

Usefulness of Fluorine-18 Positron Emission Tomography/Computed Tomography for Identification of Cardiovascular Implantable Electronic Device Infections

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Objectives

This study evaluated the usefulness of fluorodesoxyglucose marked by fluorine-18 (^{18}F -FDG) positron emission tomography (PET) and computed tomography (CT) in patients with suspected cardiovascular implantable electronic device (CIED) infection.

Background

CIED infection is sometimes challenging to diagnose. Because extraction is associated with significant morbidity/mortality, new imaging modalities to confirm the infection and its dissemination would be of clinical value.

Methods

Three groups were compared. In Group A, 42 patients with suspected CIED infection underwent ^{18}F -FDG PET/CT. Positive PET/CT was defined as abnormal uptake along cardiac devices. Group B included 12 patients without infection who underwent PET/CT 4 to 8 weeks post-implant. Group C included 12 patients implanted for >6 months without infection who underwent PET/CT for another indication. Semi-quantitative ratio (SQR) was obtained from the ratio between maximal uptake and lung parenchyma uptake.

Results

In Group A, 32 of 42 patients with suspected CIED infection had positive PET/CT. Twenty-four patients with positive PET/CT underwent extraction with excellent correlation. In 7 patients with positive PET/CT, 6 were treated as superficial infection with clinical resolution. One patient with positive PET/CT but negative leukocyte scan was considered false positive due to Dacron pouch. Ten patients with negative-PET/CT were treated with antibiotics and none has relapsed at 12.9 ± 1.9 months. In Group B, patients had mild uptake seen at the level of the connector. There was no abnormal uptake in Group C patients. Median SQR was significantly higher in Group A ($A = 2.02$ vs. $B = 1.08$ vs. $C = 0.57$; $p < 0.001$).

Conclusions

PET/CT is useful in differentiating between CIED infection and recent post-implant changes. It may guide appropriate therapy. (J Am Coll Cardiol 2012;59:1616–25) © 2012 by the American College of Cardiology Foundation

Cardiovascular implantable electronic device (CIED) infection is one of the most feared complications of device implantation. The incidence of CIED infections is 1.9 cases by 1,000 implants/year (1,2). The total number of CIED infections is increasing, mainly with new clinical indications and the growing number of implants worldwide (3). Definitive CIED infection diagnosis is often challenging. In addition, CIED infection treatment can be invasive, requir-

ing complete extraction of the generator and all leads. Lead extraction is associated with significant morbidity (major complications = 1.5% to 2%) and mortality (0.8%) (4,5). New imaging modalities to confirm the infectious process and its dissemination would be of clinical value.

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Combined fluorodesoxyglucose marked by fluorine-18 (^{18}F -FDG) positron emission tomography (PET) and computed tomography (CT) is a well-established imaging modality that allows 3-D measurement of metabolic activity within an organ obtained from the emission of positrons following disintegration of an injected radioactive product. The value of ^{18}F -FDG PET/CT is already recognized in oncology for cancer diagnosis and staging, and in cardiology

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to assess myocardial viability. ^{18}F -FDG PET/CT is also used for infection detection associated with vascular or orthopedic prostheses (6–9). There are few case reports (10–13) and only 2 small pilot studies (14,15) in the literature where ^{18}F -FDG PET/CT has been used for CIED infection diagnosis. ^{18}F -FDG PET/CT appears as an interesting adjunct for CIED infection diagnosis because it allows the use of ^{18}F -FDG as a marker. This is a glucose analogue, which is incorporated and retained within the cells with higher metabolic activity. It might help the clinician to confirm the diagnosis of CIED infection, determine the systemic extension of the infectious process, and justify an invasive procedure.

The goal of this study was first to evaluate the usefulness of ^{18}F -FDG PET/CT for the detection of CIED infections. Secondly, because there is sometimes a real clinical challenge to diagnose a CIED infection or superficial skin infection or inflammation in recent post-implant patients, we tested a group of patients with recent implants and no clinical suspicion of infection to assess their “baseline” ^{18}F -FDG uptake level.

Methods

The protocol was approved by the Ethics Committee from the Institut universitaire de cardiologie et pneumologie de Québec.

