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A relationship study between different parameters and standardized uptake values of normal liver by using positron emission tomography / computed tomography scan

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► ***Original article***

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ABSTRACT

Background: Integrated Positron Emission Tomography (PET) is widely used to diagnose, stage, and track human diseases during whole-body scanning. Standardized uptake values (SUV_{max}) of normal organs were evaluated by Fluorlne-18-Fluoro-2-doxyD-glucose [^{18}F-FDG (PET/CT)] scanning. Multimodality imaging is an interesting area of research that aims to study the relationship between SUV_{max} in normal livers and different parameters determined with PET/CT. ***Materials and Methods:*** A total of 100 people were tested for ^{18}F-FDG PET/CT. All participants fasted for at least 6 hours before PET/CT imaging, and their fasting blood glucose levels were normal. Scans were acquired following an intravenous dose of ^{18}F-FDG, and PET scans were collected 45-90 minutes after FDG injection. We measured the SUV_{max} in the livers of persons with normal BMI, high BMI, and obesity. ***Results:*** After adjusting each SUV_{max} based on the results of the BMI calculation, which were determined for each subject based on their height and weight, the relationship between SUV_{max} and BMI was statistically significant (p value < 0.05). The SUV measurement was greater in males than females, and it increased significantly in both male and female overweight and obese patients. Gender and BMI were the most reliable independent predictors of SUV value. ***Conclusion:*** The hepatic absorption of ^{18}FFDG increases with the patient's BMI. Patients' genders are the independent variables that best predict their hepatic SUV values.

INTRODUCTION

^{18}F-FDG PET/CT is an essential tool for diagnosing, staging, and restaging a variety of cancers [1]. It provides essential anatomical and functional features that aid in identifying areas of abnormal metabolic activity before morphologic abnormalities manifest, hence increasing the test's specificity and sensitivity. This is the reason for the increase in the number of PET/CT tests at the expense of other diagnostic imaging modalities, particularly Computed Tomography (CT) exams [2]. To appropriately interpret ^{18}F-fluorodeoxyglucose (^{18}F-FDG)-PET images, one must first understand the physiological distribution of the tracer component in healthy organs, as well as the SUVmax of these organs [3].

The liver is distinguished by its heterogeneous absorption of ^{18}F-FDG, which is typically larger than that of the lung, and by reinforcement in the upper exterior margin that extends superficially toward the lower external edge [4]. Furthermore, hepatic absorption of ^{18}F-FDG increases until the fourth decade of life, at which point it plateaus before rising again in the fifth decade. These facts are extremely useful for interpreting and evaluating hepatic lesions [5].

Hepatic uptake of ^{18}F-FDG can be assessed non-invasively using the Standardized Uptake Value (SUV), a semiquantitative metric related to the concentration of the radiotracer in the organ or lesion studied by a region of interest (ROI) with the activity injected and the patient's body mass [6]. To calculate SUV, by dividing the tissue concentration (in kilobecquerel per milliliter) by the activity injected per unit of body weight (in kilobecquerel per gram) [7]. This method provides additional value to the qualitative or visual interpretation of the uptake of the radiotracer. Numerous authors have utilized the SUV to evaluate the uptake of ^{18}F-FDG in diseased lesions, particularly abdomen, with the expected normal or "physiologic" value of the liver as a reference [8]. Thus, if ^{18}F-FDG uptake is larger in the tissue than in the liver, the metabolic focus is considered abnormal. Prior to interpreting examinations in search of potentially malignant lesions, it is critical to understand the scenarios that can modify the metabolic activity of the liver. The association between being overweight or obese and

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having non-alcoholic fatty liver is well known. This illness appears to be caused by a change in normal glucose metabolism (among other things), and it is part of the metabolic syndrome [9].

It is also critical to be familiar with the variable degree of concentration of ^{18}F-FDG in the liver, which may indicate not only normal distribution and artifacts, but also physiological alterations [10]. Few studies have examined the relationship between hepatic ^{18}F-FDG levels, BMI, and hepatic metabolism. As a result, we investigated the differences in hepatic SUVmax in relation to body mass index (BMI) among patients receiving whole-body PET-CT examinations for oncological disease in Iraq.

