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Application of diffusion weighted imaging in the diagnosis of bone metastases from lung cancer.

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Abstract

Objective: To investigate the application of background inhibition of fast systemic magnetic resonance diffusion imaging (DWI) in bone metastasis of lung cancer. Methods: Fifty healthy volunteers and 57 patients with lung cancer diagnosed by pathology were examined by WB-DWI, and reconstructed by 3D-MIP and black-and-white flip-flop. The skeletal system was divided into 8 regions, and the number of WB-DWI positive cases in each region was recorded. All WB-DWI images were compared with positron emission computed tomography (PET-CT) images. Results: There were 45 WB-DWI-positive cases and 207 lesions in 85 affected areas. There were 47 PET-CT positive cases and 87 involved lesions. The total number of lesions were 197. Conclusion: The consistency of WB-DWI and PET-CT is very good, and WB-DWI is fast, cheap, non-radioactive and has good reproducibility. Therefore, it has significant clinical value in the diagnosis and treatment follow-up of lung cancer.

Keywords: Lung cancer, Bone metastases, Magnetic resonance diffusion imaging, Positron emission computed tomography.

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Introduction

Early diagnosis of lung cancer is an effective way to improve the therapeutic effect. However, in the past decade the treatment effect of lung cancer did not significantly improve, the overall cure rate is only about 10%. The effect of surgical treatment depends on the patient with or without distant metastasis to some extent. Therefore, accurate preoperative staging and assessment of their resectability are important in reducing unnecessary surgical trauma, enhancing survival, and improving the quality of life of the patient. As a new functional imaging technique, WB-DWI can reflect the pathological changes of tissues and organs from the level of tissue cells [1,2]. Especially in recent years, with the development of magnetic resonance imaging, rapid imaging and parallel acquisition technology, WB-DWI showed good sensitivity and specificity for the display of systemic diseases, especially the skeletal system lesions, which can provide more complete reference information for the surgeon before surgery [3,4]. This research was aimed to review the cased included in our hospital with the diagnosis method of WB-DWI and PET-CT and to compare the difference of those two methods in order to evaluate the diagnosis ability of MRI-DWI.

Materials and Methods

General material

A total of 57 patients receiving WB-DWI and PET-CT examination from January 2011 to December 2014 in our imaging department were in retrospective analysis. All patients were pathologically confirmed as lung cancer, including 29 males and 28 females, aging from 27 to 87 years, mean age was 55.7 ± 15.5 years; In addition, 50 cases of health volunteers were recruited at the same period in the hospital physical examination center, including 25 males and 25 females, aging from 25-77 years. This study was reviewed and agreed by the Medical Ethics Committee. All subjects were volunteered to participate in the study, and were informed of the study content and signed an informed consent form. All subjects underwent WB-DWI and SPECT examinations within 1 week.

WB-DWI scanning

GE Sigma 1.5T HDe MR Scanner (GE Healthcare, USA) was used in the study; the magnet body was used to scan the coil, and the signal was collected using a magnet built-in BODY coil with application of the STIR-EPI sequence. Scanning parameters: TR=4400 ms, TE=4.4 ms, TI=200 ms; Horizontal axis, FOV: 40 cm, Layer thickness: 8 mm, Overlap lmm, Matrix: 96 × 64, b Value: 0 s/Mm^2 and 800 s/mm^2. Patients were in supine, feet advanced, then calm breathing. It was divided into 8 sections to complete, each for 4 min.

PET-CT scanning

PET-CT early and delayed imaging was performed at 1 h and 2 h after intravenous injection of 18F-FDG imaging agent at 5-10 mCi before scanning. Scanning range was controlled from skull base to the upper part of the femur, and the scanning parameters were: slice thickness=5 mm, layer distance=2.5 mm, 120 kv, 250 mA, matrix: 512 × 512, pitch: 0.812, scanning time: 20 min.

Data and diagnosis processing

After the scan, the original image was superimposed by ADD/SUB image analysis software. The post-processing and data processing of the superimposed images were performed on the sub-station (AW43) image workstation using FUNCTOOL image analysis software. In order to compare the display rate of WB-DWI and PET-CT for bone metastasis of lung cancer, the skeletal system was divided into 8 regions in this study: skull, spine, rib, scapula, thoracic clavicle, pelvis, femur, tibia and fibula. The number of lesions on each region of each patient displayed by the WB-DWI and PET-CT were recorded respectively. Image analysis was performed by a double-blind method. WB-DWI images were evaluated by two experienced radiologists, and PET-CT was evaluated by two experienced nuclear medicine physicians. The strong signal was treated as lesions. Physicians can share clinical data, but do not know about other imaging information.

Results

Among the 50 healthy volunteers, 48 patients had a low signal in the skeletal system and 2 male patients had high diffuse hyperintensity in the whole body. Then they were confirmed by bone marrow puncture as normal bone marrow.

Among the 7 cases of lung cancer, there were 45 cases of WB-DWI positive cases and 207 lesions in 85 affected cases. There were 47 PET-CT positive cases and 87 lesions, and the number of lesions was 197 (Tables 1 and 2). The results of WB-DI and PET-CT were compared, 37 cases were completely in conformity. WB-DWI positive and PET-CT negative was founded in 7 cases, PET-CT positive and WB-DWI negative in 2 cases. Affected regions were compared one by one, there were 11 WB-DWI positive and PET-CT negative regions, including 3 of spine, 2 of ribs, 3 of pelvis and 3 of femur. While there were 7 regions of PET-CT positive and WB-DWI negative, including 4 of skull, 2 of chest clavicle and 1 of shoulder blade. In addition, WB-DWI also found 37 lesions of lung cancer-related or non-associated outside the skeletal system, 27 of lymph node metastases and 10 of other lesions. Both of these two results had no statistically significant differences (χ^2=3.60; P<0.05; χ^2=2.87; P<0.05). (Tables 1 and 2).

