**Abstract**

**Background:** Differentiation of vertebral metastases from Schmorl’s nodes, especially with fluorine-18-fluorodeoxyglucose (¹⁸F-FDG) uptake, is very important for the appropriate management of these patients in case they have malignancy. We aimed to evaluate the value of ¹⁸F-FDG positron emission tomography/computed tomography (PET/CT) in differentiating vertebral metastases from Schmorl’s nodes with ¹⁸F-FDG uptake. **Subjects and Methods:** Fourteen patients with malignancy underwent ¹⁸F-FDG PET/CT, which showed abnormal ¹⁸F-FDG uptake in 19 Schmorl’s nodes. Twenty one patients with vertebral metastases underwent ¹⁸F-FDG PET/CT, which showed abnormal ¹⁸F-FDG uptake in 28 vertebral metastatic lesions. All these Schmorl’s nodes and vertebral metastases were confirmed by pathology or by follow-up. The ¹⁸F-FDG PET/CT were retrospectively analyzed, including maximum standardized uptake value (SUVmax), the distribution characteristic of ¹⁸F-FDG and the size of these lesions in PET and CT. **Results:** The mean value of SUVmax of Schmorl’s nodes with ¹⁸F-FDG uptake were 5.7±2.8, while the mean value of SUVmax of vertebral metastases were 6.6±3.2. There were no significant differences in the SUVmax between Schmorl’s nodes and vertebral metastases. However, the ¹⁸F-FDG distribution in Schmorl’s nodes and vertebral metastases showed some differences. The ¹⁸F-FDG uptake in the borderline area surrounding the nucleus pulposus was higher in Schmorl’s nodes. The size of Schmorl’s nodes on PET was significantly smaller than that on CT. The size of vertebral metastases on PET was larger or similar with that on CT. **Conclusion:** Although the SUVmax in the Schmorl’s nodes and vertebral metastases was similar, the ¹⁸F-FDG distribution characteristic in PET/CT can help differentiating the vertebral metastases from Schmorl’s nodes.

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**Introduction**

Schmorl’s nodes were considered as a herniation of the nucleus pulposus through the cartilaginous and bony endplate into the vertebral body [1]. Schmorl’s nodes present most commonly as incidental findings in asymptomatic patients or in patients with back or radicular pain due to different etiologies [1]. It is essential for appropriate management to differentiate Schmorl’s nodes from vertebral metastases in case Schmorl’s nodes were demonstrated incidentally in patients with a history of malignancy. Spine is a common bone metastases site in patients with malignancy. However, the differential diagnosis of Schmorl’s nodes from vertebral metastases is still challenging in clinical practice.

Fluorine-18-fluorodeoxyglucose positron emission tomography/computed tomography (¹⁸F-FDG PET/CT) has been used in diagnosing and staging benign diseases [2], such as Schmorl’s node [3], and malignant diseases [4, 5], such as bone metastases [6]. Lin et al. (2012) reported that Schmorl’s nodes had low to moderate ¹⁸F-FDG PET/CT uptake, which could cause false positive results in patient with malignancy [3]. The aim of this study was to study the ¹⁸F-FDG PET/CT image and especially the ¹⁸F-FDG PET/CT distribution characteristics in differentiating vertebral metastases from Schmorl’s nodes.

**Case Report**

Between January 2009 and December 2014, 14 patients with a history of malignancy, 8 male and 6 female; mean age 58.7±10.8 years old were diagnosed with Schmorl’s nodes
(Schmorl's node group). The malignancies of this group included 4 patients with lung cancer, 3 with breast cancer, 3 with digestive system cancer, 2 with prostate cancer, 1 with liver cancer and 1 with ovarian cancer. During the same period, 21 patients also with a history of malignancy (11 male and 10 female, mean age 60.2±9.6 years) were diagnosed with vertebral metastases (vertebral metastases group). The malignancies of the vertebral metastases group included 7 patients with lung cancer, 4 with digestive system cancer, 3 with liver cancer, 3 with breast cancer, 2 with prostate cancer, 1 with ovarian cancer and 1 with nasopharyngeal cancer. The diagnosis of Schmorl’s nodes and vertebral metastases was based on pathology and/or follow-up. The follow-up time was between 6-42 months, mean 16.8±9.6 months. A physician could not differentiate vertebral metastases from Schmorl’s nodes before the $^{18}$F-FDG PET/CT scan. All these patients underwent the $^{18}$F-FDG PET/CT scan. The $^{18}$F-FDG PET/CT of Schmorl’s node group showed $^{18}$F-FDG uptake in the Schmorl’s node. The $^{18}$F-FDG PET/CT images were studied retrospectively, including qualitative and semi-quantitative analysis. This study was approved by the Beijing Friendship Hospital, Capital Medical University ethics committee.

