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Review Article

Advancing cardiac tumor diagnosis: evaluating ^{18}F-FDG PET/CT against traditional imaging methods

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Abstract: Background: Cardiac tumors are rare but clinically significant lesions requiring prompt and accurate diagnosis. While echocardiography remains the first-line imaging modality, it is limited by its inability to characterize tissue. Cardiovascular magnetic resonance imaging (CMR) and cardiac computed tomography (CT) offer superior anatomical detail but cannot reliably differentiate benign from malignant tumors. ^{18}F-Fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT) provides metabolic information that may overcome these limitations. Methods: A systematic scoping review was conducted following a structured literature search covering January 2019 to September 2025. After screening 192 articles and applying predefined inclusion and exclusion criteria, 7 retrospective studies enrolling a total of 381 adult patients with newly diagnosed cardiac masses who underwent ^{18}F-FDG PET/CT were included. Results: Across all included studies, ^{18}F-FDG PET/CT demonstrated high diagnostic accuracy in differentiating benign from malignant cardiac and pericardial masses. Key quantitative metabolic parameters consistently outperformed traditional imaging modalities. Reported sensitivity and specificity ranged from 92-100% and 88-93%, respectively. In one study, ^{18}F-FDG PET/CT achieved a 100% decision-making rate and the highest area under the curve (AUC) of 0.94 compared to transthoracic echocardiography, CT, and CMR. SUVmax also emerged as an independent predictor of survival. Conclusion: ^{18}F-FDG PET/CT plays a significant diagnostic and prognostic role in evaluating cardiac tumors, offering metabolic insights that complement conventional anatomical imaging. It should be incorporated as a key adjunct in the multimodality work-up of suspected cardiac masses, particularly when malignancy is suspected or biopsy is not feasible.

Keywords: Cardiac tumor, ^{18}F-Fluorodeoxyglucose positron emission tomography/computed tomography, diagnosis

Introduction

Cardiac tumors play a crucial role in the field of cardio-oncology, where it is vital to promptly identify and treat them. These tumors can be classified as neoplastic or non-neoplastic and further categorized as secondary (metastatic) or primary (neoplastic lesions). Initial cardiac tumors are often benign, even though they can arise from the myocardium or pericardium [1, 2]. Although primary cardiac tumors are sporadic across all age categories, with an estimated prevalence of 0.001% to 0.03 percent in autopsy series or clinical examinations, accurate data are complex to come by due to the imbalanced nature of medical examinations worldwide [3-5]. The number of reports of primary cardiac tumors has gradually increased in recent years due to the introduction of non-invasive imaging technologies. Roughly 90% of these cardiac tumors that have been diagnosed are benign tumors [6]. It is important to clarify that this high proportion of benign tumors reflects the inherent biological distribution of primary cardiac neoplasms at the time of diagnosis, rather than a natural progression from benign to malignant disease. Unlike certain tumors in other organ systems, primary cardiac tumors do not typically undergo malignant transformation; rather, benign and malignant cardiac tumors represent distinct pathological entities with separate origins and biological behaviors [6, 7]. Myxomas, fibromas, lipomas, and papillary fibroelastomas account for the

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majority of benign primary cardiac tumors, while primary malignant tumors - most commonly sarcomas - arise independently and carry a markedly worse prognosis [2, 8].

Secondary cardiac tumors are substantially more common than primary cardiac tumors, occurring 22-132 times more commonly [2, 7]. The prognosis of these tumors can be significantly predicted by classifying them as malignant or benign. Nevertheless, depending on size and location, any cardiac tumor may have serious hemodynamic or arrhythmic effects regardless of its histology. Heart tumors may go unnoticed and can only be discovered by accident. When a tumor is symptomatic, the symptoms often depend on where it is located, but they can also be systemic [8, 9].

Systemic symptoms comprise paraneoplastic disorders unique to primary cardiac tumors, as well as constitutional symptoms like fever, arthralgia, weight loss, and fatigue. Myocardial dysfunction or blood flow disruption due to a mass effect can cause a variety of cardiovascular symptoms, including arrhythmias, regurgitation, and pericardial effusion (with or without tamponade). Pre-syncope, syncope, dyspnoea, and chest pain are typical symptoms. Moreover, systemic and pulmonary thromboembolic events might occur [8-10].

An accurate assessment of the extent of the masses is required to address therapeutic solutions, which range from medical therapy to aggressive surgical surgery. The prognosis can be significantly influenced by the nature of cardiac masses and the ensuing treatment. Most cardiac benign masses have a positive outcome, while individuals with primary or secondary malignant cardiac masses have a poor prognosis [11, 12].

