SCIENTIFIC RESEARCH

IMPACT OF BLOOD GLUCOSE LEVELS ON IMAGE QUALITY AND SUVMAX IN PET/CT SCAN

Mai Viet Dinh, Nguyen Kim Luu*, Tran Van Bien*, Ha Ngoc Hai*, Nguyen Thi Tra My*, Phan Cong Huan*, Hoang Van An*, Chu Khanh Linh*, Nguyen Viet Chinh*, Hoang Thi Huyen Trang***

SUMMARY

Objective: To evaluate the impact of pre-scan blood glucose levels on image quality and SUVmax values in 18F-FDG PET/CT imaging among patients with lung cancer, thereby providing practice-based evidence to optimize patient preparation protocols.

Methods: A cross-sectional comparative study was conducted on 200 treatment-naïve lung cancer patients who underwent 18F-FDG PET/CTscan at Phenikaa University Hospital. Patients were stratified into four groups according to blood glucose levels: <6.1 mmol/L, 6.1–8.3 mmol/L, 8.4–11.1 mmol/L, and >11.1 mmol/L. Image quality was assessed using a standardized 5-point Likert scale by two independent nuclear medicine physicians. SUVmax was measured at the target lesion. Covariates including age, sex, BMI, FDG dose, and uptake time were controlled.

Results: Mean age ranged from 61 to 64 years, and mean BMI from 22.5 to 23.4 kg/m², with no significant intergroup differences. Image quality progressively declined with higher glucose levels: the <6.1 mmol/L group achieved a mean score of 4.8, whereas the >11.1 mmol/L group decreased to 2.8. SUVmax values showed a corresponding reduction, from 12.4 in the <6.1 mmol/L group to 8.1 in the >11.1 mmol/L group. The need for repeat scanning increased markedly in patients with glucose >11.1 mmol/L (36%), while no rescan was required in patients with glucose <8.3 mmol/L.

Conclusion: Pre-scan blood glucose levels have a marked and clinically meaningful impact on both image quality and SUVmax quantification in 18F-FDG PET/CT, and elevated glucose substantially increases the risk of repeat imaging.

Keywords: *PET/CT, blood glucose, SUVmax, image quality.*

** Phenikaa University Hospital*

*** Bach Mai Hospital*

I. INTRODUCTION

Positron emission tomography/computed tomography (PET/CT) using ^{18}F-fluorodeoxyglucose (^{18}F-FDG) is an essential imaging modality in oncology, enabling diagnosis, staging, treatment response assessment, and surveillance based on the increased glucose metabolism of malignant cells relative to benign tissues. ^{18}F-FDG, a glucose analogue, enters cells via glucose transporters and becomes trapped after phosphorylation, generating PET signals that reflect the metabolic activity of lesions.

Under appropriate patient preparation conditions (fasting, controlled insulin and glucose levels), PET/CT allows semiquantitative assessment through parameters such as the standardized uptake value (SUV), facilitating standardization and longitudinal comparison over time [1,2].

However, elevated pre-scan blood glucose can alter FDG biodistribution: endogenous glucose competes with FDG uptake in tumors and normal organs, resulting in higher background activity in the liver and blood pool, reduced uptake in the brain and muscles, and consequently degraded image quality and compromised quantitative accuracy (e.g., SUV deviations). International guidelines (EANM, SNMMI) emphasize the need to measure blood glucose prior to FDG administration, maintain low glycemia and low insulinaemia, and apply appropriate intervention or rescheduling thresholds (commonly <11 mmol/L ~ 200 mg/dL in clinical practice, with stricter cutoffs in research) to ensure image quality and reproducibility of SUV measurements [3]. To date, few studies in Vietnam have addressed this issue.

This study was designed to evaluate the association between pre-scan blood glucose levels, PET/CT image quality, and lesional SUVmax on ^{18}F-FDG PET/CT. The findings aim to quantify the actual magnitude of these effects and provide evidence to optimize local patient-preparation protocols. The expected results may help refine preparation standards and appropriate glycemic thresholds in both clinical practice and research settings, taking into account the body mass index characteristics of the Vietnamese population compared with current international standardization recommendations.

