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The Effect of Diffuse Muscle Uptake on SUVmax Levels in ^{18}F-FDG PET/CT Imaging

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ABSTRACT

The aim of this study is to evaluate diffuse skeletal muscle uptake, which is a factor affecting the distribution of 2-[^{18}F]-Fluoro-2-deoxy-D-glucose (FDG) in the body, and its effect on the SUVmax level of malignant lesions.

Twenty-two patients (M/F=12/10) who underwent positron emission tomography-computed tomography (PET/CT) PET/CT scans with FDG and showed diffuse muscle uptake, and whose FDG PET/CT scans were appropriately repeated, were enrolled in the study. Maximised standardised uptake value (SUVmax) levels of malignant foci and normal liver parenchymal activity were measured in images with diffuse muscle uptake and normal uptake. The change in the SUVmax levels of the lesions between the two studies was calculated.

The mean dose of FDG administered to patients in each study was 248.7 (248.7±56.2) megabecquerels. When both images were compared, it was calculated that there was a 38.6% (Std. Deviation 18.7/min: 9%, max: 83%) change in the SUVmax level of the same lesion. While the mean rate of change in the lesion/liver SUVmax ratio for the same lesion was 31%, the median level was recorded as 29.4%.

SUVmax and image quality are significantly affected by diffuse muscle uptake. For this reason, the study should be repeated with FDG PET/CT scans in diffuse muscle involvement.

Keywords fluorodeoxyglucose, SUVmax, Muscle uptake,

Introduction

Positron emission tomography/computed tomography (PET/CT) is a hybrid imaging technique that has become widespread in oncology, cardiology and neurology. The most widely-used radioactive substance in this imaging technique is 2-[^{18}F]-Fluoro-2-deoxy-D-glucose (FDG) (1). FDG is a glucose analogue that is transported into cells by glucose transporters (GLUT), then it is converted to glucose-6-phosphate by the hexokinase enzyme, but it does not proceed to the other stages of glycolysis and is trapped inside the cell (2). This allows PET scanners to visualise tumour cells with increased glucose consumption compared to normal cells (3). As FDG enters the cell by GLUT, all processes affecting these transporters will alter the intracellular concentration of the radiotracer (4). Maximised standardized uptake value (SUVmax), a semi-quantitative parameter used in PET/CT scans, is also affected. The preparation process of patients before and after FDG injection is very important, especially in the evaluation of treatment response in oncology patients (5). Although this process is carefully monitored, some patients may show diffuse uptake of FDG in skeletal muscles throughout the body. Diffuse muscle uptake is rare in clinical practice and the normal FDG distribution is variable in these patients. Therefore, FDG uptake and SUVmax levels of malignant foci may be altered. In accordance with the standard practice of our nuclear medicine department, patients who show diffuse skeletal muscle uptake on FDG PET/CT scans are referred for a repeat scan. These patients will have a further FDG PET/CT scan at an appropriate time according to the schedule. As a result of the repeated FDG PET/CT scan, the images that do not show diffuse muscle uptake will be reported. However, our reports do not mention images with diffuse muscle uptake and its effect on SUVmax levels. The aim of this study is to evaluate diffuse skeletal muscle uptake as a factor affecting the distribution of FDG in the body and the effect of this involvement on the SUVmax level of malignant lesions.

Material and Methods

Twenty-two patients who underwent FDG PET/CT scans between January 2021 to January 2022 and had diffuse muscle uptake on the scan were included in

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the study. While the patients were in the study, it was important to ensure that there was no muscle uptake that would have prevented a repeat FDG PET/CT scans. In the initial and repeat imaging of all patients, blood glucose levels prior to FDG injection were below 200 mg/dl and patients were fasted for at least 4-6 hours. SUVmax levels of malignant foci and normal liver parenchymal activity were reported in both imaging studies acquired from the patients. The proportional change in lesion SUVmax levels between the two studies was calculated. The lesion/normal liver SUVmax ratios derived from images with and without muscle uptake were also compared.