MATERIALS AND METHODS

The study included 100 participants (35 males and 65 females), mean age (51.92 ± 15.29), with a range between 21 and 80 years, body weights ranged from 44 to 115 kg, with a mean weight of 74.7 ± 15.09, referred to AL- Safeer Hospital / Baghdad during Funerary 2023 until March 2023. We made sure to obtain the patients' informed consent before beginning the PET/CT scans. The ethical committee for the hospital had previously approved of our study. Patients who had recently received intravenous injections were excluded if they had malignant liver tumors.

Patients were not allowed to participate in any portion of the trial if their fasting blood sugar level was greater than 200 mg/dL at the time of the evaluation. All patients fasted for at least four to six hours before to receiving an injection of ^{18}F-FDG (made in Iraq). An intravenous cannula was put into the patient's arm or hand before administering ^{18}F-FDG, and a blood sample was collected to assess the patient's glycemia. Images were captured 45-90 minutes after the contrast agent injection. The patients were positioned supine with both of their arms up.

The BMI was calculated according to the equation (1) and shown in table 1.

$$BMI = \frac{weight\ in\ kg}{(height\ in\ m)^2} \quad (1)$$

Table1. Classification of national status based on body mass index (World Health Organization) [11]

Body mass index	Category
Less than or equal to 18.4 Low weigh	Low weight
18.5 to 24.9	Normal weight
25 to 29.9	Overweight
30 to 34.9	Obese grade I
35 to 39.9	Obese grade II
Greater than or equal to 40	Obese grade III

The World Health Organization categorizes body mass index (BMI) as follows: underweight (BMI> 18.5 kg/m^2), normal (18.5 – 24.99 kg/m^2), overweight (25 – 30 kg/m^2), and obese (≤ 30 kg/m^2) [11].

Data acquisition and image reconstruction

In the course of our investigation, we made use of Philips (Cleveland), Inc. Cleveland, OH44143, U.S.A. introduces 'big-bore'. This scanner's detector was made up of lutetium-yttrium oxyorthosilicate (LYSO) crystals, Crystal size 4 × 4 × 22 millimeters. A CT 64 slice facility with constant tube voltage of (90,120,140) kVp was used, the tube current time product (mAs) ranging from 20 to 500 mAs.

Statistical Analysis

The mean and standard deviation (SD) were used to represent all results. Microsoft Office Excel 2013 was used for all statistical analysis. In order to compare data between variables, a paired and unpaired Student's t-test was used. The result was considered statistically significant if $P < 0.05$.

RESULTS

Of the total 100 PET/CT scans evaluated, 35 were performed on male and 65 were performed on female. Subjects ranged in age from 14 and 80 years (mean ± standard deviation (SD) 51.92 ± 15.29). Consecutive participation who had undergone PET/CT with either standard registration or full dose diagnostic quality CT techniques for a variety of oncological indications, were identified.

Table 2 lists the demographic and clinical characteristics of the all populations. The average injected dose and injected dose/weight, mCi/kg, were (7.85 ± 1.36 mCi), (0.107 ± 0.0084) mCi/kg, respectively. When we plotted the injection dose versus age, there was a strong and significant, $p < 0.05$).

Table 2. Anthropometric and demographic information for enrolled participation.

Variable	Patient Cohort (n=100)
Age (year)	51.92 ± 15.29
Height (m)	1.63 ± 0.079
Weight (kg)	73.9 ± 15.74
BMI kg/(m)^2	27.73 ± 5.81
Injected dose (mCi)	7.85 ± 1.36
Dose/weight (mCi/kg)	0.107 ± 0.0084
SUV_{max} (g/ml)	2.33±0.62

Subjects were classified into three categories based on their BMI values: normal, overweight, and obese.

Table 3 shows that the values of BMI and injection dose for the normal weight group are (22.69 ± 1.69) and (6.73 ± 0.79), respectively, with a p value < 0.05. Overweight group is (26.78 ± 1.09) and (7.69 ± 0.83), respectively, which is also significant. For the obese group, the mean values for both BMI and injection dose were (mean BMI 35.32 ± 4.22, and injection dose 9.46 ± 0.733, with p value < 0.05).

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Table 3. Results for Administered 18F-FDG.