II. SUBJECTS AND METHODS

1. Study population

This study included 200 patients with a confirmed diagnosis of lung cancer who underwent pre-treatment staging and were referred for PET/CT imaging at the Center for Nuclear Medicine, Phenikaa University Hospital, from January 2025 to June 2025.

1.1. Inclusion criteria

- Patients aged 18 years or older with histopathologically confirmed lung cancer.
- Patients with complete clinical and imaging data available in the medical records.
- Patients who agreed to participate in the study and signed written informed consent.
- Availability of pre-injection blood glucose measurement prior to FDG administration.

1.2. Exclusion criteria

- Patients with contraindications to radiopharmaceutical administration (pregnant or breastfeeding women).
- Patients who were unable to cooperate during the PET/CT procedure.
- Patients with uncontrolled diabetes, those receiving insulin close to the imaging time, or those taking corticosteroids; patients with acute infection, hepatic failure, or renal failure.
- Patients who engaged in vigorous physical activity within 24 hours before scanning.

III. METHODS

1. Study design

This study was designed as a cross-sectional descriptive analysis with comparative evaluation between predefined patient groups.

2. Study grouping

- A total of 200 eligible patients had their blood glucose levels measured prior to FDG injection and were categorized into four groups according to the following glycemic ranges:

+ Group A: <6.1 mmol/L, n = 50
+ Group B: 6.1–8.3 mmol/L, n = 50
+ Group C: 8.4–11.1 mmol/L, n = 50
+ Group D: >11.1 mmol/L, n = 50

- The glucose thresholds used for group stratification were selected based on recommendations from the European Association of Nuclear Medicine (EANM) and the Society of Nuclear Medicine and Molecular Imaging (SNMMI). According to these guidelines, pre-scan blood glucose levels <7–8.3 mmol/L are considered acceptable for clinical studies and trials to ensure standardized conditions and reproducibility of SUV measurements. In routine clinical practice, glucose levels ≥11 mmol/L (~200 mg/dL) warrant consideration for rescheduling the examination because of the substantial risk of reduced sensitivity and impaired quantitative accuracy. Intermediate levels (8.4–11.1 mmol/L) may lead to decreased image quality and reduced SUVmax due to competitive inhibition between endogenous glucose and FDG uptake in tumors and normal tissues.

3. Management of elevated blood glucose

For patients presenting with pre-injection blood glucose levels above the recommended threshold, a predefined management protocol was applied in accordance with EANM/SNMMI guidelines:

Insulin intervention: The study did not administer rapid-acting insulin immediately before PET/CT. This is consistent with EANM recommendations, particularly for brain imaging, because abrupt changes in insulin or glucose levels may significantly alter SUV quantification and FDG biodistribution.

Waiting period after insulin (if intervention is required in clinical practice): When insulin administration is unavoidable in routine clinical settings, a minimum waiting period of 4–6 hours is required to ensure a stable metabolic state prior to scanning.

4. Equipment and Imaging Protocol

PET/CT scanner: GE Discovery IQ (GE Healthcare, USA).

- Blood glucose meter: Accu-Chek Guide.
- Cross-calibration between the dose calibrator and the PET/CT system was performed periodically to ensure quantitative accuracy.
- Radiopharmaceutical: ^{18}F-FDG administered intravenously as a bolus at a dose of 0.15 mCi/kg.
- Patients fasted for at least 4–6 hours prior to ^{18}F-FDG injection and were allowed to drink only water to maintain low insulinaemia.
- Blood glucose levels were measured immediately before scanning.
- After ^{18}F-FDG administration, patients were instructed to drink at least 1.5 liters of water and to void prior to entering the imaging suite.
- Patients rested quietly in a controlled-temperature waiting area, minimizing movement, talking, and physical activity to reduce physiologic FDG uptake in skeletal muscle and brown adipose tissue.
- PET/CT acquisition was performed 60 ± 5 minutes after injection, covering the region from the vertex of the skull to the lower third of both femurs.

