

Myocardial Uptake of 18F-Fluorodeoxyglucose on Positron Emission Tomography/Computed Tomography: A Window into Cardiovascular Phenotypes and Metabolic Signatures in Patients with Cancer

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Abstract

Background: Positron emission tomography/computed tomography (PET/CT) with 18F-fluorodeoxyglucose (FDG) is widely used in cancer care, but its role in assessing cardiotoxicity remains uncertain. Understanding how cardiovascular risk factors influence myocardial glucose uptake may improve its application in this setting.

Objective: To investigate associations between cardiac metabolic patterns on oncologic PET/CT and cardiovascular risk factors.

Methods: We conducted a retrospective, cross-sectional study classifying oncologic PET/CT scans by absence (G1) or presence (G2) of myocardial FDG uptake, visually defined as greater than the aortic blood pool. Clinical data and cardiovascular risk factors were analyzed, and logistic regression identified predictors of presence or absence of uptake, adjusting for potential confounders. Statistical significance was set at $p < 0.05$.

Results: We included 983 scans (64% women; mean age 56 ± 15.8 years; 39.9% with hypertension; 19.7% with diabetes), of which 559 (56.8%) were G1 and 424 (43.2%) were G2. The most prevalent cancers were lymphoma (28.9%) and breast (17.6%). Male sex ($p = 0.0008$) and higher weight ($p = 0.0001$) were independent predictors of myocardial FDG uptake, whereas diabetes ($p = 0.01$) and coronary artery disease ($p = 0.007$) predicted absence of uptake.

Conclusions: Despite limitations, this study identified distinct patterns of myocardial FDG uptake on oncologic PET/CT independently associated with cardiovascular risk factors. These findings support the potential of FDG PET/CT for evaluating cardiotoxicity after cancer treatment.

Keywords: Positron emission tomography/computed tomography; 18F-fluorodeoxyglucose; Cardiovascular risk factors; Oncology.

Introduction

Chemotherapy-induced cardiotoxicity is a growing challenge in modern oncology, driven by improved survival among patients with cancer.¹⁻³ In this context, positron emission tomography/computed tomography (PET/CT) with 18F-fluorodeoxyglucose (FDG) has emerged not only as an oncologic diagnostic tool,⁴⁻⁷ but also as a potential biomarker of cardiac metabolic alterations.^{3,8,9}

Cardiac metabolism, traditionally sustained by fatty-acid oxidation,^{10,11} is tightly regulated and influenced by multiple factors such as sex, body weight, and

comorbidities — including diabetes mellitus and coronary artery disease (CAD).^{4,12} Myocardial FDG uptake, which reflects myocardial glucose utilization,⁵ may offer valuable insight into how these determinants modulate cardiac metabolism and potentially influence susceptibility to cardiotoxicity.

Although prior studies have explored FDG PET/CT for the early detection of cardiotoxicity,¹³⁻¹⁵ the relationship between myocardial uptake patterns and traditional cardiovascular risk factors remains uncertain. This gap is particularly relevant because routine oncologic scans — performed without specific cardiac preparation — may reveal “metabolic signatures” consistent with distinct cardiovascular phenotypes.

In this study, we investigated the association between myocardial FDG uptake patterns and cardiovascular risk factors in a large oncologic population to understand the extent to which these variables influence cardiac metabolism. This knowledge may support the use of FDG PET/CT in evaluating cancer- and treatment-related cardiac alterations.