Groups	Mean ± SD					
	Weight (kg)	Height (m)	BMI kg/(m)^2	Injection dose (mci)	Dose/ weight (mci/kg)	*p*-value
Normal weight	61.11± 7.72	1.62± 0.08	22.69± 1.69	6.73± 0.79	0.11± 0.008	<0.05
Overweight	72.45± 7.72	1.64± 0.085	26.78± 1.09	7.69± 0.83	0.106± 0.006	<0.05
Obese	29.10± 12.30	1.61± 0.073	35.32± 4.22	9.46± 0.733	0.103± 0.008	<0.05

The mean value for SUV_{max} was (2.13 ± 0.53) and statistically significant with BMI ($p < 0.05$), as shown in table 4. The mean values for SUV_{max} for overweight and obese were (2.45±0.76) and (2.45 ± 0.45), respectively, with also significant ($p < 0.05$).

Table 4. SUVmax values based on BMI.

Groups	Mean ± SD				
	Weight (kg)	Height (m)	BMI kg/ (m)^2	SUV_{max} (g/ml)	p-value
Normal weight	61.11± 7.72	1.62± 0.08	22.69± 1.69	2.13± 0.53	<0.05
Overweight	72.45± 7.72	1.64± 0.085	26.78± 1.09	2.45± 0.76	<0.05
Obese	29.10± 12.30	1.61± 0.073	35.32± 4.22	2.45± 0.45	<0.05

On analyzing the mean values of SUV_{max} according to gender (Table 5), the SUV was found to significantly increase in men with overweight and obesity than with normal weight (figure 1and figure 2).

Table 5. SUVmax values according to the gender.

BMI	Male (Mean ± SD)	UV $_{max}$ (g/ml)	Female (Mean ± SD)	SUV $_{max}$
Normal weight	22.58±1.92	2.066±0.73	22.76±1.57	2.18±0.39
Overweight	26.38±0.73	2.36±0.97	27.01±1.21	2.23±0.40
Obese	35.18±4.40	2.58±0.44	35.65±4.01	2.38±0.62

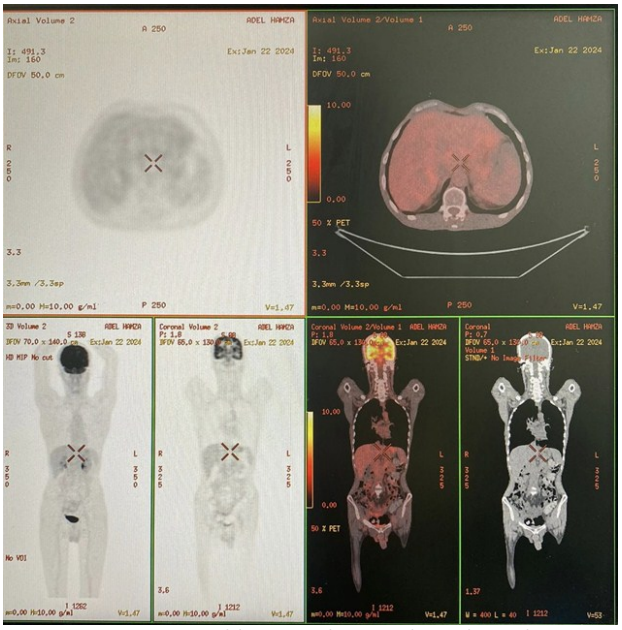

Figure 1. A 45-year-old man with normal weight underwent PET-CT. **(A)** 3D PET; **(B)** axial tomographic slice at the level of the liver.

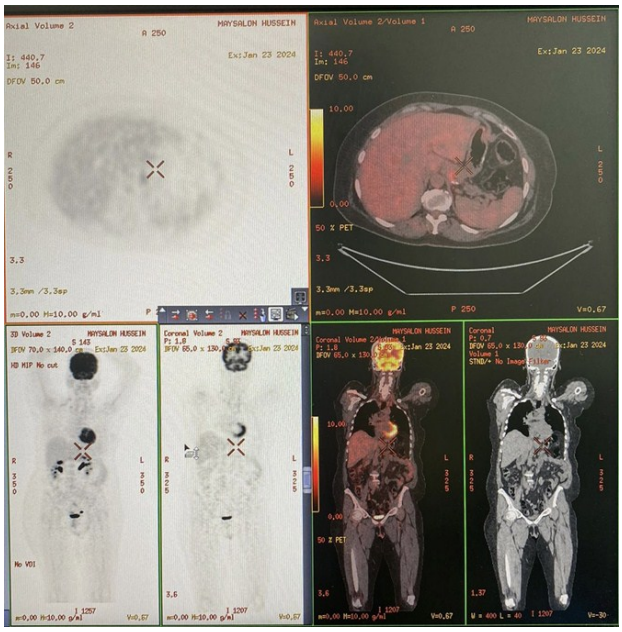

Figure 2. A 48-year-old man with grade II obesity underwent PET-CT. **(A)** 3D PET; **(B)** axial tomographic slice at the level of the liver.

