"Diffusion PETgraphy" : Technical Breakthrough in Body Diffusion Weighted Images with Non-breath-holding and High Resolution 3D Display.

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Background and Purpose

Recent advances in MR gradient technology allow acquisition of diffusion-weighted images with high b factor even in abdominal regions. Preliminary results show great potential for the capability of detection of lymph nodes and pathological lesions. This strategy is similar to PET imaging. However, it is difficult to obtain PET-like three-dimensional image due to the low signal to noise ratio in high resolution imaging. The cause of this problem is related to the limitation of acquisition time during breath-holding. Amazingly, we found that practical diffusion weighted images can be obtained without breath-holding despite accepted theory.

The purpose of this study was to analyze the potential capability of non-breath-holding diffusion weighted images in detection lymph nodes and to establish a presumptive technical solution.

Methods

All images were obtained on a 1.5T MR scanner (slew rate=40mT/m, Gyroscan Intera, Philips Medical Systems, Best, Netherlands.) with synergy body coils. Imaging parameters of diffusion weighted images were FOV=380*260mm, Matrix=160*256, thickness=4mm/-1mm (overlap), NSA=6, TE=68ms, EPI factor=47, SENSE factor=2, b=1000s/mm^2, Half scan factor=60%. Maximum intensity projection (MIP) was performed using a black & white inverse gray scale. We evaluated the following three items: 1) Comparison of breath-holding vs. non-breath-holding methods by contrast noise ratio (CNR) in lymph nodes and surrounding fat tissue of 5 patients with upper abdominal scan; 2) Comparison of SE-EPI with fat suppression (SPIR) vs. STIR-EPI (TI=180ms) by CNR and degree of fat suppression in 5 patients with cervical scan; 3) Imaging quality of STIR-EPI diffusion weighted image in 20 patients with neck, chest, and abdominal malignancy.

Results

1) CNR of lymph nodes in non-breath-holding was significantly higher than breath-holding scans ($p<0.05$) (Table 1). A 4mm-thick scan obtained in 440sec was comparable to CNR with 9mm-thick scan obtained in 120sec. Furthermore, high resolution 3D displays using MIP algorithm could be obtained. 2) CNR of STIR-EPI was lower than SE-EPI. However, fat suppression was satisfactory even in the periphery of FOV (Fig.1). 3) Spread of malignancy was visualized in whole MIP images with sufficient fat suppression (Fig.2).

Technique	CNR
Breath-holding (24sec) 9mm thick	18.1+/- 9.6
Non-Breath-holding (120sec) 9mm thick	41.5+/-19.8
Non-Breath-holding (440sec) 4mm thick, reconstruct to 9mm thick	44.8+/-20.8

Table 1. Comparison of breath-hold vs. non breath-hold scan.

Conclusion

High resolution diffusion-weighted MR imaging with STIR-EPI sequence provides adequate fat suppression and 3D display. We believe that this technique is a significant breakthrough and anticipate that it can be applied to whole-body MRI screening of malignant lesions as "Diffusion PETgraphy" in the near future.

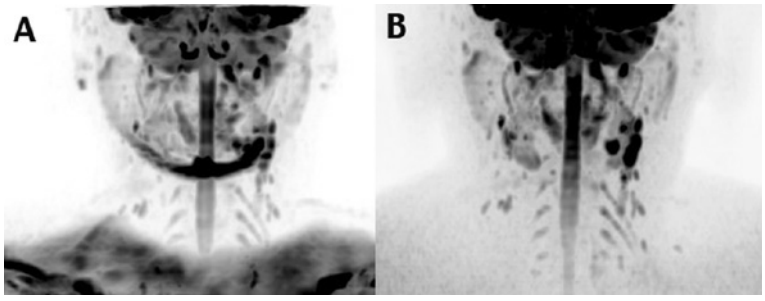

Figure 1. Comparison of SE-EPI DWI with SPIR(A) vs. STIR-EPI DWI(B).
SE-EPI DWI with SPIR (A) shows insufficient fat suppression around the jaw and clavicle. On the other hand, STIR-EPI DWI shows evidence of adequate fat suppression. Swollen lymph nodes around the left submandibular gland are well visualized without artifact.

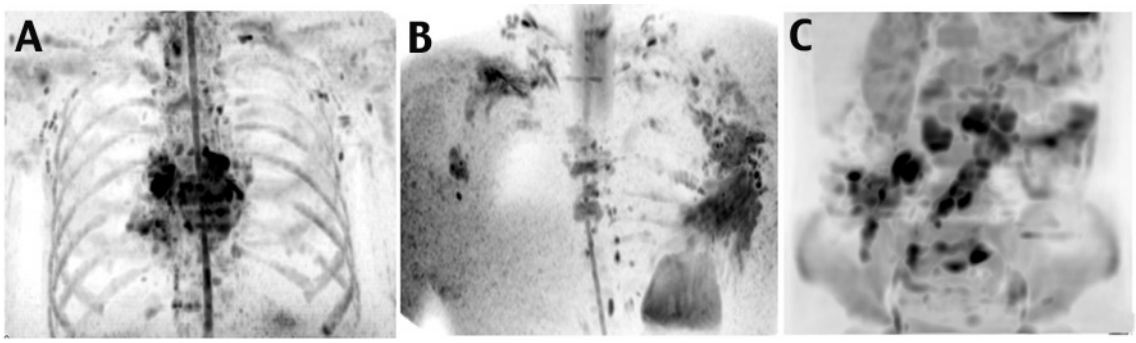

Figure 2. Application of STIR-DWI.
A: 54 y/o man with advanced esophageal cancer with sentinel LN metastasis.
B: 57 y/o woman with advanced left breast cancer with metastasis to sentinel LN, vertebra, and left sided ribs.
C: 4 y/o boy with malignant lymphoma and associated intussuseption.