$^{18}$F-FDG PET/CT imaging protocol and data analysis
Each patient was asked to fast for at least 6 hours before $^{18}$F-FDG PET/CT imaging. All scans were performed on a combined PET/CT scanner (Discovery LS; GE Healthcare, Milwau-kee, WI). Fluorine-18-FDG PET/CT images of each patient were acquired approximately 60min after the intravenous injection of $^{18}$F-FDG. In addition, their serum blood glucose levels were measured before the injection of $^{18}$F-FDG, and if the level of glucose was over 6.7mmol/L, the examination was deferred.

An unenhanced CT scan was performed first for PET attenuation correction and then PET data were acquired in two dimensional (2D) mode, for 3.5min of acquisition time per bed position. The CT images were reconstructed onto a 512×512 matrix with a section thickness of 3.75mm. Using the CT data for attenuation correction, the images were then reconstructed with an ordered set expectation maximization (OS-EM) algorithm. At the conclusion of the $^{18}$F-FDG PET/CT scan, all reconstructed image data were transferred to a workstation for clinical evaluation and also to a local server for lesion volume data analysis. The SUVmax of Schmorl’s nodules and vertebral metastases on $^{18}$F-FDG PET/CT images were recorded.

Imaging analysis and measurement of $^{18}$F-FDG PET/CT parameters
The $^{18}$F-FDG PET/CT images were assessed by two experienced nuclear medicine physicians. Any discrepancy was resolved by consensus. The SUVmax, distribution characteristics of Schmorl’s nodules and vertebral metastases of $^{18}$F-FDG PET/CT were compared and analyzed.

Statistical analysis
The average value of SUVmax on $^{18}$F-FDG PET/CT was expressed as mean±standard deviation (M±SD). The mean value of SUVmax of Schmorl’s nodes and vertebral metastases on the $^{18}$F-FDG PET/CT scan were compared using Wilcoxon’s rank-sum test. The distribution characteristics of Schmorl’s nodes and of vertebral metastases on the $^{18}$F-FDG PET/CT scan were compared. All statistical tests were performed by using SPSS 20.0 software (SPSS. Inc., Chicago, IL, USA).

Results

Patients characteristics
In the Schmorl’s nodes group, $^{18}$F-FDG PET/CT showed $^{18}$F-FDG uptake in 19 nodes of which 14 patients with malignancy. Eight of the 19 Schmorl’s nodes were located in the thoracic vertebrae and 11 in the lumbar vertebrae. Five of these patients had two Schmorl’s nodes and 9, a single Schmorl’s node. The mean value of SUVmax of Schmorl’s nodes with $^{18}$F-FDG uptake was 5.7±2.8.

In vertebral metastases group, $^{18}$F-FDG PET/CT showed $^{18}$F-FDG uptake in 28 vertebral metastases of 21 patients with malignancy. Seven patients had two vertebral metastases and 14 a single vertebral metastasis. The mean value of SUVmax of vertebral metastases were 6.6±3.2. There was no significant difference in the SUVmax between Schmorl’s nodes and vertebral metastases.

However, the $^{18}$F-FDG distribution characteristics in Schmorl’s nodes and vertebral metastases showed some differences. The $^{18}$F-FDG uptake in the borderline area surrounding the nucleus pulposus was higher than that of areas surrounding Schmorl’s node. The size of Schmorl’s nodes on the PET scan was significantly smaller than that on CT. Moreover, the higher $^{18}$F-FDG uptake of these borderline areas surrounding the Schmorl’s nodes were located around the nucleus pulposus (Figure 1). The size of vertebral metastases on the PET scan was larger or similar with that on CT (Figure 2).

Discussion

The differential diagnosis of Schmorl’s nodes from vertebral metastases is essential in patients with malignancy. Different diagnostic methods have been used in the differential diagnosis, including CT [7], MRI [8] or $^{18}$F-FDG PET/CT [3]. However, the differential diagnosis of the two diseases is still challenging in patients with malignancy. Previous studies have reported that Schmorl’s nodes caused a false positive result on the $^{18}$F-FDG PET/CT scan [3,9].

Based on the present study, the mean value of SUVmax of Schmorl’s nodes was similar with that of the vertebral metastases group. However, the $^{18}$F-FDG distribution characteristics in Schmorl’s nodes and vertebral metastases showed some differences.

Schmorl’s node is herniation of nucleus pulposus through the cartilaginous and bony end plate into the body of an ad-
Menon can explain the high F-FDG uptake in the border-line area surrounding the nucleus pulposus. Increased uptake and retention of F-FDG has been shown in high concentration of inflammatory cells lesions [14]. Any inflammatory process can demonstrate hypermetabolic activity on F-FDG PET/CT studies because of the high degree of glucose metabolism by inflammatory cells due to expression of high-concentration glucose transporters.