When evaluating and diagnosing cardiac masses, an integrated noninvasive multimodality imaging method is helpful because catheter-based biopsy is frequently impractical or may yield conflicting results. For a suspected cardiac mass, echocardiography is still the preferred imaging modality due to its accessibility, noninvasiveness, lack of radiation or contrast material exposure, and capacity to offer a dynamic assessment. However, it cannot enable tissue characterization or a worldwide assessment of cardiac and extracardiac structures [2, 6]. Transthoracic echocardiography (TTE) and transesophageal echocardiography (TEE) can reliably detect intracavitary masses, assess their location, size, mobility, and hemodynamic consequences, and guide clinical decision-making, particularly for atrial masses [13]. However, echocardiography is inherently limited by operator dependency, poor acoustic windows in certain patients, and - most critically - its inability to characterize tissue composition or provide a comprehensive assessment of extracardiac structures [2, 14].

Cardiac computed tomography (CT) offers excellent spatial resolution and is particularly valuable for evaluating tumor extent, calcification, fat content, and involvement of adjacent structures such as the pericardium and great vessels [15, 16]. Cardiac CT enables rapid image acquisition with electrocardiographic gating, making it highly useful in patients who cannot tolerate long scan durations. Nevertheless, its major limitation lies in the use of ionizing radiation and iodinated contrast agents, as well as its relatively limited soft-tissue contrast compared to magnetic resonance imaging, which can hinder reliable differentiation between benign and malignant lesions [12, 15, 17].

Cardiovascular magnetic resonance imaging (CMR) provides superior soft-tissue contrast without ionizing radiation and offers multiparametric tissue characterization through techniques such as T1-weighted, T2-weighted, late gadolinium enhancement (LGE), and perfusion imaging [18-20]. CMR is considered the gold standard for characterizing cardiac masses due to its ability to assess myocardial infiltration, tumor vascularity, and tissue composition, making it particularly useful for evaluating ventricular masses or when malignancy is suspected [13, 19]. Despite these advantages, CMR is limited by its prolonged acquisition time, susceptibility to artifacts from cardiac and respiratory motion, contraindications in patients with certain metallic implants, and limited availability in many centers [12, 17, 18]. Although both cardiac CT and CMR can provide critical structural and tissue details, these noninvasive imaging modalities cannot always reliably distinguish benign from malignant cardiac tumors [11, 12].

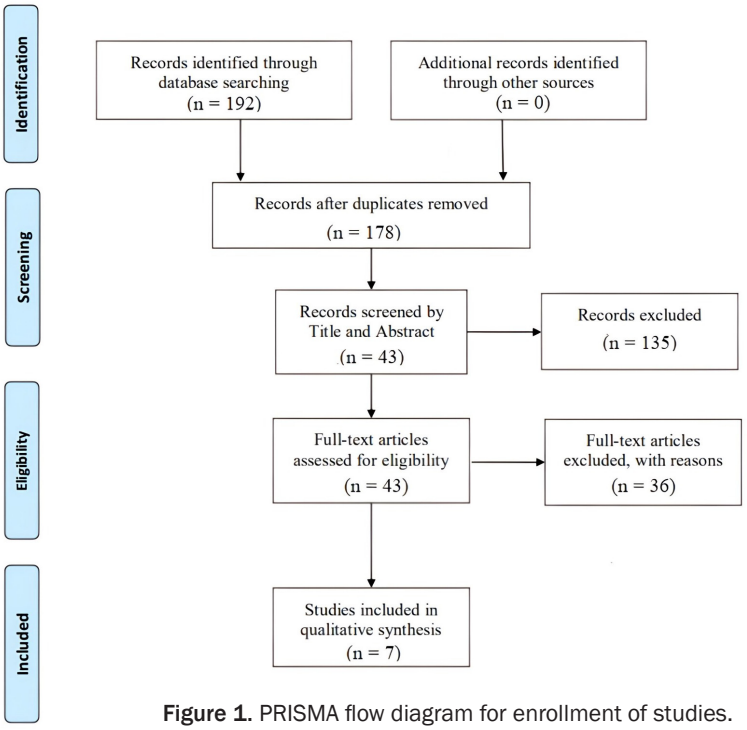

Figure 1. PRISMA flow diagram for enrollment of studies.

