of treatment (ePET) and patients referred with suspicion of relapse (rPET). Deauville scoring 1-2-3 was considered as treatment response, DS 4 and 5 were considered as no treatment response.

Information about the patients is shown in Table 1.

Table 1. *Patient characteristics and normality distribution.*

Variable	Study population (n=48)	iPET (n=19)	ePET (n=11)	rPET (n=18)	P
Age	58.5 (23-88)	62 (23-88)	61 (28-88)	55 (26-80)	0.0171
Gender, Female, n (%)	21 (45,7)	9 (50)	5 (50)	7 (38.8)	n/a
Blood Glucose (mg/dL)	95 (60-150)	89 (62-150)	102 (74-145)	97.5 (60-138)	0.0069
Height (m)	1.65±0.08	1.64±0.09	1.65±0.07	1.78±0.07	0.2746
Weight (kg)	74.29±16.93	67.89±15.27	72.90±15.87	81.88±17.01	0.1802
BMI (kg/m^2)	26.93±5.67	25.32±5.56	26.60±5.13	28.83±5.83	0.9300
Administered activity (mCi)	8 (5-13)	8 (5-12)	8 (6-12)	9.5 (5-12)	0.0390
Lymphoma Subtype, n (%)					
Hodgkin	16 (33.3)	5 (26.3)	2 (18.2)	9 (50)	
DLBCL	20 (41.7)	8 (42.1)	5 (45.4)	7 (38.8)	
Follicular	8 (16.7)	4 (21.1)	3 (27.3)	1 (6.1)	n/a
Marginal zone	3 (6.2)	2 (10.5)	1 (9.1)	0	
MALT Lymphoma	1 (2.1)	0	0	1 (6.1)	

**Shapiro Wilk test. Results are expressed as mean±standard deviation, median (minimum-maximum) or frequency (%). n: Number, m: Meter, mg: Milligrams, dL: deciliter, kg: kilograms, BMI: Body mass index, DLBCL: Diffuse large B-cell lymphoma, n/a: Not applicable*

Statistical analysis

Statistical analyses were performed with Medcalc v23 (Ostend, Belgium) software. The Shapiro-Wilk test was used to investigate normal distribution. Nonparametric variables are presented in the text and tables as median (minimum-maximum) and parametric variables are presented as mean±standard deviation. The Friedman test was used for intergroup comparison. Paired sample t test and Wilcoxon Signed rank tests were used for pairwise comparison between groups. Correlation test and Cohen Kappa coefficient were used to investigate the agreement between categorical measurements. Results with P-values below 0.05 were accepted as statistically significant.

Results

Forty-eight patients enrolled in this study. Twenty-two of the patients were female, and 26 were male. Characteristic findings and normality distribution findings of the patients are summarized in Table 1. In Friedman test performed to compare SUVmax and SUVmean values of lesions and physiologic structures, a statistically significant difference was found between the groups for all variables except liver SUVmean (P=0.0289 for MBP SUVmean, P<0.0001 for all others) (Table 2).

Table 2. *Comparison results for liver, mediastinal blood pool and lesion SUV values.*

Variable	Study population (n=48)	Pa,b
Liver SUVmax		
3iter17subset5PSF	3.57±0.71	<0.0001
B700+TOF	3.20±0.55	
B550+TOF	3.31±0.56	
Liver SUVmean		
3iter17subset5PSF	2.68 (1.54-5.02)	0.1525
B700+TOF	2.70 (1.55-3.92)	
B550+TOF	2.70 (1.53-3.91)	
MBP SUVmax		
3iter17subset5PSF	2.65 (1.04-4.14)	
B700+TOF	2.51 (0.99-3.92)	<0.0001
B550+TOF	2.56 (1.00-4.10)	
MBP SUVmean		
3iter17subset5PSF	2.09 (0.83-3.54)	
B700+TOF	2.07 (0.91-3.49)	0.0289
B550+TOF	2.05 (0.91-3.56)	
Lesion (>1cm) SUVmax		
3iter17subset5PSF	3.10 (0-41.59)	
B700+TOF	3.23 (0-40.95)	<0.0001
B550+TOF	3.55 (0-41.58)	
Lesion (>1cm) SUVmean		
3iter17subset5PSF	2.07 (0-12.43)	
B700+TOF	2.15 (0-11.47)	<0.0001
B550+TOF	2.17 (0-11.48)	
Lesion (<1cm) SUVmax		
3iter17subset5PSF	2.64 (0-7.30)	
B700+TOF	2.87 (0-8.49)	<0.0001
B550+TOF	3.12 (0-8.90)	
Lesion (<1cm) SUVmean		
3iter17subset5PSF	1.79 (0-4.37)	
B700+TOF	1.68 (0-4.99)	<0.0001
B550+TOF	1.72(0-5.14)	

