Interesting layering of excreted $^{18}$F-FDG in the urinary bladder in patients with urinary tract infection and distended bladder

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Abstract

Settlement of fluorine-18 fluorodeoxyglucose ($^{18}$F-FDG) in the bladder is often noted in whole-body PET/CT images, but this phenomenon never received any careful attention and the mechanism was unclear. These two patients, including one with T1 pathological fracture and the other with widespread bone and lymph node metastases from an unknown primary tumor, underwent the PET/CT examination. They both had urinary tract infection and a distended bladder during scanning. The interesting layering of $^{18}$F-FDG in the urinary bladder was shown in both patients. Presence of this phenomenon demands careful evaluation of the urine by the clinician, and the mechanism is hypothesized to be because of slow $^{18}$F-FDG excretion in patients with a distended urinary bladder resulting in delayed mixing with urine. In addition, urinary tract infection may be a potential cause. The clinician should pay more attention to interpreting the imaging of bladder with interesting layering.

Keywords: $^{18}$F-FDG layering; positron emission tomography/computed tomography; urinary bladder
Introduction

Accumulation of $^{18}$F-FDG in the urinary bladder usually makes the evaluation of bladder lesions on PET/CT difficult. At our institution, urinary bladder activity is minimized by asking the patient to drink at least 500 ml of plain water and to void before image acquisition. However, the settlement of $^{18}$F-FDG in the urinary bladder is occasionally observed, which could impose an interpretation challenge, obscuring or simulating pathology (1). A recent study about intravenous contrast PET/CT stated that the higher specific gravity of the contrast material displaces the excreted $^{18}$F-FDG, resulting in anterior layering of the radiotracer (2). We report herein 2 patients with bladder layering of excreted $^{18}$F-FDG on PET/CT without intravenous contrast, and hypothesized that the phenomenon was mainly due to the delayed mixing of $^{18}$F-FDG excretion with nonradioactive urine in a distended bladder and the urinary tract infection; however, the mechanism needs to be further investigated in a more comprehensive study.

Case report

The first patient was a 63-year-old woman with neck and back pain and lower limbs weakness. She has undergone PET/CT examination, and the images showed that a pathological fracture in the first thoracic vertebrae. Occasionally, there was interesting layering of excreted $^{18}$F-FDG in the urinary bladder, showing $^{18}$F-FDG-loaded urine at the bottom of a distended bladder and clear urine at the top (Figure 1A). The combination of radiologic images and clinical examinations revealed no bladder abnormalities but indicated a urinary tract infection. The second patient, who was 67 years old and male
with fever of unknown origin, was diagnosed with widespread bone and lymph node metastases from an unknown primary tumor. In addition, he had a symptom of lung infection. A clear demarcation between the urine without $^{18}$F-FDG on the top in the bladder and $^{18}$F-FDG-loaded urine at the bottom is also shown (Figure 1B). We noted that the urinary bladder was full during scanning. All these two patients had clear symptoms of urinary tract infection and the urine examination revealed that the urine was cloudy with elevated cell counts, red blood cell counts, white blood cell counts, and total protein content. Urine analysis was also positive for bacteria and fungus. The relevant features are summarized in Table 1

**Discussion**

Several examples of urinary bladder layering have been reported (3-5). Carrington, BM et al described a characteristic appearance on computed tomography (CT), with urine that contains contrast medium and has a high specific gravity layering posteriorly in the dependent portion of the bladder, while lower specific gravity, non-opacified urine is found uppermost (3). Another study showed that anterior layering of excreted FDG in the bladder is commonly observed on PET/CT scans obtained with IV iodinated contrast material and is due to displacement of $^{18}$F-FDG by excreted iodinated contrast material with higher specific gravity (5).

However, these two patients in our study did not undergo CT or MRI examinations before the PET/CT evaluation, and the urine did not contain contrast medium. As mentioned above, they all had urinary tract infections, and this might be a potential cause
of the layering phenomenon. The metabolically active cellular component of the urine such as inflammatory cells, bacteria, and fungus uptakes the excreted $^{18}$F-FDG in the urine for their metabolism, and these cells settle to the bottom of the bladder because of gravity during PET scanning when a patient lies supine for some time (4). Some patients did not empty the bladder before the scanning and the bladder already had a considerable amount of urine with metabolically active cells, which subsequently received $^{18}$F-FDG-loaded urine during scanning. In addition, we also found that their urinary bladders were full during scanning, which indicated that bladder layering was associated with a distended bladder. In a distended bladder, delayed mixing of $^{18}$F-FDG excretion with nonradioactive urine served as a cause of the layering. Moreover, PET/CT images of patients with empty urinary bladder may also help in further answering this phenomenon, whereas the settlement sign seems to be better visualized in a full bladder.

To the best of authors’ understanding, there was no standard explanation or reason for the settlement of $^{18}$F-FDG in the urinary bladder, which may alert the clinicians to interpret the lesions of the bladder or near the bladder more carefully. We may infer that urinary tract infection and a distended bladder are capable of inducing urinary bladder layering; however, one hundred percent cause and effect relationship could not be established because of the limited number of cases and limited information. A definitive explanation needs to be further investigated with a larger prospective study involving the systematical analysis of urine examination, bladder volume, bladder pressure, and specific gravity in patients with layering compared with those without layering.
In conclusion, these two cases illustrate the interesting layering of $^{18}$F-FDG in the bladder, the causes of which might be urinary tract infection and a distended bladder; however, the mechanism needs to be further investigated in a more comprehensive study. Moreover, the presence of the settlement of $^{18}$F-FDG in the urinary bladder should be reported with the aim to alert the clinicians to look at the urine more carefully. All shades of clinical presentations are possible.

**Conflicts of interest**

The authors declare no conflict of interest.

**Acknowledgements**

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References


Figure 1. Images of computerized tomography (CT) (top), positron emission tomography (PET) (middle), and fused PET/CT (bottom) with layering of $^{18}$F-FDG in the bladder. (A) A 63-year-old female with T1 pathological fracture and urinary tract infection, (B) A 67-year-old man with widespread bone and lymph node metastases from an unknown primary tumor, also with urinary tract infection.
Table 1. Clinical and pathological details of these two patients

<table>
<thead>
<tr>
<th>Age/Sex</th>
<th>Diagnosis</th>
<th>Urine examination</th>
<th>UTI</th>
<th>HIV status</th>
<th>Other site of infection</th>
<th>Patient on antibiotics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 63/F</td>
<td>T1 pathological fracture+UTI</td>
<td>Turbid/Cloudy, Protein&gt;300mg/dl, Specific gravity&lt;1.01, WBC/HP&gt;5, RBC/HP&gt;3, bacteria/uL&gt;230</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>2 67/M</td>
<td>widespread bone and lymph node metastases from an unknown primary tumor+UTI</td>
<td>Turbid/Cloudy, WBC/HP&gt;5, RBC/HP&gt;3, bacteria/uL&gt;230</td>
<td>+</td>
<td>-</td>
<td>Pulmonary infection</td>
<td>+</td>
</tr>
</tbody>
</table>

F: female; M: male; T1: the first thoracic vertebrae; UTI: urinary tract infection; HIV: human immunodeficiency; +: present; -: absent; WBC: white blood cell; RBC: red blood cell;
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