Conversely, metabolic activity can be evaluated by molecular imaging techniques like ^{18}F-Fluorodeoxyglucose positron emission tomography/computed tomography (^{18}F-FDG PET/CT), which can visualize cellular metabolic activity based on differential glucose uptake. Malignant tumors characteristically demonstrate elevated ^{18}F-FDG uptake due to their increased glycolytic activity, a phenomenon known as the Warburg effect, which allows PET/CT to provide functional information that purely anatomical modalities cannot [21, 22]. Furthermore, ^{18}F-FDG PET/CT offers the advantage of whole-body staging in a single examination, enabling simultaneous detection of extracardiac primary tumors or distant metastases, which is particularly valuable in cases of suspected secondary cardiac involvement [15, 23, 24]. Its limitations include relatively lower spatial resolution compared to CT and CMR, potential false-positive results due to physiological myocardial glucose uptake - which requires specific patient preparation protocols such as prolonged fasting or a high-fat, low-carbohydrate diet - and limited availability and high cost [15, 25, 26]. However, ^{18}F-FDG PET/CT does not yet have a well-established function in the routine evaluation of cardiac masses, largely because of their rarity [15, 27]. Consequently, we assessed the use of ^{18}F-FDG PET/CT in this systematic review in order to diagnose cardiac tumors and evaluate its diagnostic and prognostic capabilities compared to traditional imaging methods.

Methods and materials

Search strategy

We reviewed the relevant literature to assess the reliability of ^{18}F-FDG PET/CT for the detection of cardiac masses. The research was conducted according to the PRISMA criteria, known as Preferred Reporting Items for Systematic Reviews and Meta-Analyses. **Figure 1** shows the flow diagram. Studies were conducted between January 2019 and September 2025 using the following databases: Web of Science, PubMed, Scopus, Science Direct, and MEDLINE. The search was conducted using the Advanced Search Builder using terms from [Title OR Abstract]. We have limited our search to research publications written in English and utilizing these terms '(^{18}F-fluorodeoxyglucose positron emission tomography combined with computed tomography [Mesh] OR FDG-PET/CT OR Fluorodeoxyglucose F18[Mesh]) AND (Heart Neoplasms [Mesh] OR Cardiac Neoplasm [Mesh] OR Cardiac Carcinoma [Mesh] OR Cardiac Cancer [Mesh] OR Cardiac Tumor [Mesh])'.

Inclusion and exclusion criteria

Eligibility criteria were defined a priori using a PICO framework. We included studies that met the following criteria: (1) Population: adult patients (≥ 18 years) with suspected or newly diagnosed cardiac or pericardial masses; (2) Intervention: evaluation with ^{18}F-FDG PET/CT for characterization of the mass; (3) Comparator: at least one conventional imaging modality (transthoracic echocardiography, cardiac CT, and/or CMR) available for diagnostic comparison; and (4) Outcomes: diagnostic performance (e.g. sensitivity, specificity, accuracy, AUC) and/or quantitative PET parameters (e.g. SUVmax, SUVmean, metabolic tumour volume [MTV], total lesion glycolysis [TLG], tumour-to-back-

ground ratios) reported for differentiating benign from malignant lesions or for prognostic assessment.

Studies were excluded if they: (1) focused exclusively on non-neoplastic conditions without a discrete cardiac mass; (2) used PET tracers other than ^{18}F-FDG; (3) were restricted to pediatric populations; (4) were case reports, conference abstracts, editorials, reviews, or purely technical/methodological reports without extractable patient-level diagnostic data; or (5) represented duplicate publications from the same cohort, in which case the most complete or recent article was retained.

Data extraction and quality evaluation

M.G. and F.R. assessed the abstracts and titles. Data from studies were extracted according to the survey's needs after inclusion and exclusion criteria were implemented. The following data were systematically extracted from each eligible study: first author, year of publication, study design, country, sample size, patient demographics (age and sex), type of cardiac mass (primary benign, primary malignant, or secondary/metastatic), imaging protocol for ^{18}F-FDG PET/CT, comparator imaging modality (echocardiography, CT, or CMR), PET/CT quantitative parameters reported (maximum standardized uptake value [SUVmax], mean standardized uptake value [SUVmean], metabolic tumor volume [MTV], total lesion glycolysis [TLG], and/or tumor-to-background ratio [TBR]), optimal diagnostic cut-off values, sensitivity, specificity, accuracy, area under the ROC curve (AUC), and survival or prognostic outcomes where reported.

To include any relevant studies, we scanned the references of previously published review papers. In their final form, seven previously published research articles met our criteria. In certain instances, we elected to incorporate only the primary findings that aligned with the objectives of this review. **Table 1** demonstrates the data extraction tables created using the final articles' data.