[a]Repeated ANOVA test, [b]Friedman test. Results are expressed as mean± standard deviation or median (minimum-maximum).
B: Beta factor, n: Number, iter: Iteration, MBP: Mediastinal blood pool, PSF: Point spread function, TOF: Time of flight, SUV: Standardized uptake value.

In the pairwise comparative analysis of SUVmax values, liver and MBP were significantly higher for 3Iter17Subset 5PSF (P<0.001). While B550+TOF yielded higher values for both <1cm and >1cm lesion SUVmax (P<0.0001, P=0.0001 respectively). In the analysis for MBP SUVmean values were significantly higher in 3Iter17Subset5PSF (P=0.0185). When the SUVmean values of lesions compared, significantly higher values obtained with 550+TOF algorithm in the >1cm lesions (P=0.0080). Results were comparable for lesion <1cm (P=0.6982). All pairwise comparison results summarized in Table 3.

In the inter-rater agreement test performed to investigate the correlation between the reconstruction algorithms, very good agreement was found between 700+TOF and 550+TOF for lesions larger than 1cm (Kappa=91.89%), while the

agreement level was lower with the 3iter17subset5PSF algorithm (Kappa=73.42%, 65.56% respectively). For this lesion group, the Deauville 4-5 lesion rate for both 700+TOF and 550+TOF was 54.1%, while this rate was 40.1% for 3iter 17subset5PSF. The inter-rater agreement test was also performed for lesions smaller than 1cm, very good agreement was found between 700+TOF and 550+TOF (Kappa=97.27%), moderate agreement was found between for both 700+TOF, 550+TOF and 3iter17subset5PSF (Kappa=51.89%, 51.92% respectively). For lesions smaller than 1cm the Deauville 4-5 lesion rate for both 700+TOF and 550+TOF was % 41.6 while the same rate was 18.7% for 3iter17subset5PSF algorithm (Figure 1).

Table 3. *Pairwise comparison results of reference structures and lesions.*

Variable	Algorithm	Results (P)	
		3iter17subset5PSF	B700+TOF
Liver SUVmax[a]	B700+TOF	<0.0001	n/a
	B550+TOF	0.0001	<0.0001
		3iter17subset5PSF	B700+TOF
MBP SUVmax[b]	B700+TOF	<0.0001	n/a
	B550+TOF	0.0014	<0.0001
		3iter17subset5PSF	B700+TOF
MBP SUVmean[b]	B700+TOF	0.0185	n/a
	B550+TOF	0.0148	0.4273
		3iter17subset5PF	B700+TOF
Lesion(>1cm) SUVmax[b]	B700+TOF	0.0875	n/a
	B550+TOF	0.0001	<0.0001
		3iter17subset5PSF	B700+TOF
Lesion(>1cm) SUVmean[b]	B700+TOF	0.1177	n/a
	B550+TOF	0.0080	<0.0001
		3iter17subset5PSF	B700+TOF
Lesion(<1cm) SUVmax[b]	B700+TOF	0.0011	n/a
	B550+TOF	<0.0001	<0.0001
		3iter17subset5PS	B700+TOF
Lesion(<1cm) SUVmean[b]	B700+TOF	0.6982	n/a
	B550+TOF	0.0452	<0.0001

aPairwise t-test, bWilcoxon signed rank test. Results are expressed as mean±standard deviation or median (minimum-maximum). B: Beta factor, n: Number, n/a: Not applicable, iter: Iteration, MBP: Mediastinal blood pool, PSF: Point spread function, TOF: Time of flight, SUV: Standardized uptake value.