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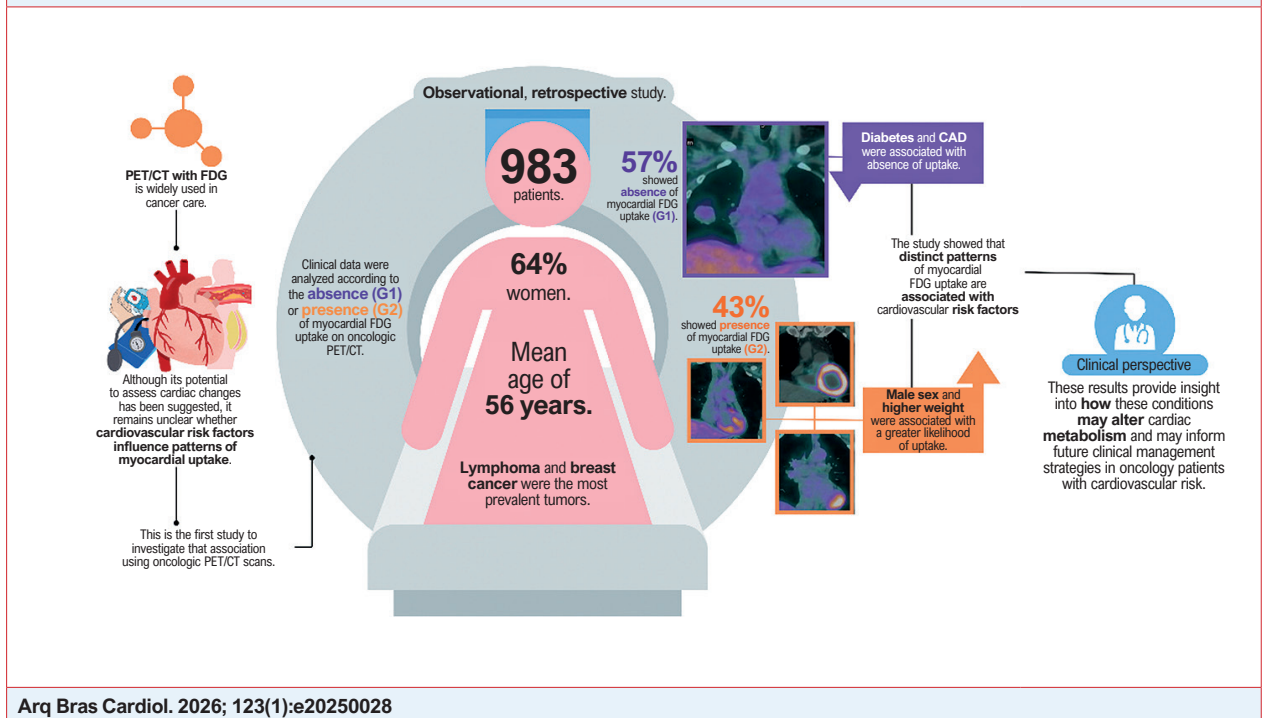
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Central Illustration: Myocardial Uptake of 18F-Fluorodeoxyglucose on Positron Emission Tomography/Computed Tomography: A Window into Cardiovascular Phenotypes and Metabolic Signatures in Patients with Cancer



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CAD: coronary artery disease; FDG: 18F-fluorodeoxyglucose; PET/CT: positron emission tomography/computed tomography.

Methods

Study design, setting, and population

This observational, cross-sectional, analytical, retrospective study was approved by the Research Ethics Committee at Hospital das Clínicas, Universidade Federal de Pernambuco (approval No. 68674623.9.0000.8807). It was conducted in the institution's Department of Nuclear Medicine, a regional referral center for FDG PET/CT. We included all patients who underwent FDG PET/CT for an oncologic indication between January 1, 2023 and December 31, 2023. We excluded cases with incomplete clinical forms and/or when PET/CT image assessment was not feasible due to technical issues or unavailability in the digital archive.

Patients and data sources

Clinical and epidemiologic data were obtained from pre-scan assessment forms, official reports, and direct image review on Xeleris 4.0 software (GE Healthcare). Collected variables included sex; age (years); weight (kg); height (m); body mass index (BMI); cardiovascular comorbidities (hypertension, diabetes, dyslipidemia, CAD); smoking status; chronic medications (cardiovascular and antihyperglycemic agents); primary malignancy; and oncologic treatments received (radiotherapy and/or chemotherapy).

CAD was considered present if the patient reported CAD (history of myocardial infarction, angina, percutaneous

coronary intervention, or coronary artery bypass grafting) or prior stroke, or if they were concurrently using acetylsalicylic acid (ASA) and a statin. Cardiovascular medications for primary or secondary prevention were defined as beta-blockers, renin-angiotensin system inhibitors, ASA, sodium-glucose cotransporter inhibitors, and statins.

For PET/CT we recorded the scan date, fasting time, pre-scan diet, indication (staging, restaging, treatment response assessment, or disease surveillance), injected FDG activity (MBq and mCi), and uptake time (minutes). All scans were re-evaluated for the presence or absence of myocardial FDG uptake as described below.

