Clinical note

18F-sodium fluoride PET/CT for the in vivo visualization of Mönckeberg’s sclerosis in a diabetic patient

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Diabetes is a major frequent cause of atherosclerosis vascular disease. Arterial calcification in diabetic patients is responsible for peripheral vascular involvement. Molecular imaging using 18F-sodium fluoride (18F-NaF) positron emission tomography (PET)/computed tomography (CT) has been recently proposed as a marker to study the in vivo mineralization process in the atheroma plaque. A 69-year-old man with a history of type 2 diabetes and no clinical evidence of peripheral arterial disease underwent an 18F-NaF PET/CT scan. A linear, well-defined 18F-NaF uptake was detected along the femoral arteries. In addition, the CT component of the PET/CT identified an unsuspected “tram-track” calcification in his femoral arteries, suggestive of medial calcification (Mönckeberg’s sclerosis). In other vascular territories, focal 18F-NaF uptake was also detected in carotid and aorta atheroma plaques. Molecular imaging with 18F-NaF PET/CT might provide new functional information about the in vivo vascular calcification process in diabetic patients.

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PET/TC con 18F-fluoruro sódico en la visualización in vivo de la esclerosis de Mönckeberg en un paciente diabético

R E S U M E N

La diabetes es una causa frecuente de enfermedad vascular aterosclerótica. La calcificación vascular en pacientes diabéticos es responsable de la afectación vascular periférica. Recientemente se ha propuesto la imagen molecular usando tomografía por emisión de positrones (PET)/tomografía computarizada (TC) con 18F-fluoruro sódico (18F-NaF) como marcador para estudiar "in vivo" el proceso de mineralización en la placa de ateroma. Presentamos los hallazgos de la PET/TC 18F-NaF en un varón de 69 años con historia de diabetes tipo 2 y sin evidencia clínica de enfermedad arterial periférica. La PET/TC 18F-NaF demostró una captación lineal, bien definida, a lo largo de las arterias femorales. Además la componente TC de la PET/TC identificó un patrón de calcificación "en vías de tranvía" ("tram-track" pattern) en las arterias femorales sugestivo de calcificación de la capa media arterial (esclerosis de Mönckeberg). En otros territorios vasculares se detectó captación focal de 18F-NaF en placas de ateroma carotídeas y aórticas. La imagen molecular con PET/TC 18F-NaF podría proporcionar nueva información funcional sobre el proceso de calcificación vascular “in vivo” en pacientes diabéticos.

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Introduction

Diabetes represents a leading cause of morbidity and mortality in the Western world. In addition, vascular calcification in diabetes is associated with a major risk factor for cardiovascular disease. The appearance of vascular calcification may be focal in atheromatous plaque (in the intima) or diffuse in the media (Mönckeberg’s sclerosis) of the vessel wall. 1,2

Diagnosis of vascular calcification requires different structural imaging techniques, such as ultrasound, angiography, CT and MR that provide anatomical visualization of the arterial lumen and the arterial wall. The typical radiographic finding of Mönckeberg’s sclerosis is the “tram-track” pattern, appearing as a linear contiguous parallel calcification which reflects the circumferential calcification of the medial arterial wall.

Currently, the combined use of positron emission tomography (PET) and computed tomography (CT) provides a non-invasive imaging technique which allows complementary functional and anatomical information on the whole body. In this sense, molecular imaging with 18-fluorine sodium fluoride (18F-NaF) PET/CT...
offers a new approach to the in vivo identification of active vascular calcification.\textsuperscript{3,4}

In this clinical case we report the \(^{18}\)F-NaF PET/CT appearance of calcified femoral arteries (Mönckeberg’s sclerosis) in a diabetic patient included in a prospective study on the contribution of the \(^{18}\)F-NaF to the study of vascular calcification.

**Case report**

We present a 69-year-old man with a history of type 2 diabetes, hypertension, smoking, hypercholesterolemia, prior myocardial infarction, and no clinical evidence of peripheral arterial disease. He was on treatment with aspirin (100 mg/day), angiotensin converting enzyme inhibitors (100 mg/day), lovastatin (20 mg/day), and metformin (850 mg/day). As part of a prospective research project on the role of \(^{18}\)F-NaF to the study of vascular calcification in diabetic patients, an \(^{18}\)F-NaF PET/CT was done. Before the study, the patient received oral information about the objective of the study and signed an informed consent. Project was approved by the ethical committee of hospital.