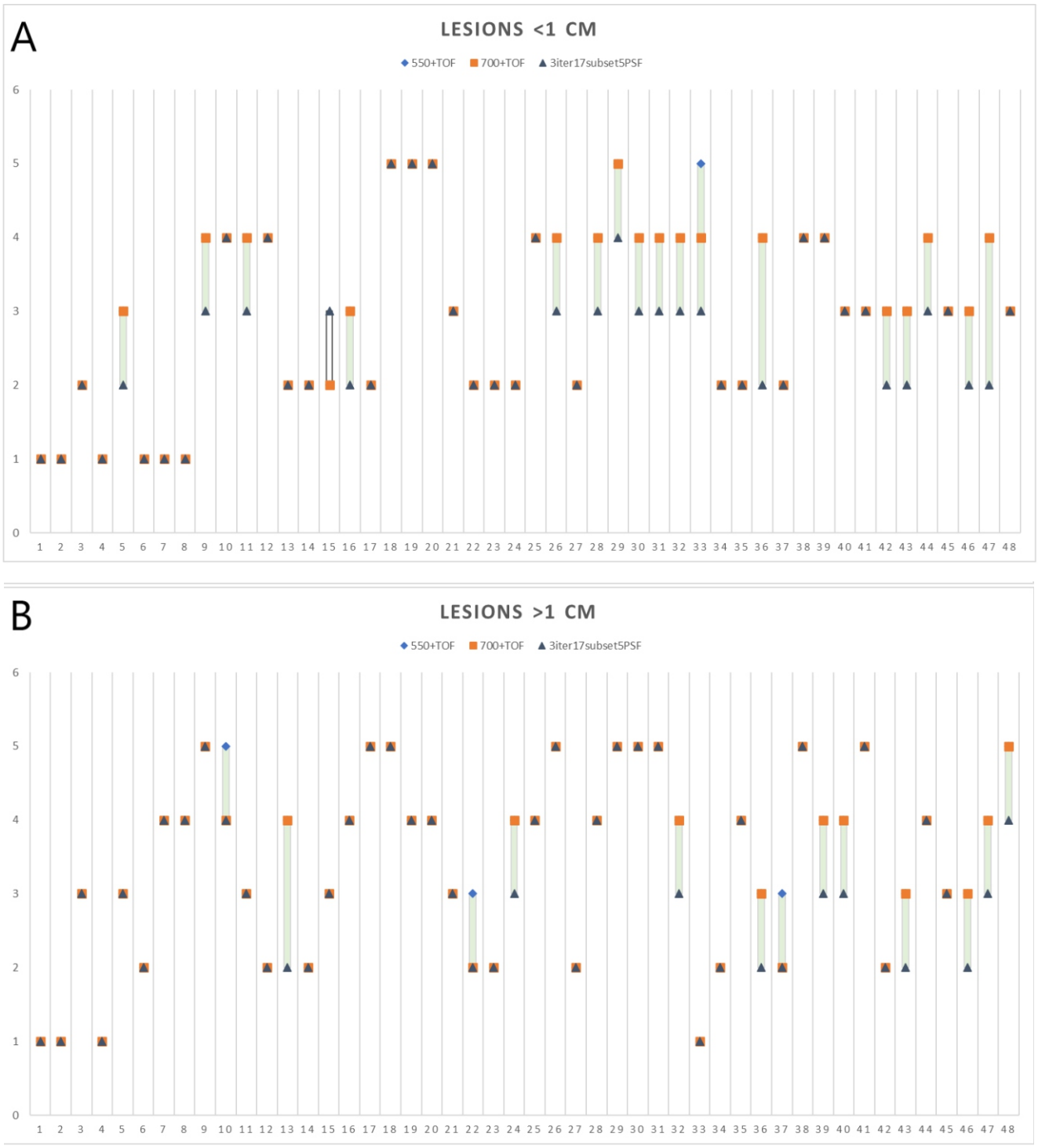

Figure1. Case-based Deauville score change graph in different reconstruction algorithms for lesions smaller and larger than 1 cm (A: <1cm lesions, B: >1cm lesions).