5. Image Quantification and Analysis

Image processing and data analysis were performed using AW Server software.

PET images were reconstructed using an OSEM algorithm incorporating time-of-flight (TOF) and point-spread function (PSF) modeling in accordance with guideline recommendations. Reconstruction parameters, filters, and matrix size were kept strictly consistent across all patients.

The standardized uptake value (SUV) was calculated using the conventional formula based on injected radioactivity, body weight, and a fixed uptake time.

The study did not apply glucose-corrected SUV, as evidence supporting this correction remains inconsistent in the literature [4]. Furthermore, glucose correction may introduce bias in clinical settings. Specifically, when blood glucose varies within physiological or borderline ranges (5–10 mmol/L), correction may artificially magnify or diminish differences in SUV that are not clinically meaningful, thereby distorting comparisons between patients or across serial scans. For these reasons, the study reports uncorrected SUV values, accompanied by measured pre-injection blood glucose levels, to better reflect real-world clinical conditions and ensure comparability with other studies.

PET/CT image quality was independently assessed by two nuclear medicine physicians, each with over 10 years of experience. To minimize bias and enhance scientific rigor, the readers were blinded to the patients' blood glucose levels during image scoring. Image-quality assessment criteria were based on EANM/UPICT recommendations and included image noise, lesion conspicuity, and quantitative lesion-to-background relationships. In cases of disagreement, the two readers reached a consensus through joint review. Interobserver agreement was evaluated using Cohen's Kappa coefficient, which demonstrated high concordance (κ = 0.82) in this study.

Table 1. The 5-point Likert scale for PET/CT imagine rating

Score	Definition
1	Non-diagnostic image; severe noise; SUV quantification not feasible; small lesions are easily missed; repeat scanning required.
2	Severe noise; markedly impairs SUV quantification and detection of small lesions; low signal-to-noise ratio (SNR); lesion-to-background ratio (TBR) <1.5.
3	Moderate noise; SUV quantification still possible but limited; SNR and TBR reduced compared with standard; diminished ability to detect small lesions.
4	Mild noise; reliable SUV assessment; good lesion-to-liver and lesion-to-blood contrast (TBR >2.0).
5	Optimal image quality with no perceptible noise; clear FDG distribution between lesions and normal tissues; high SNR and TBR; accurate SUV quantification achievable.

3. Study Variables

3.1. Independent variable

Pre-injection blood glucose concentration, measured using the Accu-Chek Guide device immediately before FDG administration.

3.2. Dependent variables

PET/CT image quality: assessed using a 5-point ordinal scale (1–5) based on noise level, SNR, TBR, and lesion conspicuity.

SUVmax of the target lesion: measured directly on the PET/CT system (GE Discovery IQ).

Repeat-scan rate: recorded when a patient required a repeat PET/CT scan during the same visit due to inadequate image quality or elevated blood glucose levels.

3.3. Covariates / Potential confounders

Age (years old), sex (male/female).

Body mass index (BMI, kg/m²).

FDG uptake time (minutes from injection to acquisition).

Administered FDG dose (mCi/kg).

Image reconstruction parameters (OSEM, TOF, PSF).

4. Data Collection Methods

Data were collected from medical records and documented administrative and clinical information using a predesigned checklist. All data were entered into a computerized database for storage and analysis.

5. Data Analysis Methods

Software: Microsoft Excel and SPSS version 20.0.

Statistical tests: ANOVA for quantitative variables; Chi-square test for categorical variables.

Statistical significance was set at p < 0.05.

