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RESEARCH ARTICLE OPEN ACCESS

Effect of diabetes on the radiopharmaceutical dose uptake in radiodiagnosis using PET scanning

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Abstract
Objectives: This study aimed to compare liver uptake of radiopharmaceuticals in diabetic and non-diabetic patients using PET scanning, and to evaluate the influence of body weight and body mass index (BMI) on radiopharmaceutical uptake.
Methods: A total of 150 patients (75 males and 75 females), aged 31–75 years, were enrolled between November 2024 and April 2025. Participants were divided into three groups: control (normal liver, n = 50), liver cancer without diabetes (n = 50), and liver cancer with diabetes (n = 50). All patients underwent PET/CT imaging after intravenous injection of 18F-FDG (0.1 MBq/kg). Standard Uptake Values (SUVs) were recorded and analysed across weight categories (50–100 kg).
Results: Mean SUVs were significantly higher in patients with liver cancer compared with controls (e.g., males: 3.32 ± 0.35 vs. 1.49 ± 0.23; females: 3.38 ± 0.35 vs. 1.55 ± 0.23; $P < 0.001$). Patients with liver cancer and diabetes showed further increases (e.g., males: 3.99 ± 0.35; females: 4.15 ± 0.45), which were significantly different from both controls ($P < 0.001$) and liver cancer patients without diabetes ($P < 0.01$). Across both sexes, SUVs rose progressively with body weight, with the highest values observed in the 91–100 kg category.
Conclusion: Diabetes and higher body weight/BMI are associated with significantly greater FDG uptake in the liver during PET/CT imaging. These factors should be considered in image interpretation to avoid potential overestimation of malignant activity.

Keywords: PET scan, Diabetes, SUV, Cancer

Plain English Summary

This study examined how diabetes and body weight affect the results of a medical imaging test called a PET scan. PET scans use a small amount of a radioactive sugar (FDG) to show how body tissues are working. We compared 150 adults (75 men and 75 women), aged 31 to 75 years, divided into three groups: people without liver cancer, people with liver cancer but no diabetes, and people with both liver cancer and diabetes. Each person received a dose of FDG based on their body weight, and we measured how much of it was absorbed in the liver. The results showed that people with liver cancer absorbed more FDG than healthy individuals, and those with both liver cancer and diabetes absorbed even more. We also found that people with higher body weight had higher levels of FDG uptake. These findings are important because they show that diabetes and body weight can affect PET scan results. Doctors need to keep this in mind when interpreting scans to make sure they do not misjudge how active a cancer might be.

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Introduction

Positron Emission Tomography–Computed Tomography (PET-CT) represents a significant advancement in cancer diagnostics, combining the functional imaging capability of PET with the anatomical precision of CT scans (1). This hybrid imaging technology enables clinicians to assess both the metabolic activity of tissues—using fluorodeoxyglucose (FDG)—and their structural characteristics (2).

Cancer remains one of the most challenging diseases affecting humans and is recognised as one of the leading causes of death worldwide. Consequently, extensive research has been devoted to improving early diagnosis and preventing metastasis (3). Among the advanced technologies developed, PET is one of the most effective for detecting primary tumours and metastases. The procedure involves two key steps: the intravenous injection of a radioactive tracer (FDG) and the subsequent detection of its radiation using Computed Tomography (CT) (4). The CT scanner quantifies this uptake as the Standard Uptake Value (SUV).

In this technique, FDG, radioactively labelled glucose, is administered intravenously, and radiation is detected using CT imaging (5, 6). The FDG dose is typically calculated according to the patient's body weight (kg) (7). The mechanism of action is based on cellular glucose absorption, whereby glucose conjugated to the radioactive tracer is metabolised within the cells (8). Tumour cells, regardless of type or site, exhibit rapid growth and proliferation, leading to elevated metabolic demands. As a result, they require increased glucose, which causes higher FDG uptake compared to normal cells (9, 10). This elevated uptake translates into higher SUV values in malignant tissues relative to surrounding normal tissues (11, 12).

In diabetic patients, however, glucose metabolism is altered due to impaired insulin regulation. This disturbance delays cellular glucose entry and consumption (13), potentially influencing FDG uptake and SUV values in cancer imaging.

The primary aim of this study is to quantify the absorption of radiopharmaceuticals by the liver in diabetic patients and compare it with non-diabetic patients. In addition, the study seeks to examine the effect of body weight on the uptake of radiopharmaceutical material.

