Diagnosis of Vascular Prosthesis Infection: PET or SPECT?

The well-established gold standard for imaging infection is scintigraphy with radiolabeled autologous white blood cells (WBCs). Indeed, 2 years ago, in a metaanalysis of all papers published in the previous 20 years on imaging techniques for the diagnosis of infection (1–4), the importance of WBC scanning in this field clearly emerged, with few exceptions. In particular, for the diagnosis of vascular graft infection, although scintigraphy with WBCs was found to be most accurate, the authors concluded that the new hybrid modalities SPECT/CT and PET/CT would have highly enhanced the use of WBCs and diagnosis or follow-up of many inflammatory diseases. Because $^{18}$F-FDG is not specific for infection but is taken up by inflammatory cells with high glucose metabolism (5), many investigators have suggested the use of $^{18}$F-FDG PET for detecting infection and, in particular, for evaluating suspected vascular graft infections (6–16). For example, in a patient with infection after orthopedic surgery, $^{18}$F-FDG PET also revealed an aortic valve infection (17). Unfortunately, because many of the studies on this topic have been case reports or have included few patients, it is not yet possible to accurately assess the value of $^{18}$F-FDG PET in the diagnosis of vascular graft infection. Similarly, it is difficult to draw any conclusions about the best image acquisition times, interpretation criteria, and methods of quantitative analysis.

Nevertheless, the data accumulated so far allow us to pose a few considerations.

CT—With its excellent spatial resolution, widespread availability, and high sensitivity—has been the first-line imaging method for assessing graft infection. Infections that are of low grade or in the early stages, the sensitivity of CT decreases because of morphologic changes preventing inflammation from being distinguished from noninflammatory changes, such as those after surgery or due to scarring or therapy (14,18). Today, scintigraphy with autologous WBCs labeled with $^{11}$In-oxine or $^{99m}$Tc-hexamethylpropylene amine oxime–WBC proposed acquisitions only within 2 h after the injection of the labeled leukocytes (21). For PET studies, some authors have suggested that images be acquired early (30 min after injection) and others have also suggested dual imaging (acquiring the first image within 1 h and the second image at about 2 h) to differentiate between inflammation and tumors or infection. Abnormal uptake of $^{18}$F-FDG is often found in vasculitis, giant-cell arteritis, Takayasu’s arteritis, venous thrombosis, retroperitoneal fibrosis, and aseptic inflammation (14,20). In addition, asymptomatic and elderly patients may present with increased $^{18}$F-FDG uptake in the lamina muscularis of large vessels or in atherosclerotic plaques.

$^{18}$F-FDG, respectively, allowing precise localization of abnormal uptake in the vascular graft. Thus, the possibility of exact anatomic localization of pathologic uptake seems as important as the choice of radiopharmaceutical. However, 2 other important factors remain to be validated when a technique is proposed for in vivo diagnosis of infection: standardization of image acquisition times and standardization of image interpretation criteria, including quantitative and semiquantitative measurements.

During the last few years, $^{18}$F-FDG PET has been widely used for the...
because of the presence of macrophages (22).

Another important aspect is the time from surgery: In the early phases of healing and, frequently, in the first months after surgery, 18F-FDG may give false-positive results. Other examinations must then be performed within the following days or weeks to prove a local decrease or increase of 18F-FDG uptake. Moreover, about 40% of infections in graft prostheses appear within 4 mo after surgery (23). If imaging is required early after surgery, WBC scintigraphy would therefore seem to be more accurate than 18F-FDG PET (21).

Unfortunately, as far as quantitative measurement of 18F-FDG uptake is concerned, few papers have been published. Some authors have proposed a progressively increasing 5-point scale based on visual analysis of 18F-FDG uptake (7,15), but this method appears to be quite observer-dependent. Still, some work should be done in this direction. Certainly, combining CT with 18F-FDG PET increases its specificity (9,11,14,24,25). If we compare all published data on the use of 18F-FDG PET in vascular graft infections (Table 1), it emerges that the combined use of PET and CT improves diagnostic accuracy (in particular, reduces the rate of false-positive cases) by allowing image interpretation based on morphologic criteria. A valid alternative to PET/CT may be SPECT/CT with labeled WBCs. The usefulness of this hybrid method has recently been demonstrated for bone and joint infections (26,27), although the literature currently includes only one case report on vascular prosthesis infection (28).

In light of the cumulated evidence, scintigraphy with radiolabeled WBCs should still be considered the gold standard for imaging vascular graft infection—particularly when improved by the use of a SPECT/CT camera—because of the extensive validation of the radiopharmaceutical, image acquisition modality, and image interpretation criteria (1). PET and PET/CT with 18F-FDG may well become a valid substitute for WBC scintigraphy, provided that large clinical trials validate the best acquisition times and the most reliable imaging analysis and interpretation criteria. The paper by Keidar et al. (29) in this issue of The Journal of Nuclear Medicine represents a well-designed attempt to achieve such standardization, and similar works are encouraged.

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**Table 1**

Summary of Published Studies Using 18F-FDG in Vascular Graft Infection

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>No. of patients</th>
<th>Method</th>
<th>18F-FDG dose (MBq)</th>
<th>Acquisition time (minutes after injection)</th>
<th>Interpretation criteria</th>
<th>True-positive</th>
<th>True-negative</th>
<th>False-positive</th>
<th>False-negative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stumpe (7)</td>
<td>2000</td>
<td>7</td>
<td>PET</td>
<td>300–400</td>
<td>30–40</td>
<td>Qualitative</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Krupnick (12)</td>
<td>2003</td>
<td>1</td>
<td>PET</td>
<td>187</td>
<td>50</td>
<td>Qualitative</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Chacko (8)</td>
<td>2003</td>
<td>3</td>
<td>PET</td>
<td>2.55/kg</td>
<td>60</td>
<td>Qualitative</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Keidar (11)</td>
<td>2003</td>
<td>1</td>
<td>PET/CT</td>
<td>370</td>
<td>60</td>
<td>Qualitative</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Städler (14)</td>
<td>2004</td>
<td>1</td>
<td>PET/CT</td>
<td>375</td>
<td>90</td>
<td>Qualitative</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Fukuchi (15)</td>
<td>2005</td>
<td>33</td>
<td>PET</td>
<td>185</td>
<td>60</td>
<td>Semiquantitative</td>
<td>10</td>
<td>14</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td>Jaruskova (9)</td>
<td>2006</td>
<td>7</td>
<td>PET/CT</td>
<td>279–717</td>
<td>40–165 (mean, 70)</td>
<td>Qualitative</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Tsenekawa (16)</td>
<td>2007</td>
<td>1</td>
<td>PET</td>
<td>185</td>
<td>60</td>
<td>Qualitative</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Tejler (25)</td>
<td>2007</td>
<td>1</td>
<td>PET/CT</td>
<td>—</td>
<td>—</td>
<td>Qualitative</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Keidar (29)</td>
<td>2007</td>
<td>39</td>
<td>PET/CT</td>
<td>185–370</td>
<td>90</td>
<td>Qualitative based on morphology</td>
<td>14</td>
<td>22</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>

*Shows morphologic accuracy in detecting site of 18F-FDG uptake.

18F-FDG dose is usually related to image acquisition time.

Qualitative or quantitative interpretation may also depend on method used.

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**REFERENCES**

8. Chacko TK, Zhuang H, Nakhoda KZ, Moussavie B, Alavi A. Application of fluorodeoxyglucose...


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