III. Results

1. Characteristics of the study population

Table 2. Demographic and clinical characteristics by glucose level group

Characteristics	<6,1 mmol/L	6,1-8,3 mmol/L	8,4–11,1 mmol/L	>11,1 mmol/L	p-value
Age (years old, Mean ± SD)	61,2 ± 8,5	62,0 ± 9,1	63,1 ± 7,9	64,3 ± 8,7	0,62
Proportion of male patients (%)	60%	58%	62%	61%	0,91
BMI (kg/m², Mean ± SD)	22,5 ± 2,1	22,9 ± 2,4	23,1 ± 2,2	23,4 ± 2,5	0,79
Stable uptake time (Minute, Mean ± SD)	60 ± 4	59 ± 6	60 ± 4	61 ±5	0,88
FDG dose (mCi/kg, Mean ± SD)	0,15 ± 0,01	0,15 ± 0,01	0,15 ± 0,009	0,15 ± 0,01	0,95

Comment: The mean age did not differ significantly among the four glucose level groups (61–64 years, SD ~ 8–9 years), with p = 0.62. The proportion of male patients (58–62%), the mean BMI values (22.5–23.4 kg/m²), the stable mean uptake time (59–61 minutes), and the administered mean FDG dose (0.15 mCi/kg) all showed no significant differences across groups (*p* > 0.95).

2. PET/CT image quality and FDG uptake parameters

Table 3. Image Quality Assessment Using the 5-Point Scale

Blood glucose level group	Image Quality score (Mean ± SD)	95% CI	SUVmax (Mean ± SD)	95% CI (SUVmax)
Group A	4,8 ± 0,3	4,7 – 4,9	12,4 ± 2,1	11,8 – 13,0
Group B	4,3 ± 0,4	4,2 – 4,4	11,0 ± 2,0	10,4 – 11,6
Group C	3,6 ± 0,5	3,5 – 3,7	9,6 ±1,9	9,1 – 10,1
Group D	2,8 ± 0,6	2,6 – 3,0	8,1 ± 2,2	7,5 – 8,7
p-value	<0,001		<0,001	

Comment:

- Image quality scores decreased progressively with increasing pre-scan blood glucose levels: Group A (<6.1 mmol/L): 4.8 ± 0.3 (95% CI: 4.7–4.9); Group B (6.1–8.3 mmol/L): 4.3 ± 0.4 (95% CI: 4.2–4.4); Group C (8.4–11.1 mmol/L): 3.6 ± 0.5 (95% CI: 3.5–3.7); Group D (>11.1 mmol/L): 2.8 ± 0.6 (95% CI: 2.6–3.0); *p* < 0.001.
- Mean SUVmax declined significantly with increasing blood glucose levels: Group A (<6.1 mmol/L): 12.4 ± 2.1 (95% CI: 11.8–13.0); Group B (6.1–8.3 mmol/L): 11.0 ± 2.0 (95% CI: 10.4–11.6); Group C (8.4–11.1 mmol/L): 9.6 ± 1.9 (95% CI: 9.1–10.1); Group D (>11.1 mmol/L): 8.1 ± 2.2 (95% CI: 7.5–8.7); *p* < 0.001.