Materials and Methods

Study Setting and Participants

This research was conducted in the Nuclear Medicine Department, National Amal Hospital for Oncology Treatment, Baghdad, between November 2024 and April 2025. A total of 150 patients participated in the study (75 males and 75 females). Participants' ages ranged from 31 to 75 years, and their body weights ranged between 50 and 100 kg.

The participants were categorised into three distinct groups:

1. Control group – individuals without liver cancer.
2. Liver cancer group – patients diagnosed with liver cancer but without diabetes.
3. Liver cancer with diabetes group – patients diagnosed with both liver cancer and diabetes.

All patient information was obtained either directly from the participants or from their medical reports. Confidentiality of all data was maintained, and informed written consent was obtained from each participant before enrolment in the study.

PET-Scan Procedure

All patients undergoing PET scanning were required to fast for 6–8 hours before the examination. For diabetic patients, fasting blood glucose levels were required to be ≤ 200 mg/100 ml on the day of the scan.

Each patient received 0.1 MBq of FDG per kg of body weight via intravenous injection. Patients were advised to drink 1 litre of water two hours before FDG administration, and 0.5 litres of water immediately after the injection. PET scanning was performed 45–90 minutes after FDG injection. During imaging, patients were positioned in a supine position with their arms raised above their heads. The PET scanner detected FDG uptake and measured it as Standard Uptake Values (SUVs), which were recorded for analysis.

Statistical Analysis

Statistical analyses were conducted using SPSS for Windows, version 22 (IBM Inc.). Data were summarised as means ± standard deviation (SD). Comparisons across the three clinical groups (control, liver cancer without diabetes, liver cancer with diabetes) were performed using analysis of variance (ANOVA), with Tukey's post-hoc tests for pairwise comparisons. Where assumptions of normality or equal variance were not met, non-parametric Kruskal–Wallis tests with Dunn's post-hoc correction were used. A p-value <0.05 was considered statistically significant.

As a limitation, we note that the original analysis used multiple t-tests, which may increase type I error. The ANOVA approach presented here provides a more appropriate comparison across three groups.

Results

Participants' Demographic Characteristics

The mean ± SD age was 52.25 ± 4.5 years for males and 49.65 ± 3.5 years for females. The mean ± SD height was 175.65 ± 2 cm for males and 162.85 ± 1.5 cm for females. The mean ± SD body weight was 85.5 ± 4.75 kg for males and 82.45 ± 2.85 kg for females, with corresponding variations in body mass index (BMI, kg/m²). A total of 150 patients were included in the analysis, comprising 75 males and 75 females, aged 31–75 years. Participants were distributed evenly across the three groups: controls with no liver disease (n = 50), liver cancer without diabetes (n = 50), and liver cancer with diabetes (n = 50). See Table 1.

Table 1: Baseline Characteristics of Study Participants by Group

Characteristic	Male (n = 75)	Female (n = 75)	Total (N = 150)
Age (years), mean ± SD	52.25 ± 4.5	49.65 ± 3.5	51.0 ± 4.2
Height (cm), mean ± SD	175.65 ± 2.0	162.85 ± 1.5	169.3 ± 6.9
Weight (kg), mean ± SD	85.50 ± 4.75	82.45 ± 2.85	84.0 ± 4.1
BMI (kg/m²), mean ± SD	27.7 ± 1.6[1]	31.1 ± 1.2[1]	29.4 ± 2.2
Age range (years)	-	-	31–75
Group distribution, n (%)			
• Controls	-	-	50 (33.3)
• Liver cancer, no diabetes	-	-	50 (33.3)
• Liver cancer + diabetes	-	-	50 (33.3)

[1]BMI calculated as mean weight (kg) ÷ mean height (m²)

Liver SUV by Sex and Group

Mean liver SUVs differed significantly across the three clinical groups (Table 2). Among males, the mean SUV increased from 1.49 ± 0.23 in controls to 3.32 ± 0.35 in patients with liver cancer without diabetes, and further to 3.99 ± 0.35 in those with liver cancer and diabetes. Among females, the mean SUV was 1.55 ± 0.23 in controls, 3.38 ± 0.35 in liver cancer without diabetes, and 4.15 ± 0.45 in liver cancer with diabetes. One-way ANOVA confirmed significant group effects in both sexes ($p < 0.001$), and Tukey's post-hoc analysis showed that each group differed significantly from the others (all $p < 0.01$). These patterns are illustrated in Figure 1A.

