Case Report

Genuine impact of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography in clinching the diagnosis and follow-up response assessment of vascular graft infections

ABSTRACT

Vascular graft infection (VGI) is a rare and severe complication after vascular surgery associated with significant morbidity and mortality, but the diagnosis is not always straightforward due to its variable and nonspecific clinical signs. Computed tomography (CT) scan is considered to be the diagnostic tool of choice for advanced VGI, but there is a high incidence of false-negative results, especially in low-grade infections. ^{18}F-Fluorodeoxyglucose positron emission tomography with contrast-enhanced CT (^{18}F-FDG PET-CT) imaging can serve as an effective alternative tool for assessment of suspected VGI and also provide accurate anatomic localization of the infective focus. Here, we describe three cases of VGI with various clinical presentations where the site of infection was diagnosed, confirmed, and documented with the help of ^{18}F-FDG PET-CT imaging.

Keywords: Aortic root infection, fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography, vascular graft infection

INTRODUCTION

Vascular graft infection (VGI) is an uncommon and serious complication after reconstructive vascular surgery, with an incidence ranging between 1% and 6%. The incidence of VGI varies according to the bypass localization[1-3] and may lead to extreme complications such as limb amputation (5%–25%) with severe mortality rates as high as 25%–88%.[1-3] In clinically suspected VGI, the real challenge is to obtain definitive proof of the graft infection. Positive cultures either from percutaneously aspirated perigraft fluid or surgical samples are considered to be the gold standard for VGI. However, in clinical practice being an invasive procedure, this is often met with difficulty.

Nevertheless, it is crucial to detect graft/patch infections at an early stage for adequate and appropriate management. The clinical presentations are usually variable, nonspecific, and subtle which include symptoms such as recurrent fevers and chills, back or groin pain, erythema, and swelling, thus delaying an early diagnosis.[4] Late infections could even present in an occult manner, with no overt symptoms of the disease. Morphological imaging with stand-alone computed tomography (CT) and magnetic resonance imaging (MRI) may

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be negative or show only subtle, nonspecific postintervention changes, especially in a low-grade infection scenario.

In this cluster of three cases, we would like to stress upon the impact and effectiveness of F-18 fluorodeoxyglucose positron emission tomography-CT (^{18}F-FDG PET-CT) in the diagnostic workup and localization of infective focus with the clinical suspicion of VGI. ^{18}F-FDG PET-CT was performed using an LSO crystal integrated PET-CT scanner (Biograph 2, Siemens Medical Solutions). After overnight fasting for at least 12 h (for adequate myocardial suppression of ^{18}F-FDG uptake), patients were injected with 10 mCi (370 MBq) of ^{18}F-FDG intravenously, and whole-body PET-CT scan (vertex of the skull to the mid-thigh) was performed after an uptake period of 1 h. Contrast-enhanced CT images were acquired at 130 kV and 90 mAs, with a section width of 5 mm. Attenuation correction of PET images was done based on CT data, and iterative reconstruction was done. In all patients, blood glucose levels were checked and ensured to be below 150 mg/dl before injection of FDG.