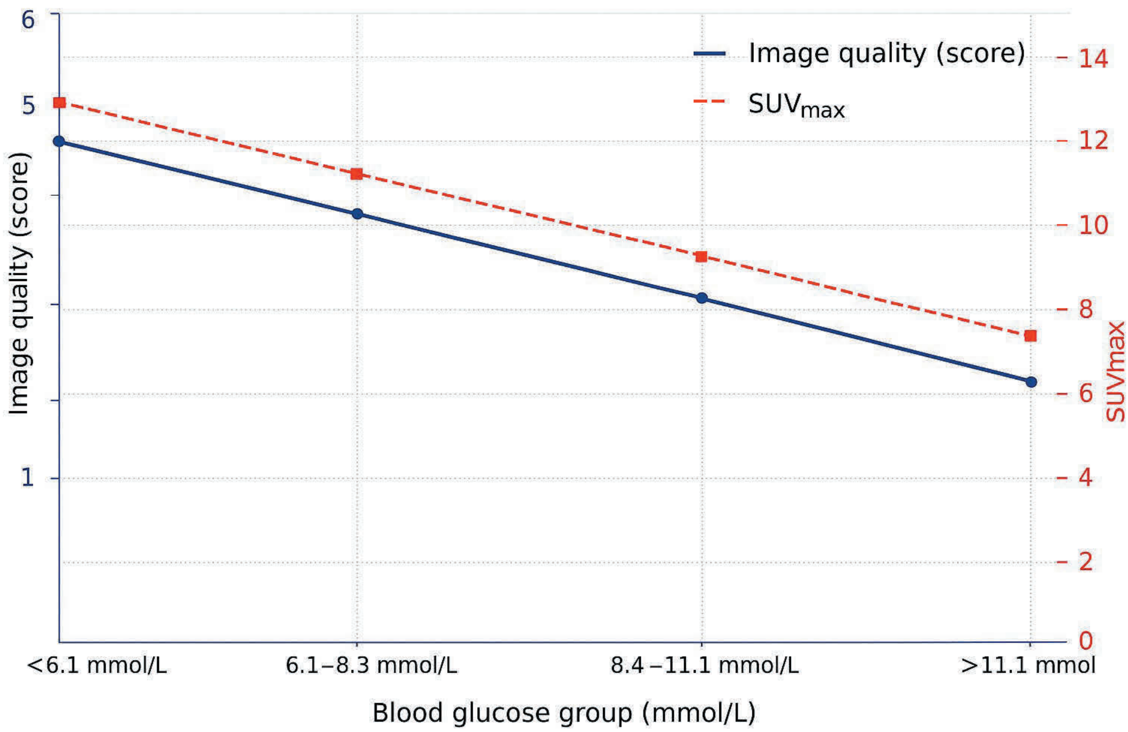

Figure 1. Linear trends of SUVmax and image quality according to blood glucose levels

Comment: The horizontal axis represents the four blood glucose groups (<6.1 mmol/L; 6.1–8.3 mmol/L; 8.4–11.1 mmol/L; >11.1 mmol/L). The vertical axis displays the mean image quality score (5-point scale) and mean SUVmax values.

3. Repeat-Scan Rate

Table 4. Proportion of Patients Requiring Repeat Scanning

Blood Glucose Group	Number of repeat scans (n)	Total number of cases	Repeat-scan rate (%)	Main reason for repeat scanning	Timing of repeat scanning
Group A	0	50	0%	-	-
Group B	0	50	0%	-	-
Group C	2	50	4%	1 case due to image noise; 1 case due to technical error	On the same day
Group D	18	50	36%	blood glucose level >11.1 mmol/L	Rescheduled to another day (after blood glucose control)

The repeat-scan rate was 0% in Groups A and B, 4% in Group C due to image noise and technical errors, and 36% in Group D attributable to elevated blood glucose levels.

IV. DISCUSSION

The results of this study are consistent with the recommendations of the EANM and SNMMI. Patient preparation, image acquisition, and reconstruction protocols were referenced according to the UPICT FDG-PET/CT and QIBA Profile guidelines to minimize intra- and inter-scan variability and to support longitudinal comparison of quantitative SUV measurements [5,6].

Elevated pre-scan blood glucose levels were shown to significantly degrade PET/CT image quality and reduce SUVmax values. The lowest SUVmax was observed in the group with blood glucose levels >11.1 mmol/L, a factor that may compromise lesion detectability, particularly for small tumors or lesions with low metabolic activity. These findings are in agreement with reports by Boellaard et al. (EANM 2015) and the study by Evangelista et al. (2020), which demonstrated that hyperglycemia reduces the detectability of lesions with low FDG uptake or small size, leading to an increased need for repeat scanning.

According to the EANM Guidelines (2015; updated 2022), blood glucose levels ≥11.1 mmol/L are associated with substantial degradation of image quality and SUVmax. The results of the present study align closely with these recommendations, as the group with blood glucose >11.1 mmol/L exhibited the lowest mean image quality score (2.8) and the lowest mean SUVmax (8.1).