DISCUSSION

The measure of SUV is widely used either to categorize a lesion as malignant or benign or to stage and monitor cancer with ^{18}F-FDG PET scanning. However, many well-known factors can affect the accuracy of SUV measurement, including patient weight, blood glucose level, length of uptake period, partial-volume effect, recovery coefficient, and type of regions of interest (ROI) [12, 13].

A study found a positive connection between serum liver enzyme levels and conventional liver uptake values on FDG-PET [14]. There is a substantial association between liver SUV and BMI, triglycerides, and HDL cholesterol [15]. This study found a substantial positive connection between SUV_{max} of the liver and BMI.

In the current investigation, based on a large, healthy population undergoing PET/CT scans for cancer screening, we found that the commonly used liver SUV was influenced by concentrations of BMI and age. Obesity leads to chronic inflammation caused by elevated levels of plasma cytokines, interleukins, and tumor necrosis factor alpha, which are also produced by Kupffer cells in the hepatic sinusoids. Indeed, the locations of accumulation of ^{18}F-FDG in infected lesions are regarded secretory macrophages of these pro-inflammatory chemicals [15].

Obese patients may have higher concentrations of ^{18}F-FDG due to persistent inflammation in their parenchyma, leading to increased hepatic SUV [9]. In our experience, we found that the largest hepatic concentration of ^{18}F-FDG (represented by a higher

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SUV) is strongly associated with the groups with the highest BMI (overweight and obese).

Lin *et al*. [10] investigated the effect of obesity on SUVmax values and discovered, similar to our findings, a substantial positive connection between BMI and SUV values. This study was categorized into three categories based on BMI (low weight, normal weight, and overweight) table 4.

Malladiet *et al*. [16], Kamimura *et al*. [17], and Mahmud *et al*. [18] reported that BMI had the strongest association with liver ^{18}F-FDG uptake. As patients with a higher BMI have more fatty tissues in their bodies, which have a relatively low glucose uptake in the fasting state, a higher proportion of the injected ^{18}F-FDG remains available for uptake by other organs, including the liver [19]. In contrast, Büsing *et al*. discovered that having a high BMI reduces the mean SUVmax in different healthy organs, including the liver [20].

The relationship between body weight and FDG uptake in the blood is likely the most important practical aspect of PET tumor imaging. Because FDG enters tumors via the bloodstream, less FDG supply from the blood would result in less FDG buildup in tumors. Similarly, increased FDG levels in the blood (with the same serum glucose level) should result in greater total FDG uptake in tumors. Algorithms used to distinguish between malignant and benign tissues based on SUV may be susceptible to errors due to body weight, especially in obese or underweight patients [21].

The gender of the patients in our investigation was another predictor that, together with the BMI, was related with an increase in SUV. Male patients who are overweight and obese are more likely to have higher values of hepatic SUV. Given that uptake of ^{18}F-FDG is frequently used as a "background activity" reference value, determining the importance of focal uptake of ^{18}F-FDG found in other sites of the abdomen and pelvis (adrenal glands, pancreas, lymph nodes), it is important to understand the variations in hepatic metabolic activity according to BMI because this increases the method's sensitivity to detect small malignant abdominal and pelvic lesions [22].

CONCLUSION

We discovered that the absorption of ^{18}F-FDG, as represented by the SUV, increases when the patient's BMI increases. Nonetheless, in addition to BMI, the patient's sex is the independent variable that best predicts the SUV value. Our findings limit the applicability of the widespread practice of using the value of normal hepatic metabolic activity as a reference for questionable uptakes in other locations of the abdomen and pelvis, particularly in male patients with overweight and obesity.

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Author contributions: S.K. conceived and designed the study. S.K., S.O, M.M, all the authors have helped in collecting and analysing the data, writing and correcting the manuscript. All authors have read and agreed to the submitted version of the manuscript. Yours sincerely.

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