Discussion

In the pairwise comparative analysis of SUVmax values in our study, SUVmax values in reference organs were found to be significantly higher for the OSEM algorithm. This result is consistent with many studies in the literature investigating the effect of OSEM algorithm and Q.Clear algorithm on background activity and SUVmax values of reference organs. Subesinghe et al. (2023) 81 patients diagnosed with Hodgkin's lymphoma compared BPL and OSEM algorithm on interim PET images and showed that SUVmax values of liver and mediastinal blood pool were higher with OSEM algorithm, similar to our study [18]. Texte et al. (2020) compared the OSEM algorithm with different beta inputs (Beta from 300 to 600) on patients and phantom samples and examined the background activity and the degree of noise by changing the acquisition times applied per bed and found that

the noise decreased as the beta value increased, but more noise was observed in all values except B600 compared to OSEM [19]. Although this situation seems to be incompatible with our study at first glance, in fact it is not; it is inevitable that the amount of noise will be high when imaging is performed with low penalisation factors such as B300, B350, B400, and it would be healthier to compare the beta value that gives the best lesion / background activity ratio with the OSEM algorithm. In this study, they showed that when the beta value reached B500 values, which is the closest value to our study, the SUVmax values of the liver and lesion background were lower than the OSEM algorithm, thus less noise was observed. Otani et al. (2019) compared BPL and OSEM on ^{18}FDG PET/CT images of lung tumours and suggested beta 500 as the optimal β value, which is very close to the beta value of our study [20]. In a previous prospective observational study conducted in our clinic on 264 patient images, it was shown that the SUVmax values of the OSEM algorithm for liver, mediastinal blood pool and background activity were higher compared to the Q.Clear algorithm [21].

In the results of our study, SUVmax values for >1cm and <1 cm lymph nodes obtained with the Q.Clear B550+TOF algorithm were significantly higher than those obtained with the OSEM algorithm. In the study in which Teoh et al. (2016) compared OSEM and BPL algorithm in pulmonary nodules, they showed that SUVmax values for both <1cm and >1cm lesions were significantly higher with the BPL algorithm in accordance with our study [22]. In a similar study conducted by Genc et al. (2023) on lymphoma patients, it was shown that SUVmax values in lymph nodes with Q.Clear were higher compared to OSEM [7]. However, this study was performed on analogue PET/CT images. In this study, we examined the effects of different reconstruction algorithms in digital PET/CT imaging, especially in lesions smaller than 1cm below the resolution limit. Wyrzykowski et al. (2020) found that SUVmax measurements of target lesions with Q.Clear were 88.8% higher than those measured with OSEM in lymphoma patients [23]. In a study investigating the effect of different reconstruction algorithms on semi-quantitative values in lung malignancies, it was shown that SUVmax values increased with BPL, similar to our study [24]. Wang et al. (2022) also reported that SUVmax values and lesion-to-background ratios of lesions with Q.Clear in lymphoma patients were higher than OSEM and showed a negative correlation with lesion diameter [9]. In another study, SUVmax values of liver metastases in colorectal cancers were compared using OSEM and BPL algorithm and BPL algorithm was found to be higher than OSEM as in our study [25].