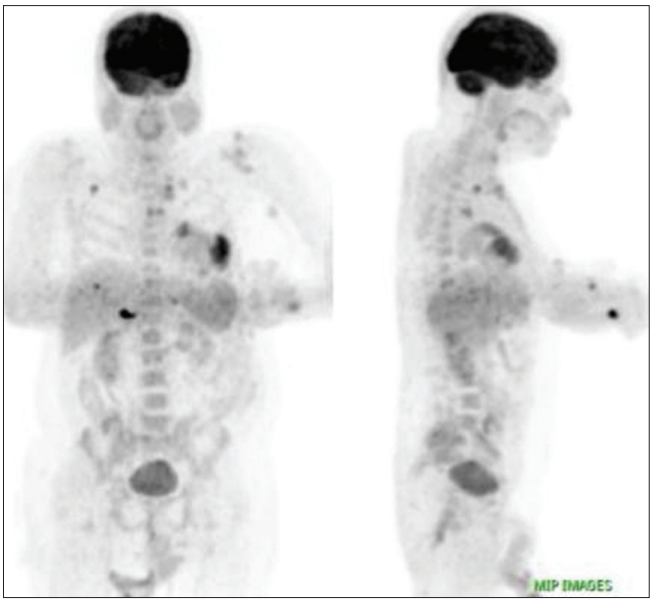

Figure 1: ^{8}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography maximum intensity projection image showing intense diffuse abnormal ^{18}F-fluorodeoxyglucose uptake (five-point visual grading score – 3) in the region of the left ventricular apex where the autologous pericardial patch repair for left ventricular aneurysm was done. Few prominent fluorodeoxyglucose-avid mediastinal and right subpectoral nodes are also seen

CASE REPORTS

Case 1

A 58-year-old man presented with complaints of breathlessness and high-grade fever of 15 days duration. There was no history of chest pain or dizziness. He was a known hypertensive for 20 years with a history of coronary artery disease for 17 years. He had a history of tuberculous lymphadenitis, diagnosed and treated 3 years back. He had undergone angioplasty to the left anterior descending artery and right coronary artery 11 years back, coronary artery bypass grafting for triple-vessel disease, and left ventricular (LV) aneurysm repair with native autologous pericardial patch 9 years back. For the past 2 years, he had recurrent episodes of fever secondary to methicillin-resistant *Staphylococcus aureus* (MRSA) bacteremia, for which he was treated with broad-spectrum antibiotics. He also had a history of one episode of cardioembolic ischemic stroke (right middle cerebral artery infarct) secondary to mobile LV thrombus and pulmonary embolism. Only contrast-enhanced CT chest and abdomen did not reveal any evidence of infection. Hence, ^{18}F-FDG PET-CT was done to rule out any occult infective focus which showed intense abnormal ^{18}F-FDG uptake (five-point visual grading score: 3) in the region of LV apex where the autologous pericardial patch repair for LV aneurysm was performed earlier [Figures 1-3]. No other significant metabolically active disease was noted in the whole-body survey. The pericardial patch repair was done 9 years back; hence, the question of postsurgical inflammation/granuloma formation was not considered. The repeat blood culture revealed MRSA bacteremia; hence, cardiac patch repair infection was confirmed, and the patient was treated with appropriate broad-spectrum antibiotics which resolved his symptoms gradually. The follow-up blood culture showed no growth after the treatment. ^{18}F-FDG PET-CT plays a vital role to create an evidence-based localization of the source of infection, to rule out other causes of fever and for accurate management of the patient.

Case 2

A 57-year-old man presented with a history of intermittent high-grade fever associated with chills of 10-day duration along with left upper quadrant abdominal pain for 3 days. He had hypertension for 17 years, diabetes for 1 year, and no history of chest pain or dyspnea. He underwent aortic root replacement (Bentall's procedure) with pericardiectomy 9 years ago for a bicuspid aortic valve with aortic stenosis and aneurysm of ascending aorta.

After initial workup, transesophageal echo (TEE) showed vegetation attached to the prosthetic aortic valve. Blood culture showed growth of *Streptococcus mitis*. Even though the diagnosis was already confirmed with TEE and positive blood culture reports, ^{18}F-FDG PET-CT was done to look for septic foci elsewhere in the body and rule out possible vasculitis. ^{18}F-FDG PET-CT showed patchy hypermetabolic focus around the prosthetic aortic valve and linear hypermetabolic