Statistical Analysis: The analysis of the acquired data was carried out using the IBM SPSS Statistics 26 programme. It was investigated whether there was a statistical difference between the mean SUVmax levels derived from malignant lesions detected in images with and without muscle uptake. The data did not show a normal distribution, so the Wilcoxon test was used to assess whether there was a statistical difference between the median values, and the p-value was accepted as less than 0.05 for the study.

Results

Of the 22 patients included in the study, 10 were female and 12 were male. The mean age of the patients was 61.8 years, the youngest patient was 41 years old and the oldest patient was 83 years old. The mean dose of FDG administered to patients for each study was 248.7 (248.7±56.2) megabecquerels (Mbq). The mean time between studies with and without muscle uptake was 7.86 (7.8±4.1) days.

In the statistical analysis performed to determine whether there was a significant difference between the SUVmax levels of the same lesion detected in the images with and without muscle uptake. A significant difference was found between the SUVmax levels derived from the two images of the same lesion (p=0.001) (Table 1). Furthermore, when comparing the two images, it was found that there was an average change of 38.6% (Std. deviation 18.7/min: 9%, max: 83%) in the SUVmax level of the same lesion. In 19 of the 22 lesions assessed, there was an increase in the SUVmax levels of the lesions in the images without muscle uptake, whereas decreased SUVmax level was observed in 3 lesions (9%, 18% and 42%).

When lesion/liver SUVmax levels for the same lesion obtained from images with muscle uptake were compared with lesion/liver SUVmax levels derived from images without muscle uptake, no significant difference was found between the results (p:0.051) (Table 1). While the mean rate of change in the lesion/liver SUVmax ratio for the same lesion was 31%, the median was found to be 29.4%.

When comparing FDG PET/CT scans with and without muscle uptake, it is noteworthy that there is a difference in the calculated SUVmax levels, which affects the reporting of the results. This is seen both by comparing the SUVmax levels of the lesions and by comparing the lesion/liver parenchym activity ratios.

A few comparative maximum intensity projection (MIP) samples of FDG PET/CT images are presented above (Figure 1). It is noteworthy that malignant lesions are difficult to identify on images with diffuse muscle uptake, and it is noted that the background activity is significantly higher due to muscle uptake.

Discussion

From the data generated in our study, it was evident that in FDG PET/CT scans in which diffuse muscle uptake occurs, the FDG uptake of malignant lesions generally decreases, and the SUVmax level is significantly affected respectively. Moreover, in muscle uptake studies, the ratio of the SUVmax level of malignant lesions to normal liver parenchymal activity derived from the same trial does not ensure the reliability of the study. Considering that FDG PET/CT imaging and metabolic parameters such as SUV are widely used to assess treatment response in malignant diseases, diffuse muscle involvement is an important problem (6, 7). An important shortcoming of our study is that only focused on SUVmax levels and visual evaluation. SUV corrected for peak lean body mass (SUL), which is a more consistent and less variable parameter, is used in the PET Response Criteria in Solid Tumours (PERCIST) criteria used to assess treatment response in malignancies. (7, 8). However, most of the published literature is based on SUV levels and it is recommended that new publications include the SUL levels in their reports (9). We used the SUVmax level in our study because most of the publications were on SUV, and the SUVmax level was generally stated in the reports from external centres that we received. In this study, in which we compared patients with and without diffuse muscle uptake in the same patients, it was found that the mean SUVmax levels of the lesions changed by 38.6% (increased SUVmax in 19 patients, decreased in 3 patients) and the lesion/liver SUVmax ratio changed by an average of 31% (increased SUVmax in 14 patients, decreased in 8 patients). In a similar study conducted by Lindholm et al. with 10 patients, it was shown that the SUVmax levels of 9 patients increased by an average of 54% in the