In our study, although SUVmax values of >1cm lymph node were found to be higher with B700+TOF compared to OSEM algorithm, this result was not statistically significant and it was observed that SUVmax values of the lesion decreased as the beta value, which is the penalisation factor, increased. In their phantom study, Teoh et al. (2015) showed that SUVmax values decreased as the penalisation factor increased in accordance with our study and suggested Beta 400 as the ideal penalisation factor [12]. However, in our study, contrary to this study, MBP SUVmean values were higher in the OSEM algorithm. This may be explained by the use of Beta 400, which is lower than our study, as a penalisation factor.

When the SUVmean values of the lesions were compared, significantly higher values were obtained with the B550+ TOF algorithm in lesions >1cm. In a phantom study, BPL, OSEM and OSEM+PSF (point spread function) algorithms were compared and an increase in SUVmean values was observed in the OSEM algorithm with the addition of PSF, but SUVmean values were found to be higher with the BPL algorithm compared to the OSEM algorithm with or without PSF as in our study [26]. However, in this study, SUVmean values were also shown to be higher with the BPL algorithm in small spheres of millimetric diameter, while this was not detected in lesions <1cm in our study, and it was observed that SUVmean values decreased only when the penalisation factor increased, but this was not statistically significant.

When we look at the effect of different reconstruction algorithms on the Deauville score, the agreement between Beta 550 and Beta 700 algorithms for >1cm lymph nodes is 92.94%, which is a high agreement. However, the agreement of the OSEM algorithm with the BPL algorithms was lower, 73.42% for Beta 700 and 65.56% for Beta 550. In lymph nodes larger than 1cm, Deauville 4-5 lesion rate was found to be higher with BPL algorithms than OSEM algorithm (54.1% and 40.1%, respectively). Genc et al. (2023) found that 30 patients with DS 4-5 with the BPL algorithm regressed to DS 1-2-3 with the OSEM algorithm, which is consistent with our results [7]. Wang et al. (2022) reported in their study on lymphoma patients that Deauville scores were higher with BPL compared to the OSEM algorithm, which is consistent with our study, and that this situation was negatively correlated with the decrease in lesion size, just like in our study [9]. Enilorac et al. (2018) showed that there was a discordance between OSEM and BPL for DS 5 in 14 out of 100 patients in patients undergoing interim PET, and a similar discordance in 8 out of 95 patients in PET images taken after the treatment was completed [27].

For lesions smaller than 1cm, a very good agreement was observed between Beta 700 and Beta 550 values (Kappa= 97.27%) and there was a moderate agreement between BPL algorithms and OSEM. For lesions smaller than 1cm, the Deauville 4-5 lesion rate was significantly lower with the OSEM algorithm than with the BPL algorithm (18.7% and 41.6%, respectively). This suggests that in single/multicentre studies involving devices using different reconstruction algorithms, harmonisation between devices should be performed or, if applicable, the same reconstruction algorithms should be used. Wang et al. (2022) reported that the BPL algorithm led to higher DS values in lymphoma patients [9]. In addition, as a result of multivariate regression analysis in this study, reduction in lesion diameter and decrease in SUV were reported as independent predictor factors with an increase in DS (P=0.014 and P<0.001).

In the study by Wyrzykowski et al. (2020), DS was found to be higher with BPL in 22 of 140 scans (15.7%) and 7.1% of the cases that would cause a change in treatment decision [23]. Genc et al. (2023) showed that 30 patients (12.5%) for DS-SUVmax and DS-SUVmean had a condition that would cause a change in treatment decision [7].

Limitations

One of our limitations is that our study was retrospective and the sample group consisted of heterogeneous lymphoma groups. Another limitation of the study is the lack of histopathologic verification of the examined lymph nodes. However, it is still important to show that the liver and mediastinal blood pool SUVmax and SUVmean parameters used in Deauville scoring are affected by different reconstruction algorithms. Again, the fact that SUVmax values of both <1cm and >1cm lymph nodes vary in different reconstruction algorithms is important regardless of the pathology of the lymph node. Because biopsy is not required for every lymph node in patients with lymphoma and Deauville scoring is used to evaluate treatment response [6].