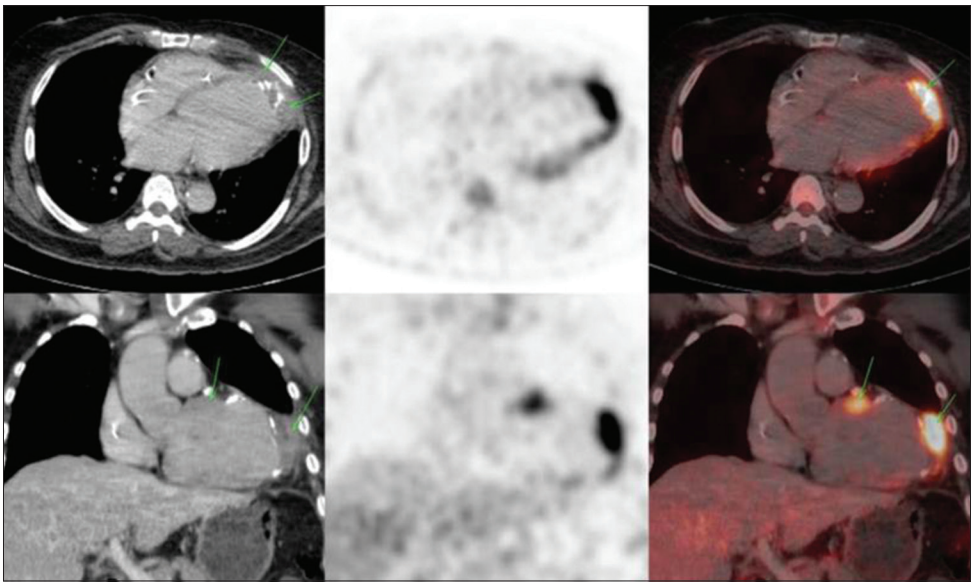

Figure 2: Axial and coronal sections of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography image showing intense diffuse abnormal ^{18}F-fluorodeoxyglucose uptake in the region of the left ventricular apex where the autologous pericardial patch repair for left ventricular aneurysm was done. Physiological fluorodeoxyglucose uptake in the base of the left ventricular myocardium is also seen

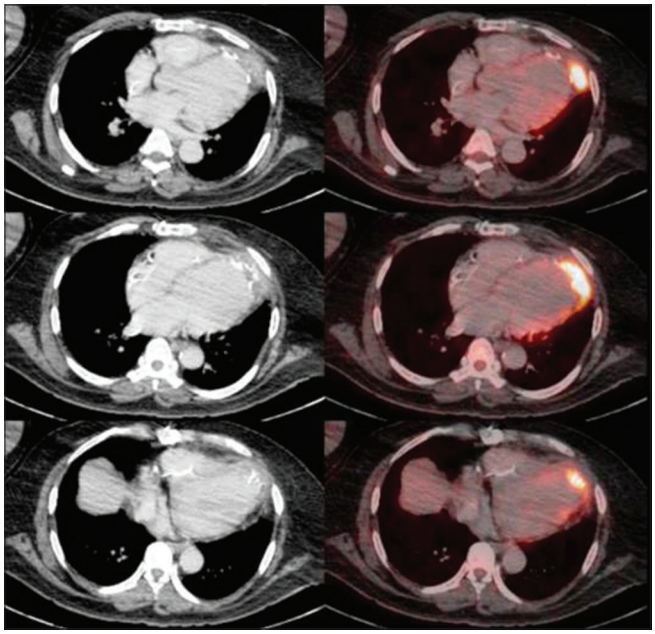

Figure 3: Axial sections of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography image showing intense diffuse abnormal ^{18}F-fluorodeoxyglucose uptake in the region of the left ventricular apex where the autologous pericardial patch repair for left ventricular aneurysm was done. Faint diffuse physiological fluorodeoxyglucose uptake in the left ventricular myocardium is also seen

focus along the ascending aortic graft with FDG-avid left supraclavicular and mediastinal nodes (five-point visual grading score: 4). No obvious morphological changes were noted in the stand-alone contrast-enhanced CT. Peripherally FDG-avid hypodense lesions were seen in the spleen, suggestive of splenic infarcts secondary to microembolism. Since the aortic root replacement procedure was done 9 years back, the question of immediate postsurgical inflammation was not a priority. The follow-up ^{18}F-FDG PET-CT after appropriate treatment showed resolution of the hypermetabolic foci around the prosthetic aortic valve and ascending aortic graft, creating an evidence-based record of a good response to therapy and retrospectively confirming the infective etiology [Figures 4 and 5]. This case illustrates that ^{18}F-FDG PET-CT could aid the treating physician in monitoring the progression or regression of disease in response to therapy.

