Images in Aortic Disease

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Magnetic Resonance Imaging Findings in a Positron Emission Tomography-Positive Thoracic Aortic Aneurysm

Alain Nchimi, MD[1]*, Thierry Couvreur, MD[1], Benoit Meunier, MD[1], Natzi Sakalihasan, MD, PhD[2]

[1]Department of Cardiovascular and Thoracic Imaging, University Hospital, Liège, Belgium; [2]Department of Cardiovascular Surgery, University Hospital, Liège, Belgium

Abstract

Diffusion-weighted MRI (DW-MRI) and ^{18}F-fluorodeoxyglucose positron emission tomography (FDG-PET) findings are described in a patient with a thoracic aortic aneurysm. Both examinations have the ability to noninvasively assess biological processes associated with aneurysm instability and therefore to potentially impact clinical decision-making regardless of the vessel size. Despite similarities between images on both techniques, FDG-PET evaluates glycolysis, while DW-MRI evaluates cell density, edema, and perfusion. Longitudinal studies including larger patient numbers are needed to investigate the temporal continuum and clinical significance of these findings.

Key Words

Magnetic resonance imaging · Positron emission tomography · Aortic aneurysm

Introduction

Atherosclerotic and inflammatory aortic diseases may cause complications at all ages, including aneurysmal dilatation and rupture, which is the 13th leading cause of death in the United States [1]. Evidence that most of these complications result from biological processes led to the emergence of imaging techniques with the capacity to evaluate these processes [2]. Using ^{18}F-fluorodeoxyglucose (FDG) (a glucose analog) positron emission tomography (PET) allows imaging of glycolysis and, therefore, tissue metabolism. FDG uptake in the aortic aneurysm wall is an important parameter, positively correlated to the magnitude of inflammatory cell infiltrates, matrix metalloprotease activation, and risk of rupture [3]. Diffusion-weighted MRI (DW-MRI), which evaluates the water motion within a milieu, has established clinical value in early stroke detection and cancer staging [4,5]. DW-MRI has, to our knowledge, never been evaluated in aortic aneurysms. In this board-approved report, we present the DW-MRI findings and clinical outcome in a patient with an FDG-avid aneurysm of the aortic arch.

Case Presentation

The patient was a 68-year-old male smoker (30 pack/years) with a history of lower limb artery claudication and a saccular aneurysm of the aortic arch, for which he was included in a large trial aiming to determine the role of FDG-PET and MRI in aortic aneurysm rupture-risk assessment (http://www.fighting-aneurysm.org).

After a nightlong fast, he underwent clinical follow-up showing normal blood cell count and levels of C-reactive protein and sedimentation rate. There-

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E-Mail: aorta@scienceinternational.org
http://aorta.scienceinternational.org

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*Corresponding author:
Alain Nchimi, MD
Department of Cardiovascular and Thoracic Imaging
University Hospital
Domaine Universitaire du Sart-Tilman B 35
B-4000 Liege, Belgium
Tel: +32 4 366 77 67, Fax: +32 4 366 77 72, E-Mail: anchimi@chu.ulg.ac.be