Data synthesis and statistical analysis

Because of the expected heterogeneity in study design, patient population, and imaging protocol among the included studies, a meta-analysis was not carried out. Rather, a narrative synthesis method was used to analyze the extracted data. Descriptive statistics were used to summarize the data. Categorical variables (such as cardiac mass type and histology) are presented in frequency and percentage form. Continuous variables (e.g., patient age and SUVmax values) are reported as mean values with standard deviations (SD) or median values with ranges, depending upon the data supplied by the original research. The diagnostic test's performance metrics, including sensitivity, specificity, accuracy, and AUC, were directly obtained from the original studies and displayed in a range format to illustrate the variability and limitations of ^{18}F-FDG PET/CT relative to traditional modalities.

Results

Study selection

Following our systematic search, 192 articles were obtained between 2019 and 2025. After removing duplicate articles, non-originals, and articles with patients under 18, 43 studies were screened based on their titles and abstracts. Thirty-six studies were excluded, and 7 remaining studies were qualified to assess their full texts. Seven studies were finally included in this systematic scoping review. **Figure 1** illustrates the study's selection process. The data extracted from 7 eligible articles are also summarized in **Table 1**.

Study characteristics and outcomes

All included studies in our investigation were retrospective. The primary population targeted was patients with newly diagnosed cardiac masses who underwent ^{18}F-FDG PET/CT. Overall, the evaluated studies had 381 participants.

In 2020, Meng et al. [23] investigated 38 patients to assess the diagnostic value of ^{18}F-FDG PET/CT in differentiating benign and malignant cardiac tumors. The study demonstrated that the SUVmax and the TBRmax could be employed to differentiate between benign and malignant cardiac tumors. Findings indicate that a TBRmax of 1.55 and a SUVmax of 3.44 are suitable thresholds for cancer diagnosis. TBRmax exhibited a 95.8% sensitivity and 92.9% specificity, while SUVmax exhibited a

Table 1. Characteristics of the included investigations evaluating the use of ^{18}F-FDG PET/CT for detecting the cardiac masses

Study	Year	Study type	Study population	Types of masses	Mean of age, year ± SD	Gender, male (%)	Conventional modalities	Reference test	Mean follow-up	^{18}F-FDG mean injected activity	Time between ^{18}F-FDG injection and image acquisition (min)	Conclusion
Hu et al.	2024	Retrospective	41	Benign masses (n = 18) Malignant masses (n = 23)	46 ± 18 (benign), 52 ± 17 (malignant)	53.7%	N/A	Pathology (surgery or biopsy) or imaging follow-up	At least 2 years	0.1-0.15 mCi/kg	50-65	^{18}F-FDG PET/CT metabolic parameters can semi-quantitatively evaluate the benign or malignant nature of cardiac/pericardial masses, with SUVmean and MTV having the highest diagnostic accuracy.
Yin et al.	2021	Retrospective	59	Benign tumors (n = 30) Primary malignant tumors (n = 23) Secondary malignant tumors (n = 6)	50 ± 13	54.2%	TTE	Histopathology	N/A	3.7 to 4.4 MBq/kg	60	^{18}F-FDG PET/CT was an effective additional imaging modality in patients with suspected malignant cardiac mass for further confirmation and to screen for potential metastasis, especially for pericardial masses.
Meng et al.	2020	Retrospective	38	Benign tumors (n = 14) Malignant tumors (n = 11) Cardiac metastases and lymphoma (n = 13)	45 ± 12	42.1%	Echocardiography, cardiac CT, CMR	Histopathology	8.5 ± 12.6 months	254 ± 67 MBq	60	18F-FDG PET/CT differentiates between benign and malignant cardiac tumors and predicts survival.
D'Angelo et al.	2020	Retrospective	60	Primary benign cardiac tumor (n = 8) Primary malignant cardiac tumor (n = 18) Secondary cardiac tumor (n = 22) Pseudotumors (n = 12)	59.1 ± 16.3	61.7%	Cardiac CT	Histopathology	18.1 months	N/A	N/A	Cardiac CT and ^{18}F-FDG PET/CT are powerful tools for diagnosing cardiac masses, with CT signs correlating with lesion nature and PET/CT providing additional information in diagnostic uncertainties.
Lemasle et al.	2020	Retrospective	119	Benign masses (n = 78) Malignant masses (n = 34)	58 ± 15	59%	TTE, cardiac CT, CMR	Histopathology	100 months	N/A	N/A	All modalities are useful for cardiac mass decision-making. TTE is efficient for atrial masses; CT and CMR are useful for ventricular masses or malignancy suspicion. ^{18}F-FDG PET-CT is most effective in differentiating benign and malignant masses.
Qin et al.	2019	Retrospective	64 (with 65 cardiac masses)	Benign (n = 27) Malignancy (n = 38)	51.2 ± 17.5	53.1%	N/A	Histopathology or long-term follow-up results	534 days	3.70-5.55 MBq	60	^{18}F-FDG PET/CT is helpful in diagnosing cardiac masses and provides prognostic information, with SUVmax as an independent prognostic factor.