PET/CT acquisition and image analysis

Per institutional protocol, patients were instructed to follow a low-carbohydrate, high-fat diet for 24 hours and to fast for at least 6 hours before the scan. On the day of imaging, body weight and fasting blood glucose (< 180 mg/dL) were measured prior to intravenous FDG administration. The mean administered activity was 233.1 ± 135.42 MBq (6.3 ± 3.66 mCi). Approximately 60 minutes after injection, images were acquired on a hybrid PET/CT system (GE Discovery 710; 128-slice CT) from the skull base to the mid-thigh, with 1–3 minutes per bed position. Acquisition parameters included 5-mm slices and 120 kV; no intravenous contrast was used.

Myocardial FDG uptake was assessed qualitatively and classified as present or absent (Figure 1). Uptake was deemed present when visual myocardial activity exceeded the aortic blood-pool activity. When present, patterns were further categorized as follows: focal (G2a, uptake limited to one wall), heterogeneous (G2b, uptake involving more than one wall), and diffuse (G2c, homogeneous uptake across all left-ventricular walls).

Statistical analysis

Categorical variables are presented as frequencies and percentages; continuous variables as mean $\pm$ standard deviation. Patients were grouped as G1 (absence of myocardial FDG uptake) and G2 (presence of uptake), and G1 was compared with G2a (focal), G2b (heterogeneous), and G2c (diffuse). The chi-square test was used for categorical variables, with Fisher's exact test when appropriate. Normality was assessed with the Shapiro-Wilk test. Continuous variables with normal distribution were compared using the independent-samples Student's *t* test. Logistic regression was applied to identify factors associated with myocardial FDG uptake, adjusting for potential confounders. Analyses were performed in MedCalc® Statistical Software, version 23.0.2 (MedCalc Software Ltd., Ostend, Belgium). A two-sided $P < 0.05$ was considered statistically significant.

Results

Of 991 oncologic FDG PET/CT scans performed, eight were excluded — five due to incomplete clinical forms and three due to technical limitations precluding image assessment. Among the 983 eligible patients, 883 (89.8%) had complete clinical data available for analysis (Central Illustration). Population characteristics are shown in Table 1. The most prevalent malignancies were lymphoma (28.91%) and breast cancer (17.6%), with overall distribution depicted in Figure 2. Approximately 75% of patients had received prior oncologic treatment before PET/CT, including chemotherapy (73.94%) and mediastinal radiotherapy (25.83%).

For scan preparation, 982 patients (99.9%) adhered to the recommended diet, with a mean fasting time of 6 hours. The primary indication was treatment response assessment in 448 cases (45.71%). On visual analysis, 559 patients (56.8%) showed no myocardial FDG uptake (G1), whereas 424 (43.2%) exhibited uptake: focal in 88 (8.95%), heterogeneous in 249 (25.4%), and diffuse in 87 (8.85%) (Figure 3).

Comparisons between G1 (absence of uptake) and G2 (presence of myocardial FDG uptake) are presented in Table 1. In univariate analyses, G1 had lower weight, height, and BMI as well as a higher prevalence of female sex, diabetes, and CAD. In logistic regression, higher weight and male sex were independently associated with the presence of myocardial FDG uptake, whereas diabetes and CAD were independently associated with the absence of uptake (Figure 4).

In subgroup analyses (G2a, G2b, G2c) versus G1, logistic regression showed that higher BMI independently predicted focal uptake (G2a); male sex predicted heterogeneous (G2b)

or diffuse uptake (G2c); higher weight was associated with heterogeneous uptake (G2b); and diabetes mellitus and mediastinal radiotherapy were associated with absence of uptake (G1) (Figure 5).

Discussion

Oncologic PET/CT scans revealed varied profiles of myocardial FDG uptake that were influenced by cardiovascular risk factors and comorbidities. Characteristics such as sex, body weight, diabetes, and CAD appear to modulate myocardial glucose utilization. In the current era of cardiac metabolism, understanding how myocardial cells use glucose is essential to clarify how cardiovascular diseases directly affect cardiac function, given the intrinsic link between energy metabolism and myocardial performance.¹⁶ This insight may broaden the clinical applications of FDG PET/CT beyond oncology.