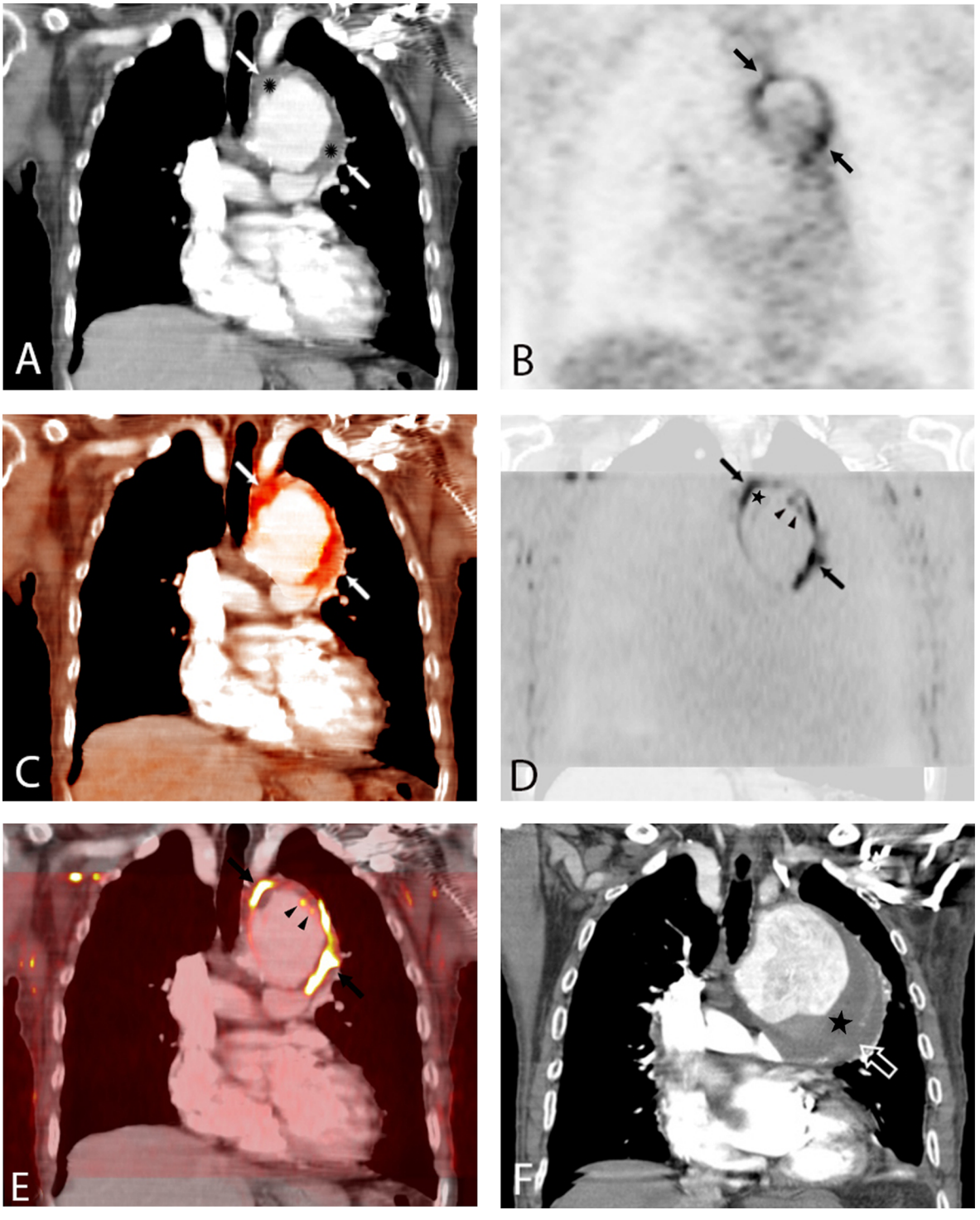

Figure 1. A. Coronal reformatted contrast-enhanced computed tomography (CT) of the chest demonstrates a large aortic arch aneurysm, with an intraluminal thrombus (ILT) (stars). ^{18}F-Fluorodeoxyglucose positron emission tomography (FDG-PET) (B) and color intensity maps fused with CT (C) showed FDG uptake on the aneurysm wall (**arrows**, D). E. Coronal reformats of transverse diffusion-weighted magnetic resonance images with a diffusion factor value of 800 s/mm^2 were fused to CT images in a similar plane and showed restricted diffusion on the aneurysm wall (**arrows**), but differed from FDG-PET by increased signaling on the luminal surface of the ILT (**arrowheads**). The patient died three months later. F. Admission CT showed aortic enlargement and rupture on thrombus-covered aneurysm wall (**open arrow**).

after, combined whole-body (neck to pelvis) computed tomography (CT) and PET (Discovery LS, GE Healthcare, Milwaukee, WI) was performed 1 h after injection of 3.7 MBq FDG/kg body weight. PET data were corrected for attenuation using CT tissue density values. The patient's aneurysm was evaluated the same day in a separate 3T MRI unit (Achieva, Philips, Best, The Netherlands), using tridirectional diffusion gradients.

DW-MRI Technique

In short, the principle of DW-MRI is that the signal change between two opposed gradient pulses of similar intensity and duration is related to the movement (diffusion) of water protons. Because MRI voxel size is much larger than water molecules, there are several sources of intravoxel incoherent motion such as closed spaces, tortuosity, and microvasculature. Rather than absolute diffusion, DW-MRI therefore refers to an apparent diffusion coefficient (ADC) whereof the tridimensional components are defined in the equation: $ADC(x,y,z) = \ln[S2(x,y,z)/S1(x,y,z)]/(b1 - b2)$; where $b1$ and $b2$ are acquisition-dependent factors, and S1 and S2 the respective image signal intensity [5]. Two b-values (0 and 800 s/mm^2) were used for 7-mm-thick cross-sections; the other MRI parameters were: repetition time/echo time: 1300/67 ms; matrix, 144×192; number of slices adjusted to the area of interest; intersection gap, 1.4 mm; and field of view adjusted to the body size. Both FDG-PET and $b = 800$ s/mm^2 diffusion images (where the signal intensity is inversely proportional to ADC) were matched to CT images using anatomical landmarks (Osirix, Pixmeo, Geneva, Switzerland).

Findings on both imaging modalities disclosed an aortic arch aneurysm containing a large intraluminal thrombus (ILT). The aneurysm diameter was 69 mm (65 mm six months earlier) and the aneurysm wall exhibited diffuse FGD uptake; the maximal standardized FDG uptake value was 4.8 g/mL. On DW-MRI, in a roughly similar distribution, ADC was strongly reduced. There was also an area of restriction at the luminal surface of the ILT (Fig. 1). The patient was informed of the increased risks related to such findings and declined any repair despite surgical insistence, but eventually died three months later from aortic rupture.

Discussion

The case presented illustrates the usefulness of a local assessment of biological processes in aortic aneurysms. Despite the fact that this patient was asymptomatic and his systemic inflammatory blood tests were normal, there was increased aneurysm glycolysis (on PET imaging), suggesting a poor outcome. DW-MRI necessitates no ionizing radiation, and the actual causes of signaling differ from that of FDG-PET but similarly address tissue cellularity at high b-values, as shown. Because DW-MRI has a lower vascular background signal, beyond just replicating findings from other modalities, DW-MRI surpasses FDG-PET in the detection of cellular infiltrates at the luminal surface of the ILT. The same characteristic was shown previously using MRI to assess superparamagnetic iron oxide phagocytosis at the luminal surface of the ILT [6], which has pivotal implications in aneurysm destabilization through proteases released by inflammatory cells and conveyed through the thrombus [7]. As observed, aneurysm rupture often occurs on the ILT-covered area.

The composite nature of DW-MRI signaling may be another important asset. T2-relaxation and perfusion effects that are prominent at very low b-values reflect other important biological processes like edema and perfusion (angiogenesis) that were not evaluated in this report. Further investigating the temporal correlations between DW-MRI and FDG-PET signaling, biological activities, and clinical outcomes may therefore help elucidate interactions and eventually improve treatment and clinical decision-making in aortic aneurysms.

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Conflict of interest

None

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