Bone metastases frequently happen in cancer patients. About 70% of patients with prostate cancer or breast cancer, and 15% to 30% of patients with colon, lung, bladder or renal cancer develop bone metastases [15]. Tumor cell dissemination to the bone is a complex process that involves reciprocal interplay between cancer cells, cells in the surrounding microenvironment, and the stroma itself [16]. Radiographic detection of bone metastases is most commonly performed by identifying sites of active bone remodeling [17]. Totally, the bone lesions arise as a function of the cancer/stroma interaction rather than as the detection of the cancer cells themselves. Bone metastases can be divided into osteolytic, osteoblastic, and/or of a mixed type. The destruction of bone by cancer cells is caused by the increasing number of osteoclasts rather than by the tumor cells [18]. In most bone destroying metastases, there is also an increase in new bone formation. Therefore, X-rays show a ring of new bone surrounding the destroyed bone [15]. In osteoblastic metastases, new bone formation is the primary feature. Therefore, the size of vertebral metastases on PET is larger or similar with that on CT. The images of PET almost overlapped completely that of CT in vertebral metastases lesion. It is well known that the F-FDG PET has a higher sensitivity in the detection of osteolytic bone metastases and lower sensitivity in osteoblastic bone metastases compared with bone scan [19]. Recently, Uchida K et al. (2013) reported that PET in PET/CT could be a substitute for bone scan regarding the evaluation of spinal metastases, especially for patients with spinal osteolytic lesions identified by CT. With the increased application of whole-body F-FDG PET/CT for the staging and follow-up of malignant disease, it is our opinion that F-FDG PET/CT may support the diagnosis of Schmorl’s nodes as related to vertebral metastases.

We recognized several limitations of this study. Firstly, this was a retrospective study with a small number of patients. Secondly, bone metastases included the osteolytic, osteoblastic, or mixed lesions. We know that F-FDG PET/CT is more sensitive in detecting osteolytic or mixed lesions than the osteoblastic lesions [20]. Lytic lesions induce continuous bone removal and increased activity of tumor cells invasion with lysosomal enzymes, which act as osteoclastic process. In contrast, sclerotic lesions like fibrosis or collagen deposits do not contain many cells which can take up F-FDG. Thirdly, some bone metastases were diagnosed by follow-up, not by pathology, which may influence the results. At the same time, we did not study the related findings in old or recent disc prolapse. Multicenter prospective studies with a larger number of patients are needed to confirm the result of the present study.

Figure 1. A 50 years old man with the history of lung cancer was diagnosed with Schmorl’s nodes based on the F-FDG PET/CT. The SUVmax of the Schmorl’s nodes was 4.3. The size of Schmorl’s nodes on PET (thin arrow in B) was smaller than that on CT (thick arrow in A). Moreover, the high 18F-FDG uptake of Schmorl’s node was located on the inferior borderline area surrounding the nucleus pulposus (thin arrow in C).

Figure 2. A 55 years old female with the history of breast cancer was diagnosed with vertebral metastases based on 18F-FDG PET/CT. The SUVmax of the Schmorl’s nodes was 5.4. The size of vertebral metastases on PET (thin arrow in B) was similar with that on CT (thick arrow in A). The image of PET almost overlapped to that of CT (thin and thick arrows in C).

A 55 years old female with the history of breast cancer was diagnosed with Schmorl’s nodes based on the 18F-FDG PET/CT. The SUVmax of the Schmorl’s nodes was 4.3. The size of Schmorl’s nodes on PET (thin arrow in B) was smaller than that on CT (thick arrow in A). Moreover, the high 18F-FDG uptake of Schmorl’s node was located on the inferior borderline area surrounding the nucleus pulposus (thin arrow in C).

A 50 years old man with the history of lung cancer was diagnosed with Schmorl’s nodes based on the 18F-FDG PET/CT. The SUVmax of the Schmorl’s nodes was 4.3. The size of Schmorl’s nodes on PET (thin arrow in B) was smaller than that on CT (thick arrow in A). Moreover, the high 18F-FDG uptake of Schmorl’s node was located on the inferior borderline area surrounding the nucleus pulposus (thin arrow in C).
In conclusion, although the SUVmax in the Schmorl’s nodes and in vertebral metastases was similar, the $^{18}$F-FDG distribution characteristic in PET/CT can help differentiate the vertebral metastases from Schmorl’s nodes.

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The authors declare that they have no conflicts of interest

Bibliography