^{18}F-FDG PET/CT: ^{18}F-Fluorodeoxyglucose positron emission tomography/computed tomography; CMR: Cardiac magnetic resonance; SUVmax: Maximum standardized uptake value; SUVmean: Mean standardized uptake value; MTV: metabolic tumor volume; TTE: Transthoracic echocardiogram.

100% sensitivity and 92.9% specificity in detecting malignancy. A significant difference ($P < 0.001$) was observed in the ^{18}F-FDG uptake of primary benign, primary malignant, and cardiac metastases/lymphoma. Additionally, they found that the SUVmax cut-off value for evaluating lesion dignity in patients with cardiac tumors was an independent predictor of mortality ($P < 0.05$).

The 2020 study conducted by Yin et al. [28] assessed 59 patients recently diagnosed with cardiac/pericardial masses and underwent ^{18}F-FDG PET/CT and TTE. The sensitivity of ^{18}F-FDG PET/CT was 96.6%, while that of TTE was 72.4% ($P = 0.039$). After excluding pericardial masses from the study, there was no statistically significant difference in sensitivity between ^{18}F-FDG PET/CT and TTE. The sensitivity of ^{18}F-FDG PET/CT was 95.6%, while TTE had a sensitivity of 78.3% ($P = 0.219$). ^{18}F-FDG PET/CT was employed to identify two malignant pericardial masses that TTE overlooked. The diagnostic strategy for 15 patients was altered due to the PET/CT data derived from the TTE findings. Seven of the 29 malignant cases were detected as having extracardiac lesions on PET/CT imaging. In summary, the investigation showed that ^{18}F-FDG PET/CT imaging could be used to evaluate cardiac and pericardial masses, particularly identifying malignancy and the potential diagnosis of extracardiac lesions.

Qin et al. [29] investigated the diagnostic and prognostic potential of ^{18}F-FDG PET/CT by analyzing 64 patients (65 of whom had cardiac abnormalities). The SUVmax 6.75 was the best cutoff value for distinguishing benign from malignant tumors. The ^{18}F-FDG PET/CT had a diagnostic sensitivity of 92.11 percent, a specificity of 88.89 percent, and an accuracy of 90.77%, respectively. They applied SUVmax, SUVmean, MTV, and TLG for survival analysis. The results indicated that survival was independently predicted by SUVmax ≥ 6.715. Indeed, the median survival periods for the cases with SUVmax < 6.715 and SUVmax ≥ 6.715 were 1460 and 342 days, respectively.

In an additional investigation, D'Angelo et al. [15] investigated the diagnostic performance of ^{18}F-FDG PET/CT and cardiac CT in detecting cardiac masses. The study showed that ^{18}F-FDG PET/CT parameters, including SUVmax, SUVmean, MTV, and TLG, exhibited exceptional diagnostic accuracy in the identification of malignant masses, superseding the capabilities of cardiac CT individually. The results indicated that, to identify malignant lesions, the optimal thresholds for these parameters were SUVmax ≥ 4.9, MTV ≥ 8.2, and TLG ≥ 29. When used with cardiac CT, ^{18}F-FDG PET/CT provides supplementary information about the metabolic activity of cardiac masses that might not be seen with CT scans alone.

In 2024, Hu et al. [30] investigated the diagnostic utility of ^{18}F-FDG PET/CT metabolic characteristics in distinguishing benign from malignant cardiac or pericardial tumors. Study results showed that all ^{18}F-FDG PET/CT metabolic parameters (SUVmax, SUVmean, TLG, and MTV) had good diagnostic accuracy in the semi-quantitative analysis. When the SUVmax cut-off value was 4.93, they found that the diagnostic effectiveness was best. However, SUVmean and MTV showed the highest diagnosis accuracy when distinguishing benign from malignant cardiac or pericardial lesions.

In 2020, Lemasle et al. [31] investigated 119 patients to assess the diagnostic efficacy of multimodal imaging in detecting cardiac masses. All patients were administered TTE, CMR, CT, and ^{18}F-FDG PET/CT. Even though all imaging modalities substantially increased decision-making rates, ^{18}F-FDG PET/CT consistently resulted in a 100% decision-making rate in the post-test. A high AUC of 0.94 for malignant cases indicated that ^{18}F-FDG PET/CT had the highest accuracy in differentiating between benign and malignant masses. This implies that ^{18}F-FDG PET/CT is significantly more accurate in identifying the nature of cardiac masses than other imaging modalities, such as TTE, CT, and CMR.