A non-contrast enhanced PET/CT (130 keV, 80 mAs) scan was performed 180 min after the intravenous injection of 370 MBq of \(^{18}\)F-NaF. The effective radiation dose of \(^{18}\)F-NaF PET/CT was 13.41 mSv. A linear and well-defined \(^{18}\)F-NaF high uptake was detected along the femoral arteries. This finding was associated with an unsuspected extensive tram-track calcification in his femoral arteries, which was identified on the CT component of the PET/CT scan (Fig. 1). In addition, focal \(^{18}\)F-NaF uptake in carotid and aortic arch atheroma plaques was detected (Fig. 2).

**Discussion**

Mönckeberg’s sclerosis, also called medial elastocalcinosis, is characterized by the calcification of the medial layer of the arterial wall. Medial arterial calcification is common in healthy elderly subjects and in patients with end-stage renal disease and type 2 diabetes. The process of arterial mineralization involves the differentiation of vascular smooth muscle cells towards osteoclasts-like cells in the vessel wall.\textsuperscript{5} Currently, vascular calcification in diabetics is considered an active process regulated in a similar way to bone formation, instead of a passive process.\textsuperscript{6} Therefore, medial arterial calcification in Mönckeberg’s sclerosis is a manifestation of extrasosseous calcification of the vasculature produced by the deposition of calcium in the form of hydroxyapatite.

\(^{18}\)F-NaF is a bone-seeking radiotracer which biological molecular distribution is related to chemisorption onto hydroxyapatite crystals. The radiotracer was introduced in the 60’s years for bone scintigraphy. With the rapid growth of PET/CT availability, the contribution of \(^{18}\)F-NaF PET/CT is being investigated for the study of vascular calcification.\textsuperscript{7}

Derlin et al. reported the uptake of \(^{18}\)F-NaF PET/CT in calcification of atheroma plaques in carotid, aorta, femoral, and coronary arteries.\textsuperscript{7} A significant correlation of vascular \(^{18}\)F-NaF uptake has been found with cardiovascular risk factors, such as age, male genre, diabetes, hypertension, prior cardiovascular events, smoking, and

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**Fig. 1.** \(^{18}\)F-NaF PET (A), CT (B), and fused PET/CT (C) coronal images. Well-defined linear \(^{18}\)F-NaF uptake associated to “tram-track” pattern of calcification along the femoral arteries.

**Fig. 2.** \(^{18}\)F-NaF PET (A), CT (B), and fused PET/CT (C) coronal images. Focal radiotracer uptake in atheroma plaques located at right carotid artery and aortic arch (arrows).
hypercholesterolemia. Similar $^{18}$F-NaF PET/CT features have been reported by Li et al.\(^5\) In a recent retrospective evaluation, Janssen et al. observed a significant relationship between linear arterial $^{18}$F-NaF pattern and cardiovascular risk factors, including diabetes and calcified plaque burden.\(^6\)

The patient included in this clinical case showed a linear $^{18}$F-NaF uptake in femoral arteries. This $^{18}$F-NaF distribution was associated to diffuse “tram-track” artery calcification observed on CT which would be in accordance with the medial arterial calcification of Mönckeberg’s sclerosis. Despite the extensive femoral arterial calcification, our patient did not present intermittent dysasia. An explanation to this clinical picture is that medial arterial calcification in Mönckeberg’s sclerosis linked to vascular stiffness but preserved blood flow may be seen in absence of intima atheroma plaques.

Interestingly, in the case reported here, the peripheral $^{18}$F-NaF femoral artery uptake was associated to focal radiotracer uptake in other vascular territories, such as aorta and carotid atheroma plaques. The focal $^{18}$F-NaF uptake in calcifying carotid plaques has been correlated with conventional cardiovascular risk factors, the extent of wall calcification, the intensity of uptake and the patient symptomatology.\(^7,9\) These findings allowed the identification of the extent of vascular calcification in other atheromatous lesions and may contribute to an early identification of cardiovascular risk in diabetic patients.

In conclusion, functional molecular imaging using $^{18}$F-NaF PET/CT might provide a new insight into the nature of the vascular calcification in Mönckeberg’s sclerosis by showing the active mineralization process. This report is encouraging to carry out further research on the impact of the technique in diabetic patients and to identify the potential field of application in the clinical setting.

Conflict of interest

The authors declare no conflicts of interest

References