Three groups of consecutive patients were prospectively compared. The first group (Group A = suspected CIED infection) included patients with clinically suspected CIED infections ($n = 42$). CIED infection was defined by the presence of 1 of the following (5,16): 1) pocket infection = local signs of inflammation at the generator pocket, including erythema, warmth, fluctuance, wound dehiscence, tenderness, or purulent drainage ($n = 26$); 2) device erosion = cutaneous erosion with percutaneous exposure of the generator and/or leads ($n = 6$); 3) lead endocarditis = mass adherent to a lead in a patient with positive blood cultures or other suggestive features for infection or lead tip cultures ($n = 7$); and 4) persistent or recurrent bacteremia in the absence of another identifiable source ($n = 3$).

Treatment decisions were on the basis of the degree of certainty of the CIED infection diagnosis, results of conventional tests, and clinical guidelines (5). Results of the ^{18}F -FDG PET/CT were transmitted to the treating physicians, but the exam was only complementary and never used alone for the final decision on the management of these patients. Extraction was performed when deep CIED infection (i.e., infection involving the generator and/or the leads) was suspected. The second group (Group B = controls: acute phase) included patients with recent device implantation but without signs of infection in order to know the background residual inflammation at 4 to 8 weeks post-implant ($n = 12$), the period where the diagnosis can be more challenging. These patients were recruited at the time of their first follow-up visit approximately 1

month post-implant. Finally, the third group (Group C = controls: chronic phase) included patients with remote device implantation (>6 months) without signs of infection who underwent ^{18}F -FDG PET/CT for another indication ($n = 12$).

Clinical data were collected from all patients, including blood work (white blood cell count, neutrophils count, C-reactive protein level, and blood cultures if available). A clinical correlation was performed in patients who had a transesophageal echocardiogram (TEE) and/or extraction in addition to ^{18}F -FDG PET/CT.

^{18}F -FDG PET/CT. All patients underwent ^{18}F -FDG PET/CT (GE Discovery PET/CT, GE Healthcare, Piscataway, New Jersey) after an 8-h fasting period. PET imaging was performed 65 ± 17 min after injection of 8.1 ± 1.8 mCi of FDG (equivalent to 293.1 ± 74.4 MBq). Simultaneously, a low-dose CT without intravenous contrast but with gastric opacification was obtained for attenuation correction and anatomic localization. The capillary glucose was measured at the time of the injection. Limited imaging to the torso and superior abdomen was performed in Group B to limit radiation exposure.

Each case was reviewed by 2 experienced nuclear physicians. Discordant analyses were resolved by consensus. The analysis was performed using MIMvista software (MIM Software Inc., Cleveland, Ohio). Both attenuation-corrected as well as non-attenuation-corrected images were reviewed in order to recognize artifacts related to the correction of attenuation in proximity of an object of high density (e.g., metal of generator), but only the non-attenuation-corrected images were used for final interpretation. A positive ^{18}F -FDG PET/CT was defined as an abnormal ^{18}F -FDG uptake near the generator pocket and/or along the CIED (i.e., generator or leads). Sites of abnormal ^{18}F -FDG uptakes were noted as well as the site of maximal ^{18}F -FDG uptakes. Sites of abnormal ^{18}F -FDG uptakes were separated by areas: skin (superficial), subcutaneous tissue, surrounding of generator, overlying leads, and intravascular/intracardiac. A qualitative visual score was noted: none (score = 0), mild hypermetabolism (equal or less to lung parenchyma; score = 1), moderate hypermetabolism (more intense than lung parenchyma; score = 2), and severe hypermetabolism (very intense uptake; score = 3). There was interobserver agreement for the qualitative visual score as well as for the final PET/CT conclusion on whether or not CIED infection was present. A semi-quantitative ratio was also collected from non-attenuation-corrected images. A ratio was created between the maximum count

Abbreviations and Acronyms

^{18}F-FDG	=	fluorodesoxyglucose marked by fluorine-18
CIED	=	cardiovascular implantable electronic device
CT	=	computed tomography
LVEF	=	left ventricular ejection fraction
PET	=	positron emission tomography
ROC	=	receiver-operating characteristic
TEE	=	transesophageal echocardiogram

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