The heart, an organ with high energy demand, relies predominantly on oxidative phosphorylation to sustain contraction. Under stress — such as during chemotherapy — cardiac metabolism may adapt with increased reliance on anaerobic glycolysis.¹⁷ Myocardial FDG uptake, however, is mediated by hexokinase, whose activity can be amplified in response to oxidative stress, suggesting that FDG may signal not only glycolysis but also antioxidant activity.¹⁸ Another plausible explanation is infiltration by activated inflammatory cells, which display increased expression of glucose transporters and thus higher affinity for FDG.¹⁹⁻²² Accordingly, interpreting patterns of myocardial uptake requires caution: elevations observed after chemotherapy may reflect not only changes in glucose consumption but also processes such as antioxidant activity or treatment-related inflammation.³

Retrospective studies indicate that elevated myocardial FDG uptake may serve as an early marker of cardiotoxicity, associated with reductions in left-ventricular ejection fraction.²³ This possibility is promising because it could allow simultaneous monitoring of cancer and potential cardiotoxic effects in a single scan.²⁴ However, a prospective study in patients with lymphoma evaluated before and after chemotherapy (unpublished data) did not find an association between increased myocardial FDG uptake and worsening ventricular strain.²⁵ This suggests that, while useful for staging and assessing tumor response, FDG may not capture the full complexity of subclinical cardiac functional alterations.

In the present study, male sex and higher body weight were significantly associated with the presence of myocardial FDG uptake, whereas diabetes and CAD were associated with its absence. No statistically significant differences were detected between patients with and without a history of oncologic therapy (chemotherapy or radiotherapy). These findings highlight the complexity of interactions between cardiovascular risk factors and glucose metabolism, indicating that FDG may not be a sensitive marker for all cardioprotective metabolic changes. They also point to distinct uptake patterns linked to comorbidities such as diabetes, excess weight, and CAD, reflecting heterogeneous metabolic responses according to patients' clinical profiles.

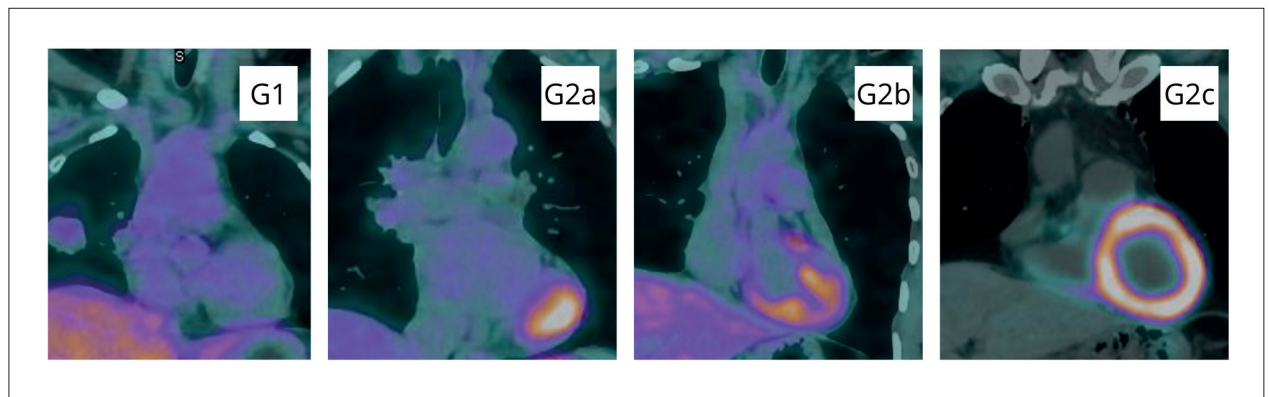


Figure 1 – Patterns of myocardial FDG uptake analyzed. Coronal positron emission tomography fused with computed tomography images illustrating the myocardial FDG uptake patterns assessed. From left to right: absence of myocardial FDG uptake (G1); focal uptake (G2a); heterogeneous uptake (G2b); and diffuse uptake (G2c). FDG: 18F-fluorodeoxyglucose.