Table 1. *The number of lesions displayed with WB-DWI and PET-CTin 57 cases of lung cancer patients.*

Inspection Method	Skull	Spine	Rib	Scapula	Clavicle	Basin	Thighbone	Tibiofibula	In Total
Wb-Dwi	3	86	51	7	2	38	18	2	207
Pet-Ct	6	81	49	9	5	34	13	2	197

Table 2. *The positive number of affected areas displayed with WB-DWI and PET-CT in 57 cases of lung cancer patients.*

Inspection Method	Skull	Spine	Rib	Scapula	Clavicle	Basin	Thighbone	Tibiofibula	In Total
Wb-Dwi	2	25	19	5	2	19	11	2	85
Pet-Ct	5	23	17	6	4	16	8	2	81

In addition, in 207 lesions detected by WB-DWI, 169 lesions were confirmed as bone metastasis of lung cancer by pathology. The accuracy rate was 81.6% (169/207). Of the 197 lesions detected by PET-CT, 173 were confirmed as bone metastasis of lung cancer by pathology, with accuracy of 87.8% (173/197). There was no significant difference between the two groups (P>0.05).

Discussion

In recent years, with the development of magnetic resonance imaging technology and by the introduction of rapid imaging sequence and parallel acquisition technology, a single MRI whole body scan was achieved. Diffusion-weighted imaging (DWI) is the only method currently available for the measurement and imaging of water molecules on living organisms [5,6]. The WB-DWI imaging technique is critical to achieving high contrast between tumor and normal tissue. Conventional diffusion imaging employs EPI sequence with high tissue signal, interfering with the detection of lesions. The whole body diffusion weighted imaging (WB-DWI) technique uses the STIR-EPI method. The time interval between the STIR pulse and the 90° excitation pulse is T1 time, which is set to saturation/60% of suppression object. At a 1.5 T field strength, T1 is typically set at 160-180 ms. First, 180° RF pulse is applied to suppress muscle and fat signals, and the background of the image will appear as a uniform low signal background to achieve the imaging requirements and increase the sensitivity of the lesion display. In order to increase the sensitivity of diffusion, a position symmetric gradient field is added to the 180° RF pulse of the conventional SE sequence, which causes the dephasing and complex phase of the proton respectively. The signal attenuation of the stationary water molecule is not obvious, while the moving water molecules have moved out of the detection plane during the application of the complex phase gradient, causing signal attenuation and a significant low signal on the DWI [7, 8].

PET-CT has a good sensitivity, and gives an overview of the entire skeletal system, and is considered as gold standard for clinical detection of malignant bone metastases in a long time [9,10]. This technique can be used to detect bone metastases in malignant tumors based on ingestion of tracers in the osteogenic and/or osteoclastic regions. However, because of its high sensitivity, it is often difficult to distinguish between metastases, degenerative changes, old fractures, leading to a higher false positive rate [11]. In addition, bone metastases of some malignant tumor do not exist in the case of concentrated tracer. Some lesions are in quick progress, the bone was too late to produce reactive new bone or some early metastases have not yet appeared metabolic abnormalities; a small number of bone metastases super bone imaging A small number of bone metastases appear super-bone imaging; due to reduced absorption of the kidney nuclide, the bone resorption activity is enhanced relative to the soft tissue background, and the nuclide in the bone was evenly distributed, these phenomena can lead to false positive bone scan. At the same time, because the patient needs to inject radionuclides, the subject suffers from ionizing radiation injury; and the cost of examination and the financial burden of patients increased.

The results showed that in 57 cases of lung cancer patients, 45 cases were WB-DWI-positive, with 85 affected areas of 207 lesions detected; 47 cases were PET-CT-positive, involving 87 affected areas of 197 lesions. The results of WB-DI were compared with that of PET-CT, 37 cases were completely in conformity. 7 cases were WB-DWI positive and PET-CT negative, of which 1 case is a huge mass of sacroiliac joint, while PET-CT failed to show. 2 cases were PET-CT-positive and WB-DWI-negative, both were thoracic hemangioma. Studies have found that vertebral body benign lesions such as vertebral hemangioma PET-CT are one of the main causes of false positives. In healthy volunteers, 2 male patients showed a slightly higher systemic diffuse signal. Clinically they were suspected to be in blood system diseases, bone marrow puncture proved normal bone marrow, but blood showed mild anemia. The results showed that lung cancer bone metastases accompanied with focal patchy or nodular high signal changes. So that the systemic diffuse slightly higher signal may be associated with subjects with mild anemia, and followed with the activation of bone marrow hematopoietic system, which remains to be confirmed by further studies. Therefore, if the clinical manifestations of patients with systemic diffuse high signal by WB-DWI should be treated with caution, which should not be easily diagnosed as malignant diffuse systemic metastasis or blood diseases, closely followed up or bone marrow puncture will be conducted. As a new imaging technology, WB-DWI has some shortcomings, including neck magnetic susceptibility artifacts, poor image quality, high gastrointestinal interference signal, difficult display of distal limb lesions. So the technology needs to be further improved.

Conclusion

In conclusion, WB-DWI has characteristics in high coverage, low cost, noninvasive, non-radiation, sensitivity, specificity and good display capability. Due to the consistence with PET-CT, it is v suitable for routine screening of bone metastasis of lung cancer. Combination of local conventional imaging technology including X-ray and CT can provide clear guidance for the next treatment of lung cancer. As a result, WB-DWI is more and more widely used as a routine screening tool for preoperative lung cancer patients.

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