Case 3

A 66-year-old man presented with lower abdominal pain and backache of 5-day duration, with a history of nausea. There was no history of chest pain or dyspnea. Comorbid conditions were diabetes for 7 years, hypertension for 10 years, and coronary artery disease for 4 years. He had a history of percutaneous angioplasty done 5 years back and infrarenal abdominal aortic aneurysm, for which he underwent repair with vascular prosthetic graft (polytetrafluoroethylene) 2 years ago. Initial contrast-enhanced CT imaging showed evidence of right infrarenal para-anastomotic pseudoaneurysm with focal eccentric thrombus. Blood culture showed growth of staphylococci. ^{18}F-FDG PET-CT was done to look for septic foci elsewhere in the body and rule out possible vasculitis. ^{18}F-FDG PET-CT showed circumferentially FDG-avid saccular outpouching with soft-tissue thickening and diffuse fat stranding around the prosthetic aortic graft extending from D11 to L2 vertebral level (five-point visual grading score: 5) and hypermetabolic tortuous graft involving both common iliac arteries [Figures 6-9]. ^{18}F-FDG PET-CT confirmed the

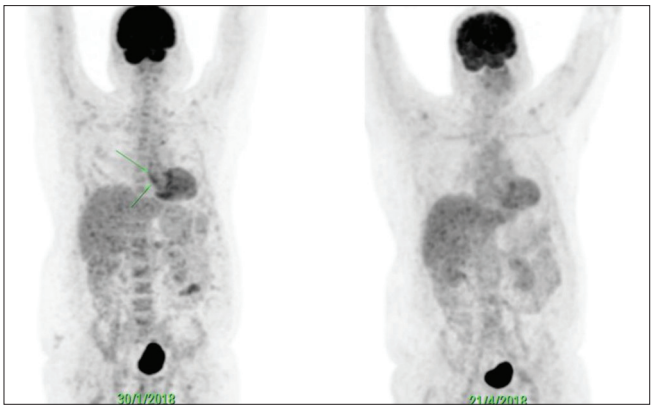

Figure 4: Maximum intensity projection images of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography showing patchy hypermetabolic focus around the prosthetic aortic valve and root of the ascending aorta. Follow-up imaging done 3 months later shows resolution of hypermetabolic focus around the prosthetic aortic valve and root of the ascending aorta

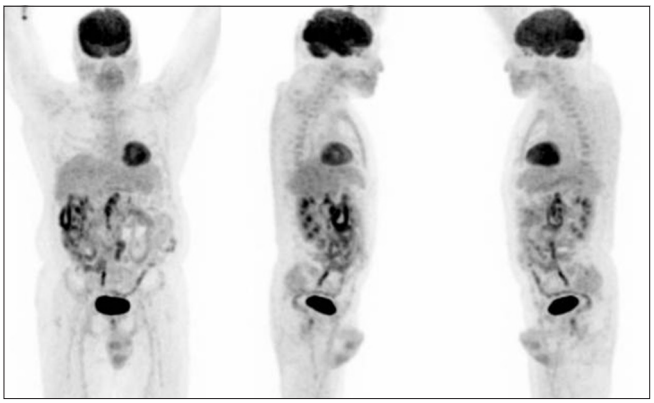

Figure 6: ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography maximum intensity projection image showing abnormal heterogeneous fluorodeoxyglucose uptake in the saccular outpouching surrounding the prosthetic aortic graft extending from D11 to L2 level (Five-point visual grading score – 5) and hypermetabolic tortuous graft involving both common iliac arteries

source of infection only in the prosthetic grafts, ruled out vasculitis, and aided the treatment to be focused accordingly.