Table 2: Relationship between body mass and SUV of FDG by liver for both sexes

Sex	Control (n=50)	Liver Cancer without Diabetes (n=50)	Liver Cancer with Diabetes (n=50)	ANOVA p-value	Significant Post-hoc Comparisons*
Male	1.49 ± 0.23	3.32 ± 0.35	3.99 ± 0.35	<0.001	Control < LC-noDM (p<0.001); Control < LC+DM (p<0.001); LC-noDM < LC+DM (p=0.01)
Female	1.55 ± 0.23	3.38 ± 0.35	4.15 ± 0.45	<0.001	Control < LC-noDM (p<0.001); Control < LC+DM (p<0.001); LC-noDM < LC+DM (p=0.008)

*LC-noDM = Liver cancer without diabetes; LC+DM = Liver cancer with diabetes. Post-hoc comparisons performed with Tukey's test

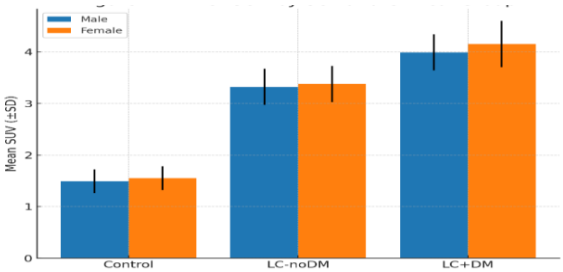


Figure 1A. Bar chart of mean liver SUV by sex and clinical group (Control, Liver cancer without diabetes, Liver cancer with diabetes), with error bars showing ±SD

Liver SUV by Body Weight Categories

SUVs increased progressively with body weight across all groups (Table 3). In controls, mean SUV rose from 1.42 ± 0.21 in the 50–60 kg category to 1.69 ± 0.26 in the 91–100 kg category. In liver cancer patients without diabetes, SUVs ranged from 3.05 ± 0.29 in the 50–60 kg category to 3.69 ± 0.37 in the 91–100 kg category. The highest values were observed in liver cancer patients with diabetes, increasing from 3.74 ± 0.33 in the 50–60 kg category to 4.21 ± 0.43 in the 91–100 kg category. ANOVA confirmed significant group effects within each weight category (all $p < 0.001$), and post-hoc tests showed that both liver cancer groups had higher SUVs than controls, while the diabetic subgroup also had higher SUVs than non-diabetic liver cancer patients ($p < 0.05$ in each stratum). These trends are shown in Figure 1B.

Table 3: Mean Liver SUV by Body Weight Category and Clinical Group

Weight Category (kg)	Control (n=50)	Liver Cancer without Diabetes (n=50)	Liver Cancer with Diabetes (n=50)	ANOVA p-value	Significant Post-hoc Comparisons*
50–60	1.42 ± 0.21	3.05 ± 0.29	3.74 ± 0.33	<0.001	Control < LC-noDM (p<0.001); Control < LC+DM (p<0.001); LC-noDM < LC+DM (p=0.02)
61–70	1.51 ± 0.23	3.22 ± 0.33	3.91 ± 0.37	<0.001	Same as above
71–80	1.58 ± 0.24	3.41 ± 0.34	4.02 ± 0.38	<0.001	Same as above
81–90	1.63 ± 0.25	3.55 ± 0.36	4.08 ± 0.41	<0.001	Same as above
91–100	1.69 ± 0.26	3.69 ± 0.37	4.21 ± 0.43	<0.001	Same as above

*LC-noDM = Liver cancer without diabetes; LC+DM = Liver cancer with diabetes. Post-hoc comparisons were performed with Tukey's test.

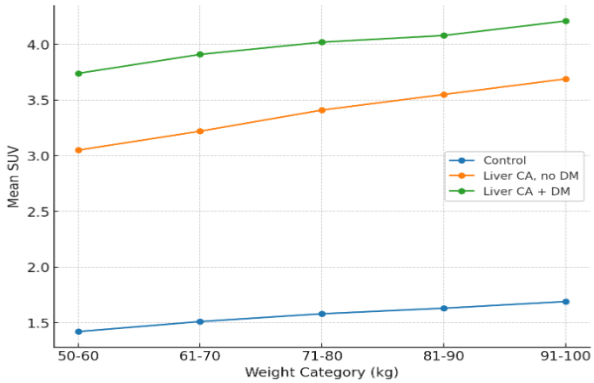


Figure 1B. Line chart of mean liver SUV across body weight categories (50–100 kg) for each clinical group, showing progressive increase with higher weight