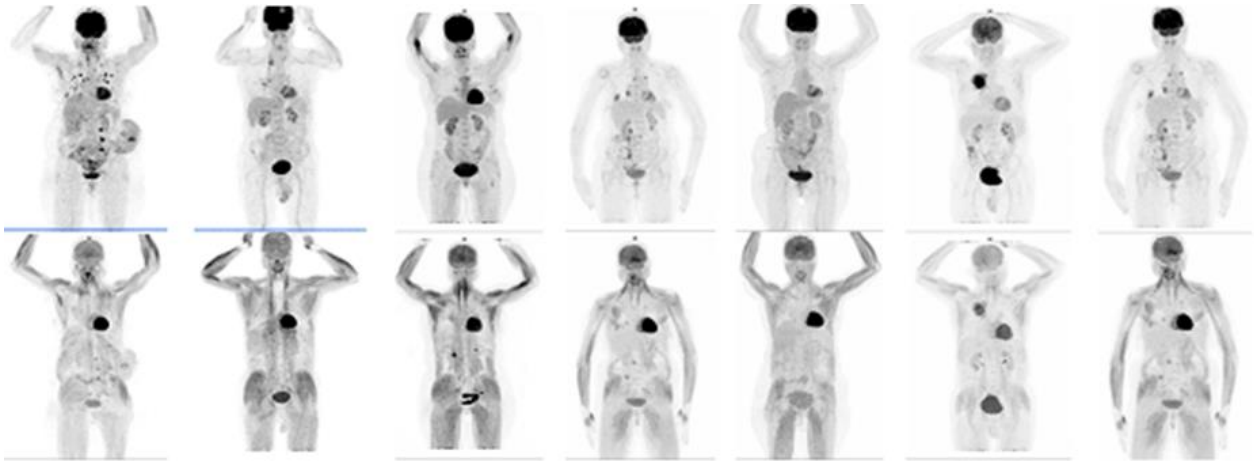

Fig. 1. Comparison of maximum intensity projection (MIP) images from FDG PET/CT scans with and without muscle uptake. In these images of seven different patients, the images in the bottom row are those with diffuse muscle uptake and the images in the top row of the same patients show a normal distribution

Table 1. Mean SUVmax Levels of Lesion and Lesion/liver Suvmax Levels In Images With and Without Muscle Uptake

		Mean	n	Std. Deviation
Lesion	With muscle uptake	7,3	22	4,9
	Without muscle uptake	11,5	22	7,7
Lesion/ Liver	With muscle uptake	2,5	22	1,8
	Without muscle uptake	2,9	22	1,9

repeated scan, while the SUVmax levels of 1 patient decreased. In the same trial, it was reported that the SUV levels of other tissues/organs in repeated evaluations were similar to the SUV levels with patients included in the control group, thus reducing the statistical margin of error as much as possible (10).

Considering the widespread use of SUVmax levels in reporting and the fact that clinicians manage oncology patients based on changes in these levels, studies involving muscle should be repeated. Although a change in SUL of 30% or more is interpreted in favour of response or progression using the PERCIST criteria, clinicians use SUV levels in reporting for patient management. Muscle uptake on FDG PET/CT scans may be regional or diffuse (6). These can be voluntary, such as talking, chewing and moving, or involuntary, such as forced breathing and muscle spasms. (11). In a study by Jackson S et al in 1164 patients, muscle involvement was generally found in 5 anatomical regions of the body in 12.8% of patients. Head and neck, thoracic, and upper extremity muscle involvement were more common, whereas diffuse muscle distribution and lower extremity muscle involvement were less rare (12). Diffuse muscle uptake, which is the subject of our study, were seen in a patient group of less than 1% in the study by Jackson S et al. The cause of diffuse muscle uptake is shown to be whole-body exercise, insulin injection or the patient eating before the FDG injection (13-15). In our department, 2115 patients underwent FDG PET/CT scans between 2021 and 2022. These patients were analysed retrospectively and 22 patients were noted who presented with diffuse muscle uptake and had a repeat scan, which is about 1% of the patients. This ratio is close to that observed in the study by Jackson S et al. These associations are physiological and can be prevented by patient management prior to FDG injection.

The results of this study illustrate that SUVmax and image quality are significantly affected by diffuse muscle involvement. Considering that FDG PET/CT scans is an important parameter in the assessment of treatment response, especially in malignant diseases, it is important to repeat the study in cases of diffuse muscle uptake, which seriously affects the SUVmax

level and image quality, for the benefit of both the clinician and the patient.

Declarations

Ethics Aproval: The study has been approved by the Ethics Committee (date:15/04.2022, decision number:2022/04-13).

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