In conclusion, in this study in which we examined the effect of different reconstruction algorithms on semi-quantitative values, we found that SUVmax and SUVmean values changed especially in reference organs such as liver and mediastinal blood pool. This result refers to the comparative use of ^{18}F-FDG PET/CT imaging with different reconstruction algorithms in treatment response evaluation and restaging changes to the standardization and that caution should be exercised in the DS evaluation based on semi-quantitative values. This leads to a challenge in single and multicenter comparative evaluations with PET/CT scanners using different reconstruction algorithms including digital systems. In this study, we have shown that the reconstruction algorithms used in digital PET/CT devices cause changes in Deauville scoring in patients diagnosed with lymphoma. Therefore, being aware of the reconstruction algorithm may be helpful in evaluating treatment response. Furthermore, it is important to perform ^{18}F-FDG PET/CT imaging with the same reconstruction algorithms under standardized conditions or to take this into consideration if not done. In this study, we examined the effect on treatment response in lymphomas by using digital PET/CT, compared the reconstruction algorithms in conventional and digital PET/CT devices and found significant differences. It is concluded that supporting these findings with prospective studies in homogeneous patient groups may contribute to patient management.

Bibliography

1. Akamatsu G, Mitsumoto K, Taniguchi T et al. Influences of point-spread function and time-of-flight reconstructions on standardized uptake value of lymph node metastases in ^{18}F-FDG-PET. *Eur J Radiol* 2014; 83(1): 226-30.
2. Barrington SF, Mikhaeel NG, Kostakoglu L et al. Role of imaging in the staging and response assessment of lymphoma: consensus of the International Conference on Malignant Lymphomas Imaging Working Group. *J Clin Oncol* 2014; 32(27): 3048-58.
3. Cheson BD, Pfistner B, Juweid ME et al. Revised response criteria for malignant lymphoma. *J Clin Oncol* 2007; 25(5): 579-86.
4. Brendle C, Kupferschlager J, Nikolaou K et al. Is the standard uptake value (SUV) appropriate for quantification in clinical PET imaging? - Variability induced by different SUV measurements and varying reconstruction methods. *Eur J Radiol* 2015; 84(1): 158-62.
5. Kwee TC, Cheng G, Lam MG et al. SUVmax of 2.5 should not be embraced as a magic threshold for separating benign from malignant lesions. *Eur J Nucl Med Mol Imaging* 2013; 40(10): 1475-7.
6. Meignan M, Gallamini A, Meignan M et al. Report on the First International Workshop on Interim-PET-Scan in Lymphoma. *Leuk Lymphoma* 2009; 50(8): 1257-60.
7. Genc M, Yildirim N, Coskun N et al. The variation of quantitative parameters and Deauville scores with different reconstruction algorithms in ^{18}F-FDG PET/CT imaging of lymphoma patients. *Rev Esp Med Nucl Imagen Mol (Engl Ed)* 2023; 42(6): 388-92.
8. Ly J, Minarik D, Edenbrandt L et al. The use of a proposed updated EARL harmonization of ^{18}F-FDG PET-CT in patients with lymphoma yields significant differences in Deauville score compared with current EARL recommendations. *EJNMMI Res* 2019; 9(1): 65.
9. Wang Y, Lin L, Quan W et al. Effect of Bayesian penalty likelihood algorithm on ^{18}F-FDG PET/CT image of lymphoma. *Nucl Med Commun* 2022; 43(3): 284-91.
10. Reader AJ, Zaidi H. Advances in PET Image Reconstruction. *PET Clin* 2007; 2(2): 173-90.
11. Tong S, Alessio AM, Kinahan PE. Image reconstruction for PET/CT scanners: past achievements and future challenges. *Imaging Med* 2010; 2(5): 529-45.