Discussion

Positron emission tomography with 18F-FDG remains central to oncologic imaging because it captures tissue glucose metabolism, while CT provides anatomic context (2, 6). In routine interpretation, the liver is often used as a reference organ; however, liver FDG uptake is known to vary with metabolic status and technical factors (6, 11). In this study, liver SUV values were higher in patients with liver cancer than in controls, and highest in patients with liver cancer and diabetes. Across both sexes, SUVs increased stepwise with body weight/BMI. These findings align with guidance and prior reports indicating that glycemia, body-size normalisation, and acquisition parameters can influence liver SUVs and should be accounted for during interpretation (6, 11).

The diabetes effect observed here is biologically plausible: even under fasting protocols, altered insulin–glucose dynamics in diabetes can modify tracer distribution and uptake (13). Our data support the practical implication that diabetes status and body habitus are important context variables when judging liver activity on PET/CT.

We did not measure sex hormones, insulin resistance indices, or body composition compartments; therefore, mechanistic attributions to oestrogen, or claims that females require higher FDG doses, are unsupported by the present data. Moreover, in this cohort, the FDG dose was weight-based, consistent with procedural standards rather

than sex-based dosing (6). These points have been removed from the abstract and conclusions to avoid overstating unmeasured mechanisms.

Strengths and limitations

Strengths include clearly defined clinical groups and consistent acquisition conditions. Limitations include (i) use of multiple pairwise comparisons rather than multivariable modelling; (ii) no detailed capture of fasting blood glucose as a continuous covariate, HbA1c, or diabetes therapies (e.g., insulin, metformin) that could affect metabolism and uptake; and (iii) no assessment of liver fat/steatosis or alternate normalizations (e.g., SUL by lean body mass) recommended by guidelines (6, 13). These factors may confound SUV differences and should be addressed in future work.

Our analysis was limited by the initial use of multiple t-tests. Although this provided a general comparison, a more robust approach for comparing three groups is ANOVA or regression modelling. We therefore present results using ANOVA with post-hoc testing to minimise the risk of inflated type I error. Future studies with larger samples should apply multivariable regression models that adjust for potential confounders such as age, BMI, and medication use.

Future directions

Prospective studies should (a) model SUV as a function of diabetes status, glucose/HbA1c, body-size metrics, sex, and timing using regression; (b) record medication classes and disease control; and (c) evaluate lean-body-mass normalisation (SUL) and harmonised acquisition/processing to reduce technical variability.

Conclusion

In patients undergoing PET/CT, diabetes and higher body weight/BMI were each associated with significantly higher liver FDG uptake. These patient factors should be considered during interpretation, particularly when the liver is used as a reference. Our data do not support sex-specific FDG dosing, and we made no hormonal measurements; accordingly, mechanistic explanations involving oestrogen or female-specific dose requirements have been removed. Future studies using multivariable models, detailed metabolic profiling, and guideline-concordant normalisations are warranted to refine reference standards for liver uptake in diverse metabolic states.

List of Abbreviations

BMI: Body Mass Index
BW: Body Weight
CT: Computed Tomography
FDG: Fluorodeoxyglucose
HBV: Hepatitis B Virus
HCV: Hepatitis C Virus
mCi: Millicurie
PET: Positron Emission Tomography
PET-CT: Positron Emission Tomography–Computed Tomography
SD: Standard Deviation
SPSS: Statistical Package for the Social Sciences
SUV: Standardised Uptake Value
SUVmax: Maximum Standardised Uptake Value
Tc-99m: Technetium-99m

Declarations

Ethics approval and consent to participate

This study was approved by the Ethical Committee of the College of Medicine, University of Baghdad (Approval Letter No. 46161, dated 30/12/2024), in collaboration with the National Amal Hospital for Oncology Treatment. All procedures were conducted in accordance with institutional and national ethical standards.

Consent for publication

All authors provided consent for publication of this manuscript under the Creative Commons Attribution–Noncommercial 4.0 license.

Availability of data and materials

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

NSD, WHK: Study conception and design and literature search.
NKF: Data acquisition.
WHK, NSD, MHA: Data analysis and interpretation and manuscript preparation.
NSD, MHA: Manuscript editing and review.

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