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EDITORIAL

Pattern recognition on fluorodeoxyglucose positron emission tomography/computed tomography in infective endocarditis: within the normal limits?

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This editorial refers to 'Morpho-metabolic post-surgical patterns of non-infected prosthetic heart valves by [^{18}F]FDG PET/CTA: "normality" is a possible diagnosis', by A. Roque *et al.*, pp. 24–33.

During the last years, multimodality molecular imaging has been progressively increased the clinical indication in cardiovascular disease, moving from the historical horizon of coronary artery disease into the arena of cardiovascular infection and inflammation.

Technical developments have been relatively fast and resulted into a new-concept development widened the scope of what imaging as a single technology can enable in terms of patients' management. The introduction of positron emission computed tomography with ^{18}F-fluorodeoxyglucose positron emission tomography/computed tomography ([^{18}F]FDG PET/CT) in the clinical work-up of patients with infective endocarditis (IE) represents a successful story based on the integration of image data across different modalities and fusion of the available information. [^{18}F]FDG PET/CT has shown to significantly improved the diagnostic yield in the prosthetic valve endocarditis (PVE).[1–3] Consequently, the [^{18}F]FDG PET/CT has been incorporated in the diagnostic algorithm of PVE in the latest European Society of Cardiology (ESC) Guidelines for the management of IE.[4]

Whole-body [^{18}F]FDG PET/CT has also emerged as an excellent tool in the detection of septic embolism or metastatic infections, in the management of cardiovascular implantable electronic device infection[3] and, finally for prognostic assessment in IE.[5]

However, interpretation of [^{18}F]FDG PET/CT findings with regard to what is to be considered normal and knowledge of the potential confounders is not yet fully established. From the application in daily routine, it has become clear that [^{18}F]FDG PET/CT findings should always be correlated to clinical and other diagnostic findings and, as also recommended in the ESC guidelines need a discussion in a multidisciplinary 'Endocarditis Team'.[4,6] Indeed, the proper interpretation of [^{18}F]FDG PET/CT findings requires profound knowledge of the patients clinical situation, which include the microbiological results and the ongoing anti-microbiotic treatment(s),[7] the 'valve'surgical history, starting from the time of the first surgical procedure to the subsequent procedures, including the used materials and potential surgical-related complications, factors that all significantly may affect the intensity of [^{18}F]FDG uptake.[8] For the latter, the ESC Guidelines suggest delaying PET/computed tomography angiography (CTA) until 3 months after surgery.[4] However, one recent study suggests that when appropriate criteria of imaging interpretation are applied, the number of false-positive scans performed early after surgery is very low.[8] Literature is very scarce on data on [^{18}F]FDG uptake pattern in non-infected prosthetic valves.

Roque *et al.*[9] published in this issue reinforce our understanding of the concept of normal finding on [^{18}F]FDG PET. In this study, they prospectively evaluated patients without suspected infection who underwent serial cardiac PET/CTA examinations at 1, 6, and 12 months after surgery. The [^{18}F]FDG uptake distribution pattern and anatomic changes were evaluated. Their results show no significant differences in [^{18}F]FDG distribution or uptake values between 1, 6, or 12 months. No abnormal anatomic changes or endocarditis lesions were detected in any patient during follow-up, meaning that the recommended 3-month safety period could maybe be reconsidered to be shortened, in which [^{18}F]FDG PET findings are assigned as 'within the normal limits'. The demonstration of a typical pattern of [^{18}F]FDG uptake in (recently) implanted normal Prosthetic valves, as result of post-operative inflammation represents a step towards a more harmonized and standardized image interpretations.[10,11] From a pathophysiology perspective, it is extremely common feature of

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Table 1 Procedural pitfalls and recommendations of FDG PET/CT imaging in infective endocarditis (IE) and cardiac implantable electronic device (CIED) infection

	FDG PET/CT in IE and CIED infection		
	Confounding factors	**Pitfalls**	**Recommendations**
False positive	Surgical procedure	• Duration procedure • Recent valve implantation • Surgical adhesives • Complications	• Information procedure needed
	Pathological conditions	• Lipomatous hypertrophy of the interatrial septum, thrombi, vasculitis, tumour metastases, atherosclerotic plaques, and marantic IE	• Excluding non-infectious causes • Proper use of the combined CT • Learning curve
False positive or false negative	Patient preparation	• Physiological myocardial uptake: false positive or negative (masked)	• Optimal procedural preparation: fasting and low-carbohydrate diet (±heparin i.v.)
	PET technical procedure	• Motion artefacts • Metal artefacts (CIED, dense PHV) and over-correction due to beam hardening • Mismatch PET and CT fusion	• Proper quality check images
	PET imaging reading	• No standardized qualitative and quantitative scoring method	• Standard procedures (EANM), reproducibility warranted
False negative	PET imaging reading	• Isolated, small, or mobile vegetations due to limited temporal and spatial resolution • NVP	• Need for a multimodality approach in which each imaging modality covers the other's possible shortcomings

every early post-operative setting, yet not unsurprising that such uptake occurred in early surgical valve implants. However, [^{18}F]FDG uptake in inflammatory cells is just one of the (several) potential pitfalls (see *Table 1*). Despite obtained in a relatively small number of patients and decontextualized from any clinical setting, these results have the power to reinforce the need for continued engagement for unsolved issues to transform PET/CT image interpretation in IE from a purely qualitative task to one that is reproducible and into clinically meaningful outcomes. In fact, while we still have to solve technical challenges to harmonize and standardize image acquisition protocols, quantification approaches, and reporting/scoring systems, we also have to work to improve the available PET/CT for a vast majority of patients. This also includes quick access to PET/CT procedures, availability also for critical patients, quick decision-making through comprehensive multimodality imaging and clinical data integration, with the ultimate goal of modify the unacceptable high mortality of patients with IE.

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