Prescan optimization for Whole Body Diffusion Weighted Imaging.

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Introduction:

Magnetic resonance imaging with its excellent tissue contrast, high spatial resolution, and detailed morphological information appears promising for tumor screening. Heavy diffusion weighting and inversion recovery method can suppress most healthy tissue, which are composed mainly by free water and fat[1]. Thus superior disease contrast with sufficient background body signal suppression can be found in STIR-DWEPI sequence. But due to B1 uniformity and EPI distortion, whole body (WB) DWI could not generate a continuous image in Z direction and its application was limited. Here we proposed our work in optimizing the WB-DWI protocol and evaluate its feasibility in tumor imaging.

Methods:

WB-DWI protocol always includes several adjacent locations (Loc). Normally different location will have different shimming result due to different B1. But EPI sequence will have offset in phase direction if the center frequency (CF) changes. We analyzed the adjacent slices A and B, one at the bottom of Loc1 and one at the top of Loc2. The displacement between two slices will be

$$\delta y = [F_{a0}-F_{a1}]-(F_{b0}-F_{b1})] * esp * FOV / (2\pi).$$

F_{a0} and F_{b0} are the CF determined by the scanner after each shimming process, F_{a1} and F_{b1} are the B1 induced frequency difference. If the B0 field is uniform or lateral symmetry of the magnetic center, and Slice A is very close to Slice B, which means their B1 is similar, then F_{a1} will be equal to F_{b1}, δy will only be affected by F_{a0} and F_{b0}. So a fixed CF for all location is crucial for slice continuity. To determine the optimized CF of each patient, we scanned 30 volunteers (age ranged, 18-80 years) with a 5 locations protocol. A "Location" is defined as a scanning region acquired in one acquisition and composed with 39 slices with 7mm thickness each and 1mm overlap. After calculation, the averaged CF from Loc1 and Loc3 is most similar to the average of all 5 locations. So in the final protocol, we first let the scanner automatically calculate the CF of Loc3 and Loc1, then, use the averaged CF of these two locations to be the fixed one for the whole exam. The optimized result is best demonstrated as Fig1A&B: marrow infiltrated B-cell lymphoma patients. Little distortion and misregistration can be found in the enhanced diffusion image.

Another modification is the receiving gain. To generate a uniformed 3D reformatted image, The analogical and digital receiving gain for different locations was fixed. The prescan procedure of STIR_DWEPI sequence was changed dramatically. Original procedures include "low resolution CF", "transmission gain calculation", "gradient shimming", "high resolution CF" and "receiving gain calculation". Now, only "transmission gain" and "gradient shimming" was kept after determine the CF from full prescan procedure of Loc3 and Loc1. The prescan time was reduced from 50s to 20s.

30 patients (mean age, 48 years; range, 13-77 years; 12 females/18 males) with histologically proven malignant disease were included in this initial study. The subjects included: non-Hodgkin lymphoma (n=13) and Hodgkin lymphoma (n=2), chronic lymphatic leukemia (n=1), acute myeloblastic leukemia (n=1), breast cancer (n=1), sarcoma (n=1), multiple bone metastases from lung cancer (n=9), recurrent bladder cancer (n=1) and pancreatic cancer (n=1). In two patients, one with acute myeloblastic leukemia and the other with multiple bone metastases from lung cancer, two examinations were performed before and after chemotherapy with an interval of three months. In four patients, three with non-Hodgkin lymphoma and one with multiple bone metastases from lung cancer, WB-DWI was compared with a PET scan within a 7 days interval.

Result:

All these 30 exams were scanned successfully with this new protocol, without significant none-uniformity or slice offset. An example from this patient group was shown as Fig1C&D, Lung cancer before and after chemotherapy. All lesions, including the large lung mass and metastasis in liver and bone were evidently diminished and the improvements were well recognized on WB-DWI image. Also there is a good consistence between the WB-DWI and PET. More evaluation on the sensitivity, specificity and accuracy are under investigation.

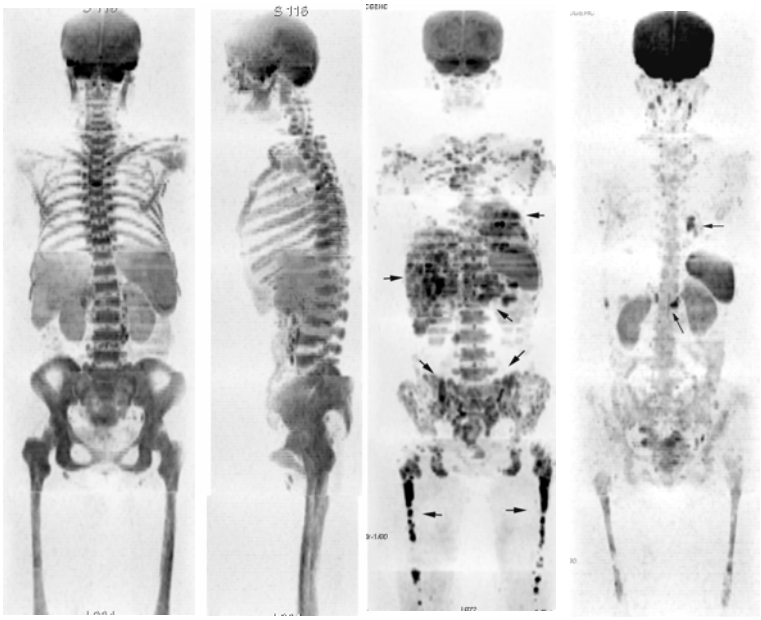

Fig1. A B C D

A,B: 65-year-old female with chronic lymphatic leukemia. A:Coronal MIP image of whole body DWI with inverted intensity; B: Sagittal view. C,D: 65-year-old female with multiple metastases from lung cancer. C: Before chemotherapy. D: After chemotherapy. Three months after C. Its WW/WL was difference with C, to address the remaining lesion.

Reference:

[1] Takahara et al. Radiat Med. 2004 Jul-Aug;22(4):275-282