Table 1 – Sample characteristics and comparison between absence (G1) and presence (G2) of myocardial FDG uptake

Variable	Total (n = 983)	G1 (n = 559)	G2 (n = 424)	p-value
Female sex	628 (64%)	389 (70%)	238 (56%)	<0.001
Age (years)*	56 ± 16	56 ± 16	56 ± 16	0.665
Weight (kg)*	69 ± 17	65 ± 16	70 ± 18	<0.001
Height (m)*	1.61 ± 0.09	1.60 ± 0.09	1.62 ± 0.1	0.001
BMI (kg/m²)*	26 ± 6	25 ± 7	27 ± 8	0.004
HGT (mg/dL)*	104 ± 22	99 ± 24	100 ± 19	0.277
Scan indication				
Assessment of treatment response	448 (46%)	251 (45%)	197 (47%)	0.633
Surveillance	113 (12%)	66 (12%)	47 (11%)	
Staging	196 (20%)	120 (22%)	76 (18%)	
Restaging	223 (23%)	120 (22%)	103 (24%)	
Mediastinal radiotherapy	251 (26%)	152 (28%)	99 (24%)	0.162
Chemotherapy	718 (74%)	409 (74%)	309 (74%)	0.923
Hypertension	392 (40%)	214 (38%)	178 (42%)	0.260
Diabetes mellitus	193 (20%)	124 (22%)	69 (16%)	0.020
Dyslipidemia	107 (11%)	69 (12%)	38 (9%)	0.088
Smoking	155 (16%)	87 (16%)	68 (16%)	0.856
CAD	30 (3%)	24 (4%)	6 (1%)	0.009
Use of cardiovascular medications	349 (36%)	199 (36%)	150 (35%)	0.915

BMI: body mass index; CAD: coronary artery disease; HGT: hemoglucotest. * Mean values ± standard deviation.

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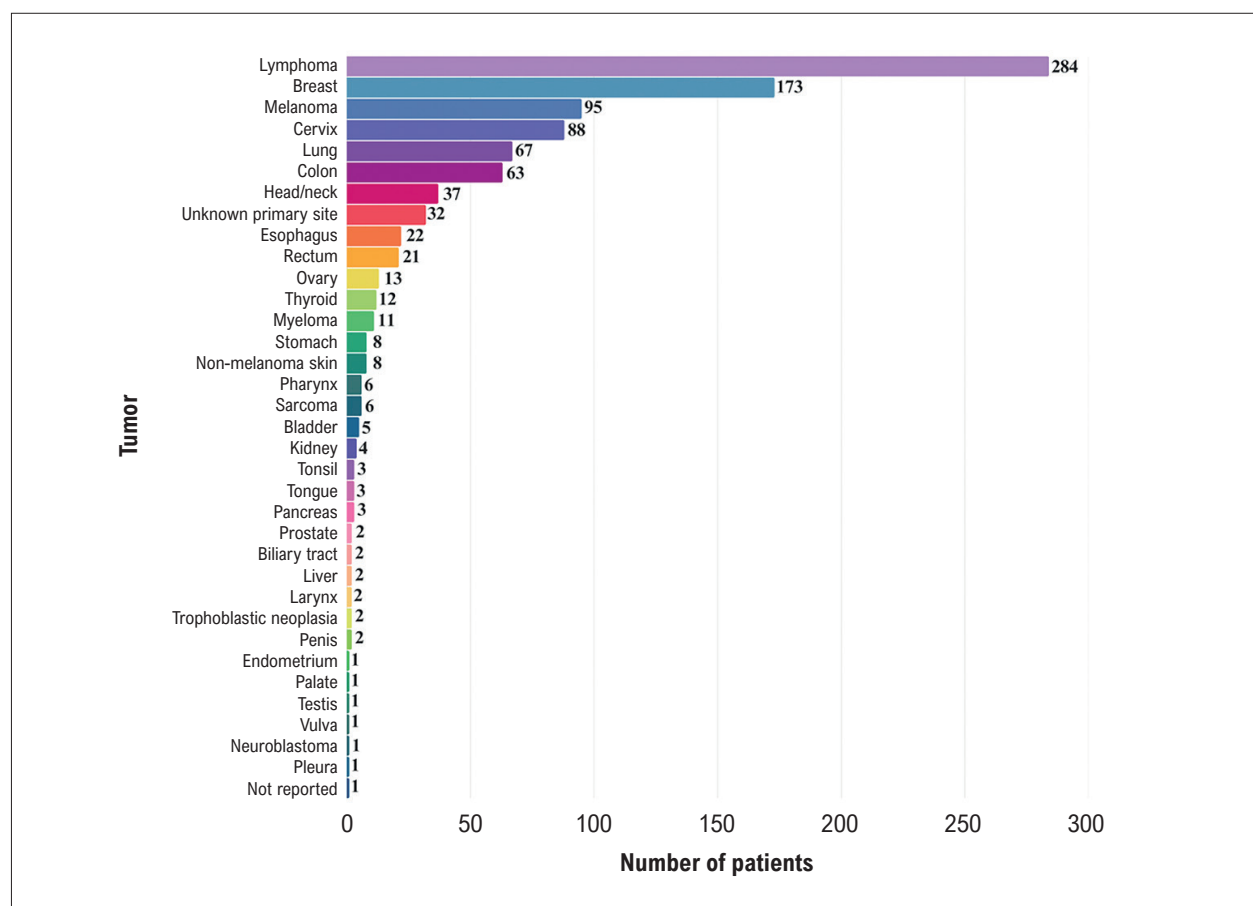