Cardiac tumor imaging modalities

Cardiovascular imaging is designed to ascertain the morphology and cause of tumors, identify potential complications, and assist in establishing the most suitable treatment [32]. Furthermore, it is imperative to ascertain the malignancy of a tumor prior to any surgical planning, particularly for those that are not amenable to biopsy. Various methods can be used to assess hemodynamic impairment, myocardial or pericardial infiltration, and the

tumor's location, size, and vascularization [33, 34].

Due to its availability, noninvasiveness, and lack of contrast medium or radiation exposure, echocardiography has been the primary imaging modality for assessing cardiac masses. Furthermore, echocardiography may be implemented to execute dynamic assessments on-site. Nevertheless, echocardiography is restricted in its ability to assess right atrial masses, which are likely the result of a wide range of etiologies and ventricular masses. Echocardiography is incapable of conducting a comprehensive assessment of the entire cardiac structure and extracardiac lesions [12, 35].

Because cardiac CT has an excellent spatial resolution for evaluating the heart and adjacent structures, it is the modality of choice for patients with suspected cardiac metastases. Cardiac CT can also characterize tissues by utilizing varying radiodensity and tissue attenuation [16]. Since CMR can examine the entire anatomic position and extent of the tumor, determine mass movement, perform functional assessments, and highlight differential tissue qualities, it is the most comprehensive test for finding and diagnosing cardiac masses [19]. Consequently, CT or CMR may offer additional information regarding the location of masses, the adjacent anatomy, and tissue characterization, which could potentially inform management decisions. In the identification of cardiac masses, both CT and CMR have exhibited superior diagnostic performance compared to echocardiography due to the availability of extracardiac examination and enhanced soft tissue contrast [17, 18]. However, the task force teams of American societies do not make any distinctions when recommending echocardiography, CT, and CMR for cardiac assessment [36].

The ^{18}F-FDG PET/CT scan is another imaging method that can distinguish between malignant and benign tumors by measuring the tissue ^{18}F-FDG absorption. Through its comprehensive whole-body assessment, high sensitivity and specificity, and capacity to provide metabolic information, ^{18}F-FDG PET/CT imaging is a valued tool in the diagnostic workup of cardiac tumors, providing significant advantages in diagnosing cardiac masses [24, 27, 37].

^{18}F-FDG PET/CT imaging protocol

Metabolic activity is correlated with ^{18}F-FDG uptake, which enables the characterization and localization of a wide range of tumor types. In the 1980s, ^{18}F-FDG PET/CT was initially employed in nuclear cardiology to evaluate the metabolic viability of coronary artery disease. The myocardium utilizes glucose as one of its primary substrates. Similar to glucose, myocardial cells absorb ^{18}F-FDG. Furthermore, activating inflammatory cells, including macrophages and lymphocytes, accumulate ^{18}F-FDG in inflammatory foci. The main sources of energy for the myocardium are glucose and free fatty acids (FFAs). Normal cardiomyocytes primarily use glucose after meals, while during prolonged fasting periods, they utilize FFAs [38, 39].

The physiology and patterns of myocardial FDG uptake, which are contingent upon the levels of glucose, FFAs, and plasma insulin, should be taken into account to accurately diagnose cardiac neoplasms. Insulin levels decrease during fasting, resulting in elevated lipolysis in peripheral tissues and plasma FFA levels. Reduction in glycolytic metabolism occurs, leading to decreased myocardial glucose/FDG uptake [25, 40].

The ability to distinguish between benign and pathological cardiac activity is a prerequisite for using FDG as a PET tracer for imaging cardiac pathology. This can be accomplished by completely suppressing physiological myocardial absorption [41].

Standard oncology regimens involving 4-6 hours of fasting in normal patients can often result in non-specific heterogeneous, diffuse, or localized FDG cardiac uptake. Several methods have been suggested to suppress basal myocardial glycolytic activity, such as unfractionated heparin infusion, long-term fasting (5-18 hours), and a diet high in fat and low in carbohydrates [26, 42, 43].

Optimal imaging timing after FDG injection is still up for debate, although most studies have shown that it is best to wait 60-90 minutes after the tracer injection [42, 43]. In some cases, including when evaluating native valve endocarditis, delayed capture improves the lesion signal-to-background activity by making

it easier to eliminate background blood pools. On the other hand, its applicability to evaluating cardiac structures has not been explored [43, 44].