DISCUSSION

In the three different case scenarios as described above, the infective foci are localized in different types of vascular grafts including the one with an autologous pericardial patch. The point to stress is that all the three patients had undergone vascular interventional procedures many years back and presented with heterogeneous nonspecific symptoms which were insufficient to direct the clinical diagnosis toward VGI.

The various investigations to evaluate VGI are laboratory parameters such as elevated infection markers in the blood such as erythrocyte sedimentation rate, white blood cell count

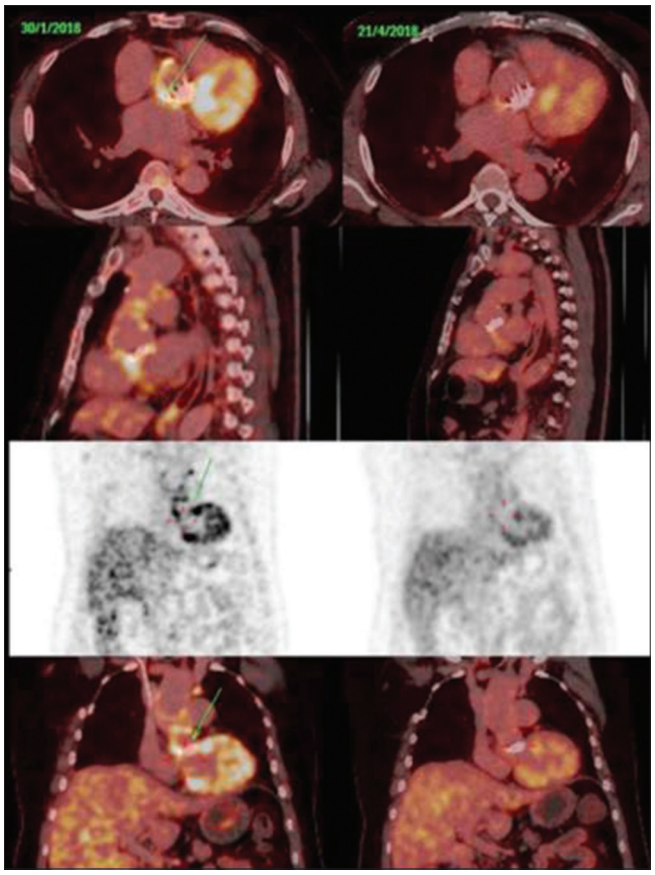

Figure 5: Comparison views of axial, sagittal, and coronal sections of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography image showing resolution of patchy hypermetabolic focus around the prosthetic aortic valve and root of the ascending aorta in follow-up imaging

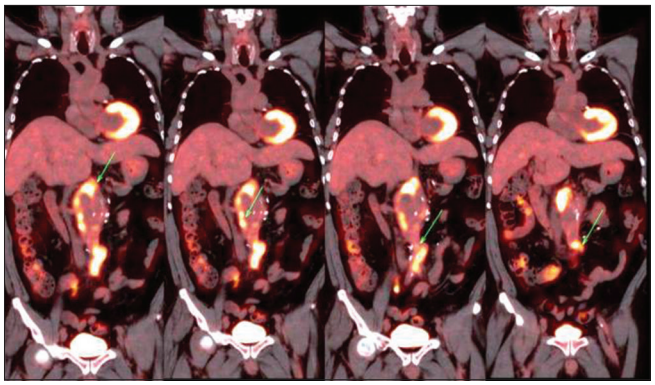

Figure 7: Coronal sections of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography image showing circumferentially fluorodeoxyglucose-avid saccular outpouching with soft-tissue thickening and diffuse fat stranding around the prosthetic aortic graft extending from D11 to L2 level and hypermetabolic tortuous graft involving both common iliac arteries

and C-reactive protein, ultrasound Doppler, CT imaging, and MRI. However, the predictive value for diagnosing VGI with these diagnostic tools has proven to be relatively low.[5] To date, CT is considered to be the gold standard for diagnosing