Figure 2 – Absolute distribution of cancer types in the study population ($n = 983$).

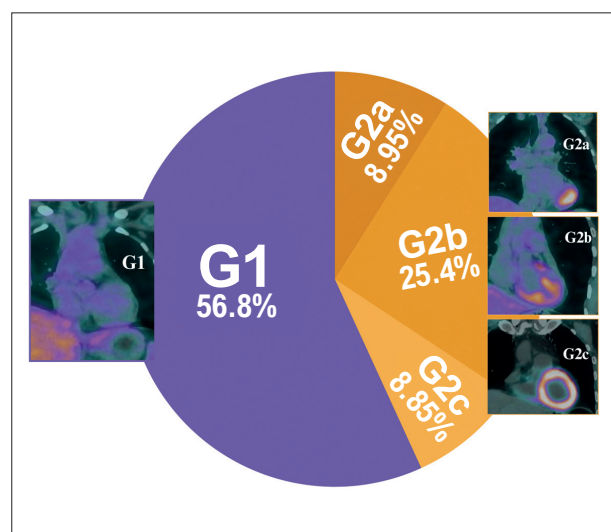


Figure 3 – Pie chart illustrating the distribution of myocardial FDG uptake patterns in the study population. Next to the chart, coronal PET/CT images exemplify the analyzed patterns: G1, absence of uptake; G2a, focal uptake; G2b, heterogeneous uptake; G2c, diffuse uptake. FDG: 18F-fluorodeoxyglucose; PET/CT: positron emission tomography/computed tomography.

Evidence suggests that reduced myocardial glucose utilization in individuals with diabetes, CAD, or obesity arises from multiple mechanisms. These include decreased expression of transmembrane glucose transporters and reduced insulin-stimulated translocation of these transporters due to the insulin resistance typical of these conditions.^{26,27} Additional contributors include diminished pyruvate dehydrogenase activity and impaired mitochondrial oxidative capacity.²⁸⁻³¹ Another relevant factor is the elevation of circulating fatty acids, which is associated with lower glucose uptake — particularly in the presence of increased visceral adiposity.²⁸⁻³¹ Findings in G1 are consistent with prior research.

In the present study, higher BMI was not significantly associated with the absence of myocardial FDG uptake, contrary to what the mechanisms above would suggest. Instead, individuals with greater body weight — not necessarily those with obesity — showed a higher likelihood of uptake. Future investigations should therefore examine the relationship among BMI, body-fat distribution, and the presence or absence of myocardial FDG uptake, particularly in people with cancer, where body-composition assessment has added relevance.³²