The roles of ^{18}F-FDG PET/CT imaging of cardiac tumors

Evaluating and managing various oncologic conditions is a typical application of ^{18}F-FDG PET/CT [45]. ^{18}F-FDG PET/CT has also been employed to evaluate a variety of cardiac diseases, such as coronary artery disease, myocarditis, sarcoidosis, and cardiac tumors [46]. ^{18}F-FDG PET/CT is a valuable tool for predicting survival, distinguishing benign from malignant cardiac tumors, and assessing the metabolic activity of cardiac tumors. In most cases, malignancy can be ruled out when a lesion does not exhibit ^{18}F-FDG uptake [47, 48]. It is possible to get a false-positive result for ^{18}F-FDG absorption due to poor patient preparation, inflammation, infection, abscess, surgical alterations, radiation changes, brown fat, or both. Also, the patient preparation and image acquisition processes for cardiac imaging with ^{18}F-FDG PET/CT are distinct from those of standard oncological imaging [49].

Our review shows that ^{18}F-FDG PET/CT contributes unique, complementary information beyond echocardiography, CT, and CMR by combining whole-body coverage with quantitative metabolic assessment, which is particularly relevant in a setting where secondary (metastatic) cardiac involvement is much more frequent than primary tumors. The whole-body nature of PET/CT allows simultaneous evaluation of the index cardiac mass and extracardiac disease, facilitating the identification of occult primaries or distant metastases that may not be apparent on conventional cardiac-focused imaging alone.

The study by Meng et al. [23] demonstrated the diagnostic value of ^{18}F-FDG PET/CT in differentiating benign and malignant cardiac tumors. They found that the SUVmax and the TBRmax could effectively distinguish between benign and malignant tumors with high sensitivity and specificity. Additionally, they identified SUVmax as an independent predictor of mortality in cases with cardiac tumors. This study provided important quantitative parameters to help characterize the malignant potential of cardiac masses using ^{18}F-FDG PET/CT. In line with these findings, we interpret SUVmax and TBRmax as practical first-line metabolic markers that can flag lesions with aggressive biology, while recognizing that their absolute cut-off values are influenced by patient preparation, scanner differences, and underlying disease prevalence [47].

Similarly, the study by Yin et al. [28] assessed the utility of ^{18}F-FDG PET/CT in evaluating cardiac and pericardial masses. When compared to TTE, ^{18}F-FDG PET/CT was far more sensitive in detecting malignancy, especially pericardial masses. Additionally, ^{18}F-FDG PET/CT helped identify extracardiac lesions that were missed on TTE, leading to changes in the diagnostic strategy for 15 patients. This highlights the complementary role of ^{18}F-FDG PET/CT in characterizing cardiac and pericardial masses beyond the capabilities of traditional imaging modalities. From a clinical standpoint, these results support the selective use of ^{18}F-FDG PET/CT when echocardiography or other anatomical imaging raises suspicion for malignancy but cannot confidently define the nature or extent of disease, especially in patients with known or suspected systemic cancer [50].

Qin et al. [29] further investigated the diagnostic and prognostic potential of ^{18}F-FDG PET/CT in cardiac tumors. They determined that a SUVmax threshold of 6.75 was optimal for distinguishing benign from malignant tumors, with excellent diagnostic accuracy. Importantly, they also demonstrated that SUVmax $\geq$ 6.715 was an independent predictor of survival, highlighting the prognostic value of this metabolic parameter. When considered alongside Meng et al. [23], these data suggest that metabolic activity measured by SUVmax reflects not only the presence of malignancy but also its biological aggressiveness, offering clinicians an additional, non-invasive tool for risk stratification and follow-up planning.

Building on these findings, the study by D'Angelo et al. [15] compared the diagnostic performance of ^{18}F-FDG PET/CT and cardiac CT in detecting cardiac masses. They found that ^{18}F-FDG PET/CT parameters, including SUVmax, SUVmean, MTV, and TLG, exhibited superior diagnostic accuracy in identifying malignant lesions compared to cardiac CT alone. This study underscored the additional metabolic

and functional information provided by ^{18}F-FDG PET/CT that can complement the anatomical information from CT, ultimately improving the characterization of cardiac masses. In particular, volumetric indices such as MTV and TLG integrate both lesion size and metabolic intensity, which may better capture tumor burden and heterogeneity than SUVmax alone, and should be incorporated into reporting whenever quantitative software and expertise are available [21].