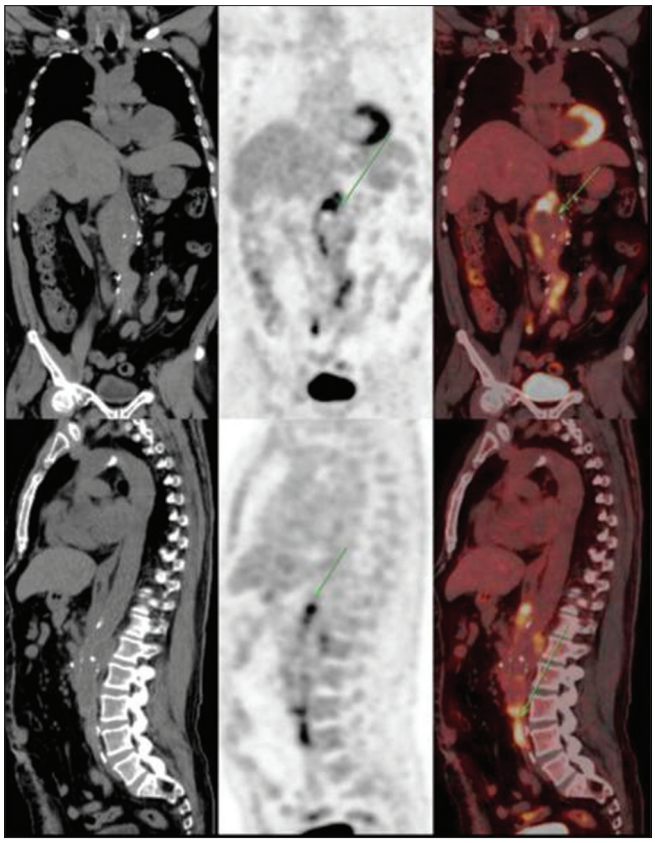

Figure 8: Coronal and sagittal sections of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography image showing circumferentially fluorodeoxyglucose-avid saccular outpouching with soft-tissue thickening and diffuse fat stranding around the prosthetic aortic graft extending from D11 to L2 level and hypermetabolic tortuous graft involving both common iliac arteries

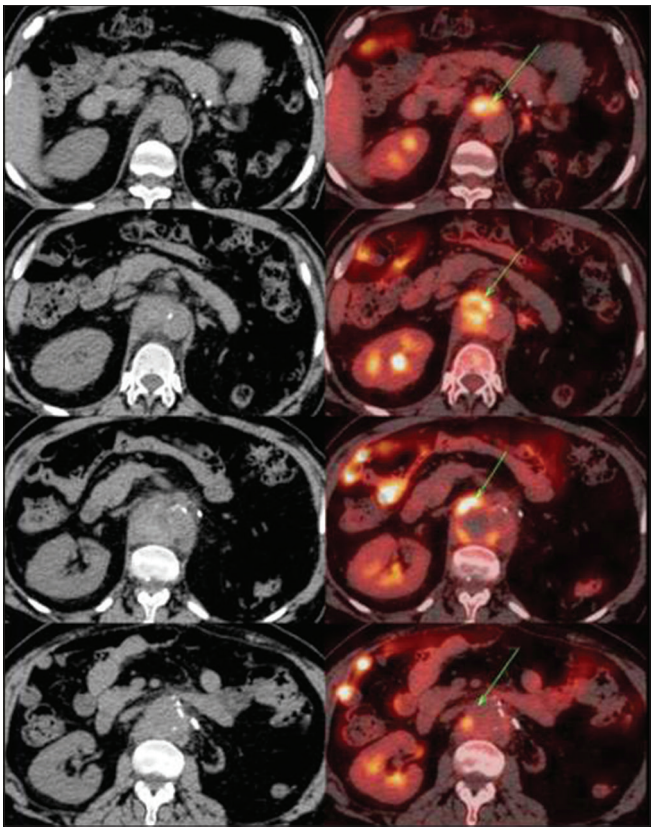

Figure 9: Axial sections of ^{18}F-fluorodeoxyglucose positron emission tomography with contrast-enhanced computed tomography image showing circumferentially fluorodeoxyglucose-avid saccular outpouching with soft-tissue thickening and diffuse fat stranding around the prosthetic aortic graft extending from D11 to L2 level and hypermetabolic tortuous graft involving both common iliac arteries

