Stereotactically Inserted Tube-Guided Brain Biopsy Using Positron Emission Tomography and Magnetic Resonance Coregistered Images

—Case Report—

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Abstract

A 53-year-old man presented with malignant lymphoma manifesting as disturbances of walking and standing. Magnetic resonance (MR) imaging showed multifocal bifrontal lesions which were enhanced by gadolinium-diethylenetriaminepenta-acetic acid. Positron emission tomography (PET) with [18F]fluorodeoxyglucose showed high uptake of tracer in the lesion. The PET-MR coregistered image was used to determine the biopsy target. After right frontal craniotomy, a sterilized probe controlled by a neuronavigation system was directly passed into the tumor, and a guide tube was inserted along the same track. After dura opening, a small corticotomy was performed along the guide tube track and the tumor was biopsied. Histological examination revealed malignant lymphoma. The stereotactically inserted tube-guided brain biopsy was less invasive and provided an accurate diagnosis. The PET-MR coregistered image was helpful for determining the most active lesion of the brain tumor.

Key words: positron emission tomography, fluorodeoxyglucose, neuronavigation, malignant lymphoma, stereotactic biopsy

Introduction

Stereotactic procedures based on magnetic resonance (MR) imaging are commonly used to biopsy intracranial lesions.7,8) These techniques are anatomically very accurate, but fail, even in experienced hands, to provide a pathological diagnosis in approximately 5% of patients.1) The relative lack of accuracy in stereotactic biopsy is mainly due to an insufficient number of samples or inadequate localization. The neuronavigation system is now widely used in neurosurgery for tumor biopsy with good accuracy.5) However, misdiagnosis may occur because of brain shift during surgery. Biopsy based on neuronavigation systems may provide inaccurate diagnosis or underestimation of histological grading. Stereotactic biopsy based on positron emission tomography (PET) with [18F]fluorodeoxyglucose ([18F]FDG) is also useful for accurately identifying brain tumor.11,14) [18F]FDG PET is clinically useful for evaluating patients with brain tumor11,15) and provides independent metabolic information that may be helpful in determining the degree of malignancy.

Here, we present a case of malignant lymphoma biopsied under guidance of a tube stereotactically inserted using a neuronavigation system. The PET and MR images were coregistered to determine the accurate target position.

Case Report

A 53-year-old man was treated in another hospital for depression. The patient came to our hospital because of continuous disturbance of walking and standing. On admission, the patient had slight right hemiparesis and memory disturbance.

T1-weighted MR imaging with gadolinium-diethylenetriaminepenta-acetic acid (Gd-DTPA) showed multifocal bifrontal enhanced mass lesions (Fig. 1A). [18F]FDG PET was performed using an ECAT EXACT HR camera (Siemens Medical Solutions, Knoxville, Tenn., U.S.A.), which covers the whole brain within 47 slices at a spatial resolution of 4.5 mm (Fig. 1B). 185 MBq FDG was injected
intravenously and a total of 23 frames of data were acquired. PET was performed with 1-hour dynamic acquisition.

The image obtained from PET was coregistered with the T1-weighted MR image with Gd-DTPA (Fig. 1C). The coregistered image showed heterogeneous tracer uptake within the contrast-enhanced lesion. The right frontal mass lesion was targeted for biopsy because of the higher uptake of tracer, and was closer to the surface of brain.

Right frontal craniotomy was performed. A sterilized probe was inserted into the tumor before dura opening using the Stealth neuronavigation system (Medtronic Sofamor Danek, Louisvi, Colo., U.S.A.) under guidance by MR imaging with Gd-DTPA (Fig. 2), and a guide tube was inserted along the track. Methylrosaniline chloride was injected into the guide tube to mark the location of the top of
the tube. After dura opening, a small corticotomy was performed along the guide tube track which reached the mass lesion without disorientation (Fig. 3). Histological examination of the specimens from the mass lesion showed diffuse large B cell lymphoma, whereas the specimens outside the lesion which showed high uptake of $[^{18}F]$FDG contained no tumor cells.

Postoperative computed tomography showed no hemorrhage around the biopsy site. The patient received two courses of chemotherapy and subsequent external irradiation therapy. Follow-up MR imaging showed the tumor had almost completely disappeared.

**Discussion**

This case demonstrates that stereotactically inserted tube-guided biopsy is clinically useful to achieve accurate diagnosis with reduced surgical invasion. The PET and MR coregistered image was helpful to determine the biopsy target. Cranial neuronavigation is mainly used for intraoperative anatomical orientation, and MR imaging is the best imaging modality. However, enhanced MR imaging sometimes cannot distinguish between tumor and gliosis.\(^2\)

The $[^{18}F]$FDG PET technique is helpful for assessing the degree of malignancy and the prognosis of a brain tumor independently of the histological grading.\(^5\)$[^{18}F]$FDG PET can also help to differentiate the effects of various treatments and to assess tumor persistence, progression, or recurrence.\(^4\)

Therefore, the PET-guided stereotactic biopsy technique is expected to improve the results of stereotactic biopsies of intracranial tumors.

Lymphoma in the central nervous system (CNS) is a collection of diseases involving malignant transformation, usually of the B lymphocyte. In recent years, the number of patients suffering from CNS lymphoma has increased, partly due to the increase in immunocompromised patients, including those with acquired immunodeficiency syndrome and those undergoing chemotherapy or organ transplantation.\(^9\)$[^{18}F]$FDG PET is useful for diagnosing and staging lymphoma patients,\(^13,15\) because the tumors rely on a substrate of glucose for energy production and replication.

In this case, the PET-MR coregistered image showed that the specimens outside the lesion had no signs of tumor invasion and that the histology would be same in the whole lesion. Therefore, PET might not be necessary in this case. PET-MR coregistered images are most likely to be useful for tumors such as malignant glioma, in which tumor, necrosis, and gliosis are sometimes difficult to distinguish.

The lack of accuracy in stereotactic biopsies is mainly due to an insufficient number of samples or inadequate localization.\(^3\) Samples may consist of specimens irrelevant to the identification or grading of a brain tumor, such as non-tumoral parenchyma, gliosis, or necrosis. In this case, we inserted a guide tube inside the tumor using a neuronavigation system before dura opening, so minimum brain shift occurred. By using this procedure we also avoided the complications due to blind procedures. The
reported rate of intracranial hemorrhage with stereotactic brain biopsy ranges from 0% to 11.5%. The guide tube technique in this report may be beneficial for getting enough samples with fewer complications.

Stereotactically inserted tube-guided biopsy using a PET-MR coregistered image may be beneficial for the diagnosis of a malignant tumor which is particularly small and deep-seated.

References

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