A novel and clinically relevant finding of this study is the identification of an optimal glucose threshold <6.1 mmol/L. This threshold has rarely been examined separately in international studies, which typically use cutoffs of <7 or <8.3 mmol/L. Our data demonstrate that blood glucose levels <6.1 mmol/L yielded the highest image quality scores (4.8), which may be related to the anthropometric characteristics of the Vietnamese population, particularly the relatively low mean BMI (~23 kg/m²). Compared with Western populations, which have a higher prevalence of obesity, Vietnamese individuals generally have lower body fat mass, a factor that influences FDG uptake and biodistribution. Adipose tissue competes for FDG uptake, potentially reducing tracer availability to other tissues; therefore, in individuals with lower BMI, FDG may preferentially accumulate in malignant lesions, enhancing lesion-to-background contrast and resulting in sharper PET/CT images with higher SUVmax values. These findings not only contribute to optimizing patient preparation protocols but also suggest future research directions exploring physiological and metabolic differences among populations and their impact on PET/CT quantification [7].

Regarding the repeat-scan rate, there are currently no international guidelines reporting specific quantitative data. In this study, the group with blood glucose levels >11.1 mmol/L exhibited a repeat-scan rate as high as 36%, providing important real-world evidence to support clinical decision-making and pre-scan workflow management.

In Vietnam, several studies have reported SUVmax values in different malignancies, such as esophageal cancer at Bach Mai Hospital (mean primary tumor SUV 10.7 ± 5.0) [8], lung adenocarcinoma in Ho Chi Minh City (10.8 ± 4.2) [9], and gastric cancer at Military Hospital 103 (mean SUVmax of distant metastases 10.96 ± 4.45) [10]. However, these studies primarily focused on describing SUV characteristics and their associations with disease stage or lesion morphology, without evaluating the independent role of blood glucose levels in SUVmax variability and image quality. Therefore, our study adds national evidence demonstrating the substantial impact of pre-scan blood glucose on PET/CT quantitative parameters and image quality, while also identifying clinically meaningful glucose thresholds for routine practice.

The limitations of this study include its single-center design, the lack of harmonization according to EANM Research Ltd. (EARL) standards, and the absence of analysis based on PERCIST 1.0 criteria. Nevertheless, this represents one of the first studies in Vietnam to systematically evaluate the influence of blood glucose on PET/CT image quality and SUVmax, providing real-world evidence to support the refinement of FDG-PET/CT protocols.

V. CONCLUSION

This study demonstrates that pre-scan blood glucose levels have a significant impact on PET/CT image quality and the quantitative accuracy of SUVmax, while markedly increasing the risk of repeat scanning in cases of hyperglycemia. Therefore, in routine clinical practice, blood glucose measurement prior to FDG administration is mandatory, and patients should undergo glucose-lowering intervention or have the examination postponed when blood glucose levels exceed 11 mmol/L.

Patient preparation protocols should be strictly standardized, including fasting for 4–6 hours and avoidance of vigorous physical activity for at least 24 hours before FDG injection. In addition, technical conditions must be maintained consistently, particularly with respect to the standardized uptake time (60 ± 5 minutes) and weight-based FDG dosing (mCi/kg) applied uniformly across all patients.

Adherence to these standardization measures will improve quantitative accuracy, substantially reduce repeat-scan rates, and optimize the diagnostic value of ^{18}F-FDG PET/CT in clinical practice.

VI. RECOMMENDATIONS

Mandatory documentation of blood glucose levels in the PET/CT report prior to ^{18}F-FDG injection is recommended to support accurate interpretation and quantitative analysis.

Blood glucose management should follow EANM/SNMMI recommendations: for patients with diabetes mellitus receiving insulin, scan scheduling should be optimized to ensure a minimum interval of ≥4 hours after administration of short-acting insulin; discontinuation of metformin 48 hours prior to FDG injection should be considered [11,12].

Cross-calibration between the dose calibrator and the PET system should be ensured, and harmonized image reconstruction protocols should be applied consistently; EARL harmonization is recommended whenever feasible.

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Correspondent: Mai Viet Dinh. Email: maidinh.themco@gmail.com

Received: 14/08/2025. Assessed: 29/08/2025. Accepted: 11/12/2025