VGI because of its high spatial resolution providing a detailed view of the vascular structures and perivascular spaces. The presence of fluid collection, perigraft soft-tissue thickening, pseudoaneurysm and focal thickening with air pockets, and thickening of the graft wall with adjacent fat stranding are considered to be the important diagnostic signs for VGI,[6] though these findings are present in just 50% of VGI cases and are even considered normal findings in the early postoperative period. The sensitivity and specificity of only a CT scan were claimed to be 95%, but this high percentage is seen only in cases with a high clinical suspicion of VGI.[7-9] Hence, the reliability of CT scan in cases of low-grade and/or less severe infection is low, which reduces the sensitivity and specificity of 55% and 100%, respectively.[10-12]

As the metabolic change precedes the anatomic change, the increase in glucose metabolism may be detected much earlier and in less severe stages of infectious processes by ^{18}F-FDG PET-CT. The anatomical changes such as graft thickening, perigraft soft-tissue enhancement, pseudoaneurysm formation, or air pockets could be picked up easily when an additional contrast-enhanced CT is performed. A sound knowledge in typical FDG uptake patterns of foreign body reactions,[13] such as mildly increased diffuse FDG uptake and no focal abnormal FDG uptake along the graft, and adding the value of subjective image scoring methods might prevent false-positive image interpretation and improve the specificity as well. We followed a semi-quantitative assessment using a five-point visual grading score as described by Sah *et al*.,[14] which took into account the FDG uptake patterns and CT information as follows: Grade 1, normal background activity; Grade 2, mildly increased but diffuse FDG uptake along the graft (uptake less than twice the blood pool activity in the ascending aorta); Grade 3, focal but only mild FDG uptake or strong diffuse FDG uptake along the graft; Grade 4, focal and intense FDG uptake (± diffuse FDG uptake along the graft); and Grade 5, focal and intense FDG uptake plus fluid collections/abscess formation. Score values of 3, 4, and 5 were considered to be positive for graft infection and score values of 1 and 2 as negative. Semi-quantitative measurements of metabolic activity in all the grafts were also calculated as standardized uptake value max which can

be used in case of follow-up imaging with PET-CT. ^{18}F-FDG PET-CT also has some intrinsic advantages over conventional scintigraphic planar and single-photon emission CT-CT imaging with Tc-99m HMPAO-labeled white blood cells for VGI in terms of higher spatial resolution, higher sensitivity, a good target-to-background ratio, less laborious, and time-consuming than white blood cell scintigraphy.

Nevertheless, even if ^{18}F-FDG PET-CT is normal in symptomatic patients with prosthetic grafts and patches, the clinical suspicion of graft or patch infection should be considered by the treating physician in correlation with laboratory parameters unless proven otherwise. A false-negative ^{18}F-FDG PET-CT is always a possibility, especially in diabetic patients. FDG as a marker of increased intracellular glucose metabolism is taken up by malignant as well as infectious and inflammatory processes. As a result, FDG uptake is increased not only in infection but also in many other conditions. Therefore, in the process of using FDG uptake to diagnose an infection, the risk of a false-positive result also exists.

CONCLUSION

Patients with VGI constitute a heterogeneous population with multiple causal micro-organisms, with a wide array of prosthetic materials used and variable sites of localization of infection. This case series shows the vital and incremental role of ^{18}F-FDG PET-CT imaging to provide a higher accuracy for diagnosing unsuspected vascular graft/patch infections and in follow-up response assessment as compared with stand-alone CT, especially in patients with challenging clinical dilemma and with a history of vascular intervention done many years back.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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