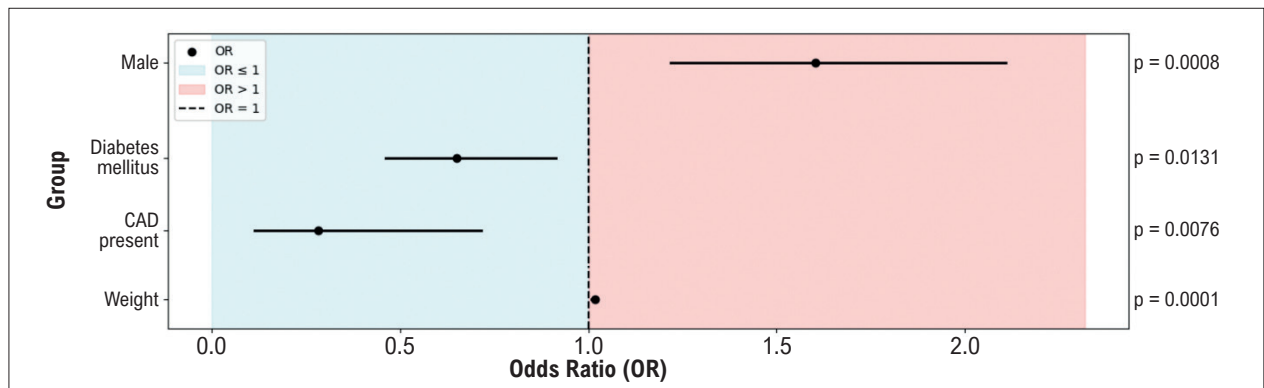


Figure 4 – Predictor variables associated with the presence of myocardial FDG uptake on PET/CT. ORs and their 95% CIs (solid black lines) were estimated by logistic regression. OR > 1 indicates a positive association with myocardial uptake; OR < 1, a negative association. The p value reflects the statistical significance of each variable. CAD: coronary artery disease; FDG: 18F-fluorodeoxyglucose; OR: odds ratio; PET/CT: positron emission tomography/computed tomography.

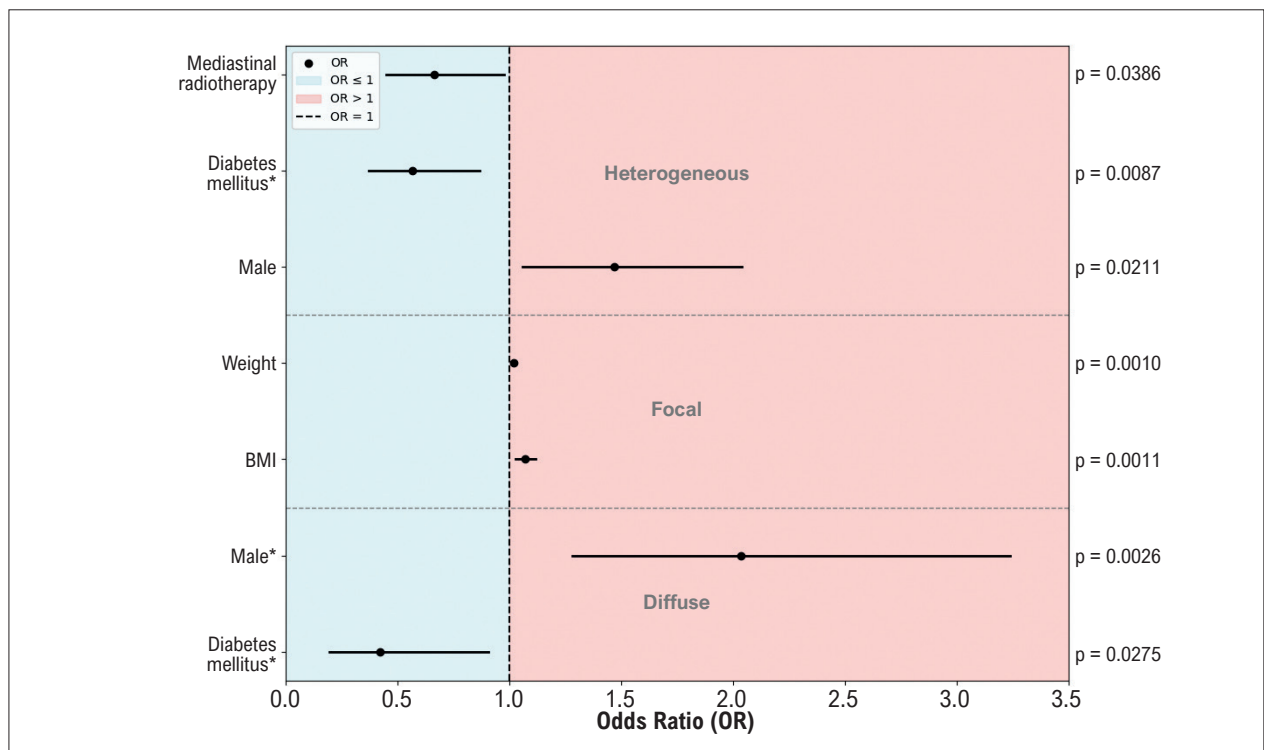


Figure 5 – Predictor variables of myocardial FDG uptake on PET/CT. ORs and their 95% CIs (solid black lines) were estimated by logistic regression. OR > 1 indicates a positive association; OR < 1, a negative association. The p value indicates statistical significance. *Variables analyzed specifically for diffuse uptake. BMI: body mass index; FDG: 18F-fluorodeoxyglucose; OR: odds ratio; PET/CT: positron emission tomography/computed tomography.