12. Teoh EJ, McGowan DR, Macpherson RE et al. Phantom and Clinical Evaluation of the Bayesian Penalized Likelihood Reconstruction Algorithm Q.Clear on an LYSO PET/CT System. *J Nucl Med* 2015; 56(9): 1447-52.
13. J. Nuyts, D. Beque, P. Dupont and L. Mortelmans. A concave prior penalizing relative differences for maximum-a-posteriori reconstruction in emission tomography. *IEEE Transactions on Nuclear Science* 2002; 49: 56-60.
14. T. Frach, G.Prescher, C. Degenhardt et al. The digital silicon photomultiplier-Principle of operation and intrinsic detector performance. In: IEEE Nuclear Science Symposium Conference Record (NSS/MIC): 2009; Orlando, FL, USA; 2009: 1959-65.
15. Rausch I, Ruiz A, Valverde-Pascual I et al. Performance Evaluation of the Vereos PET/CT System According to the NEMA NU2-2012 Standard. *J Nucl Med* 2019; 60(4): 561-7.
16. Aljared A, Alharbi AA, Huellner MW. BSREM Reconstruction for Improved Detection of In-Transit Metastases With Digital ^{18}F-FDG-PET/CT in Patients With Malignant Melanoma. *Clin Nucl Med* 2018; 43(5): 370-1.
17. Salvadori J, Imbert L, Perrin M et al. Head-to-head comparison of image quality between brain ^{18}F-FDG images recorded with a fully digital versus a last-generation analog PET camera. *EJNMMI Res* 2019; 9(1): 61.
18. Subesinghe M, Ilyas H, Dunn JT et al. The frequency of change in five-point scale score with a Bayesian penalised likelihood PET reconstruction algorithm on interim ^{18}F-FDG PET-CT and its potential implications for therapy decisions in Hodgkin's lymphoma. *Clin Radiol* 2023; 78(2): e89-e98.
19. Texte E, Gouel P, Thureau S et al. Impact of the Bayesian penalized likelihood algorithm (Q.Clear(R)) in comparison with the OSEM reconstruction on low contrast PET hypoxic images. *EJNMMI Phys* 2020; 7(1): 28.
20. Otani T, Hosono M, Kanagaki M et al. Evaluation and Optimization of a New PET Reconstruction Algorithm, Bayesian Penalized Likelihood Reconstruction, for Lung Cancer Assessment According to Lesion Size. *Am J Roentgenol* 2019; 213(2): W50-W56.
21. Ozulker F, Babacan GB, Cengiz S, Özülker T. The effect of reconstruction algorithms on semi-quantitative measurements in ^{18}F-FDG PET/CT imaging. *Hell J Nucl Med* 2024; 27(2): 85-92.
22. Teoh EJ, McGowan DR, Bradley KM et al. Novel penalised likelihood reconstruction of PET in the assessment of histologically verified small pulmonary nodules. *Eur Radiol* 2016; 26(2): 576-84.
23. Wyrzykowski M, Siminiak N, Kazmierczak M et al. Impact of the Q.Clear reconstruction algorithm on the interpretation of PET/CT images in patients with lymphoma. *EJNMMI Res* 2020; 10(1): 99.
24. Kurita Y, Ichikawa Y, Nakanishi T et al. The value of Bayesian penalized likelihood reconstruction for improving lesion conspicuity of malignant lung tumors on ^{18}F-FDG PET/CT: comparison with ordered subset expectation maximization reconstruction incorporating time-of-flight model and point spread function correction. *Ann Nucl Med* 2020; 34(4): 272-9.

25. Parvizi N, Franklin JM, McGowan DR et al. Does a novel penalized likelihood reconstruction of ^{18}F-FDG PET-CT improve signal-to-background in colorectal liver metastases? *Eur J Radiol* 2015; 84(10): 1873-8.
26. Te Riet J, Rijnsdorp S, Roef MJ, Arends JA. Evaluation of a Bayesian penalized likelihood reconstruction algorithm for low-count clinical ^{18}F-FDG PET/CT. *EJNMMI Phys* 2019; 6(1): 32.
27. Enilorac B, Lasnon C, Nganoa C et al. Does PET Reconstruction Method Affect Deauville Score in Lymphoma Patients? *J Nucl Med* 2018; 59(7): 1049-55.