Most recently, Hu et al. [30] assessed the diagnostic efficacy of various ^{18}F-FDG PET/CT metabolic parameters in differentiating benign from malignant cardiac or pericardial masses. They found that SUVmean and MTV demonstrated the best diagnostic accuracy, suggesting that SUVmax may not be the most appropriate reference for assessing the nature of these tumors. This highlights the importance of considering multiple metabolic parameters when using ^{18}F-FDG PET/CT for cardiac mass evaluation. Our interpretation is that SUVmax should be viewed as a useful but incomplete descriptor of tumor biology; combining SUVmax with SUVmean, MTV, and TLG yields a more nuanced metabolic profile that can refine decision-making in borderline or discordant cases. In future practice, standardized multiparametric PET reporting for cardiac tumors could help to harmonize thresholds and facilitate the incorporation of PET-derived metrics into risk models and treatment algorithms [21, 47].

Also, Lemasle et al. [31] demonstrated that ^{18}F-FDG PET/CT had the highest accuracy in differentiating benign and malignant masses, outperforming other modalities like TTE, CT, and cardiac MRI. This underscores the pivotal role of ^{18}F-FDG PET/CT in the comprehensive assessment and characterization of cardiac tumors. However, our synthesis supports using ^{18}F-FDG PET/CT within a multimodality pathway rather than as a stand-alone test; anatomical modalities remain essential for defining morphology, hemodynamic impact, and resectability, while PET/CT refines the assessment of malignancy and systemic spread [48].

Despite these advantages, several limitations must be acknowledged. Physiological myocardial FDG uptake and non-neoplastic inflammatory or thrombotic processes can lead to false-positive results; therefore, meticulous patient preparation (high-fat, low-carbohydrate diet, prolonged fasting, and, in selected cases, heparin administration) is crucial to suppress background myocardial uptake and improve lesion conspicuity. Moreover, tumors with low glycolytic activity, such as some well-differentiated neuroendocrine neoplasms, may show minimal FDG uptake, in which case alternative tracers (e.g. ^{68}Ga-DOTATATE or ^{18}F-DOPA) or hybrid PET/MRI may provide better characterization [21].

Overall, the available evidence indicates that ^{18}F-FDG PET/CT should be considered a key adjunct in the diagnostic work-up of suspected cardiac tumors, particularly when malignancy is suspected, histologic confirmation is challenging, or there is a need to evaluate systemic disease. By integrating metabolic, anatomical, and clinical information, ^{18}F-FDG PET/CT can help clinicians move from purely descriptive imaging toward a more biologically informed, personalized approach to the management of cardiac masses [21, 47].

The future of diagnosing cardiac tumors

There is a lack of research that evaluates PET/CT and PET/MRI in combination. The majority of research investigations that are currently accessible lack randomization and are retrospective. Evaluating results and building a management regimen for cardiac tumors is crucial in performing standardized, multicenter prospective studies. This will provide optimal patient care. However, in order to provide treatment and prognostication advice, imaging characteristics pertaining to the histology of various cardiac tumors are necessary. Developing an evaluation approach and placing each modality inside the procedure is more difficult due to the lack of consistency in the existing literature surrounding imaging techniques [21]. While ^{18}F-FDG PET/CT has become an essential diagnostic tool for heart cancers, it is useless for tumors like well-differentiated neuroendocrine tumors that do not absorb ^{18}F-FDG. Other tracers, such as ^{68}Ga-DOTATATE and ^{18}F-DOPA, are more effective in identifying cardiac metastases originating from neuroendocrine tumors [51, 52]. In addition, the potential use of gut microbiome markers as auxiliary diagnostic or risk assessment tools should be investigated, similar to their ongoing evaluation in colorectal

cancer [53]. Additional research with larger samples and studies involving multiple sites is necessary to address the current lack of information in this area. This will allow for a more comprehensive evaluation and determination of the possible function that ^{18}F-FDG PETCT could play in detecting cardiac malignancies.

Conclusion

Although limited evidence exists about the usefulness of ^{18}F-FDG PET/CT imaging in assessing cardiac tumors, this systematic review has revealed the significant diagnostic and prognostic role that ^{18}F-FDG PET/CT plays in the diagnosis of cardiac and pericardial masses. Information gleaned from ^{18}F-FDG PET/CT quantitative metabolic indicators like SUVmax, SUVmean, MTV, and TLG is vital for improving tumor classification between benign and malignant, directing treatment decisions, and predicting patient outcomes. Hence, it should be part of the assessment procedures to aid in tumor identification and estimate of results. While CMR is unquestionably important, ^{18}F-FDG PET/CT offers remarkable metabolic data about the tumor. It aids in predicting lesion type, tumor invasion extent, metastasis evaluation, distant metastasis detection, and biopsy guidance.

Disclosure of conflict of interest

None.

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