Regarding male sex, body composition — characterized by a higher proportion of lean mass compared with females — and a profile of lower insulin resistance may contribute to greater glucose uptake and, consequently, higher FDG uptake.³³ Although the mechanisms are not fully elucidated, it has been proposed that myokines released by skeletal muscle can enhance insulin sensitivity in the myocardium³⁴ and confer cardiovascular protection.^{34,35}

Medications and comorbidities may also influence myocardial FDG uptake.^{4,12} Agents such as sodium–glucose cotransporter-2 inhibitors and metformin, for example, can modify uptake by reflecting shifts in energy metabolism, without necessarily indicating cardiac injury.^{34,35} In the present study, we did not observe differences in uptake patterns according to the use of cardiovascular drugs; however, given the retrospective design, this aspect could

not be assessed conclusively. Moreover, comorbidities such as diabetes and ischemic heart disease warrant more granular stratification, as varying degrees of metabolic impairment may alter FDG uptake and complicate its interpretation.

Generalizability is limited by the sample composition — predominantly patients from the public health system, with a high prevalence of lymphoma and breast cancer. In addition, cardiac-specific FDG protocols, which include longer fasting periods, were not applied because cardiac evaluation was not the primary purpose of the scans. As a retrospective study, variable definitions were constrained by the clinical forms, including the characterization of CAD based on concomitant use of ASA and a statin — a combination that may have been prescribed for reasons other than coronary or cerebrovascular disease. We also acknowledge as a limitation the grouped analysis of different cardiovascular and antihyperglycemic medications, which have distinct mechanisms of action, half-lives, and withholding regimens, precluding more specific assessment of class-level metabolic effects. Despite such constraints, the large sample provides a solid foundation for future studies and underscores the need to investigate, in greater detail, how cardiovascular risk factors shape myocardial glucose metabolism and how these patterns relate to phenotypes and potential mechanisms of protection against cardiotoxicity.

Conclusion

Despite its limitations, this study is, to our knowledge, the first to identify distinct patterns of myocardial FDG uptake that suggest specific metabolic phenotypes associated with cardiovascular comorbidities in patients with cancer. Factors such as male sex, higher body weight, diabetes, and CAD appear to play a meaningful role in myocardial FDG utilization. Diabetes and CAD independently predicted absence of uptake, whereas male sex and higher body weight predicted its presence. These findings underscore the need to elucidate the mechanisms underlying these associations — not only to advance understanding of cardiometabolic disease, but also to solidify the potential of FDG PET/CT for evaluating cardiotoxicity after cancer therapy.

Author Contributions

Conception and design of the research: Ribeiro Sobrinho JMD, Mourato FA, Becker MMC, Brandão SCS; Acquisition of

data: Ribeiro Sobrinho JMD, Leão EDLM, Accioly BB, Becker MMC, Brandão SCS; Analysis and interpretation of the data: Ribeiro Sobrinho JMD, Leão EDLM, Accioly BB, Mourato FA, Becker MMC, Brandão SCS; Statistical analysis and Writing of the manuscript: Ribeiro Sobrinho JMD, Mourato FA, Brandão SCS; Obtaining financing: Ribeiro Sobrinho JMD, Brandão SCS; Critical revision of the manuscript for content: Mourato FA, Brandão SCS.

Potential conflict of interest

No potential conflict of interest relevant to this article was reported.

Sources of funding

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Study association

This study is not associated with any thesis or dissertation work.

Ethics approval and consent to participate

This study was approved by the Ethics Committee of the Hospital das Clínicas da Universidade Federal de Pernambuco under the protocol number 68674623.9.0000.8807. All the procedures in this study were in accordance with the 1975 Helsinki Declaration, updated in 2013.

Use of Artificial Intelligence

During the preparation of this work, the author(s) used ChatGPT (OpenAI) to correct grammatical errors and a search tool to gather relevant information and references.

Data Availability Statement

The underlying content of the research text is contained within the manuscript.

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