Tumor detection by Diffusion Weighted MRI and ADC-Mapping – Initial Clinical Experiences in Comparison to PET-CT

M. P. Lichy[1], P. Aschoff[1], C. Plathow[1], A. Stemmer[2], M. I. Menzel[2], W. Horger[2], B. Kiefer[2], C. D. Claussen[1], C. Pfannenberg[3], and H-P. Schlemmer[1]

[1]University of Tuebingen, Tuebingen, BW, Germany, [2]Siemens Medical, Erlangen, BY, Germany, [3]University of Tuebingen, BW, Germany

INTRODUCTION

The betimes and correct estimation of metastatic spread is essential for a patient-adopted and highly efficient therapy regime. Taking into account all possible pathologic-anatomic relationships, whole-body (wb) MRI could already proof its potential to revolutionize workflow in oncology [1]. However, detection of metastasis and therapy follow-up with wbMRI is (mainly) based on morphological changes. Also amount and complexity of wbMRI data hampers the widespread use of this technique in clinical routine. As an alternative, positron emission tomography (PET) with integrated computed tomography (CT) scanner provides detailed morphological data, too, and additional, dedicated (and compared to wbMRI "easy-to-read") metabolic information. But compared to wbMRI, PET-CT is associated to high radiation dosages and tracer production, transport and its application is highly labor- and cost intensive. But tumors are not only characterized e.g. by pathologic glucose uptake; also higher cellularity and therefore restriction of water diffusion was found to be a common feature of tumors. Diffusion-weighted-imaging (DWI) with high b-values was therefore already used for highlighting potential metastasis and lymph nodes in wbMRI [2], Purpose of this work was to establish high b-value DWI for tumor staging in wbMRI with the potential for respiratiory triggering and mapping of the apparent diffusion coeffecient (ADC).

MATERIALS & METHODS

A total of 19 patients were examined with clinical indication for PET-CT and additional wbMRI scan including DWI for selected areas of interest: 11 patients with melanoma (tracer: 18FDG with 421±29 MBq; mean age was 51±16 a; time-interval between DWI and PET-CT was 0.5±1 d), 4 patients with prostate carcinoma (tracer: 11Choline with 832±36 MBq; mean age was 71±5.4 a; time-interval between DWI and PET-CT was 1.5±1.7 d), 4 patients with lung cancer (tracer: 18FDG with 444±19 MBq; mean age was 62±10 a; time-interval between DWI and PET-CT was 2.7±2.9 d) and 1 patient with a non-Hodgkin lymphoma (18FDG with 479 Mbq; age was 59 a; time-interval between DWI and PET-CT was 6 d). The wbDWI application based on a single-shot echo-planar-imaging (EPI) sequence with diffusion-module and fat-supression-pulse was implemented on a 1.5T MR scanner, equipped with 32 RF-channels (Magnetom Avanto, Siemens Medical, Germany). For respiratory synchronization a navigator can be used. For non-triggered DWI, the patients were breathing freely. Sequence parameter for non-triggered DWI examinations were: TR = 3900 ms, TE = 79 ms, 3-trace scan with 3 b-values (b = 0 s/mm^2, b = 400 s/mm^2, b = 1000 s/mm^2), application of parallel imaging techniques for reduction of susceptibility artifacts (Grappa, iPAT factor of 2), 4-5 averages, 30 slices per slab in transversal orientation. Resulting resolution was (2.0 * 2 .0* 4.0) mm^3. Relative signal intensities (SI) for selected tissues were evaluated by a region-by-region analysis. Evaluation of DWI included also documentation of artifacts, signal-to-noise and contrast-to-noise impression, visualization of detected lesions by DWI and PET-CT and overall diagnostic quality / additional diagnostic value of b-value images / ADC maps (consensus read by two radiologists).

RESULTS

A total of 424 regions of interest (ROI) were used for DWI and 73 ROI for PET data evaluation. 120 ROI were placed within tumor and 304 within normal tissues. In all patients with melanoma and prostate cancer lymph node and soft tissue metastasis with increased ^{18}FDG/^{11}Choline uptake could also be characterized by restriction of water diffusion and visualized by high b-value MR-imaging (compare figure). Also diffuse muscle infiltration in the case of non-Hodgkin lymphoma was visualized by MR?. Artifacts caused by spatial distortions were observed with EPI imaging in areas with high susceptibility (e.g. bowel) but in abdominal or pelvic DWI no influence on diagnostic accuracy was observed. However, restrictions in image quality were obvious in DWI of the thorax (patients were breathing freely). ADC maps were of high quality and ADC-values were in concordance to literature data [3] (mean ± standard deviation ADC: liver 58±22 * 10^{-5} mm^2/s; spleen 75±17 * 10^{-5} mm^2/s; right kidney 136±14 * 10^{-5} mm^2/s). Based on PET findings, detection rates by DWI at b=1000 s/mm^2 were at 100% for metastases of melanoma and the single case of lymphoma, 100% for lymph node metastases of prostate cancer, 13% for lymph nodes and 100% for lung metastases in case of lung cancer. The single osteoplastic prostate cancer metastasis was missed.

CONCLUSION

(Whole-body) DWI for tumor staging is a feasible technique with the used combination of hardware and imaging techniques. Based on our initial data, high b-value DWI is also a promising technique to further improve sensitivity (and potentially specificity) of wbMRI tumor staging scans and therefore in predicting total tumor load. In this study, ADC maps were evaluated in this study because relative changes of ADC values could already be proven to be a precise and early marker in foreseeing therapy response in animal models [4]. However, the potential role of ADC mapping cannot be answered with the database we evaluated yet.
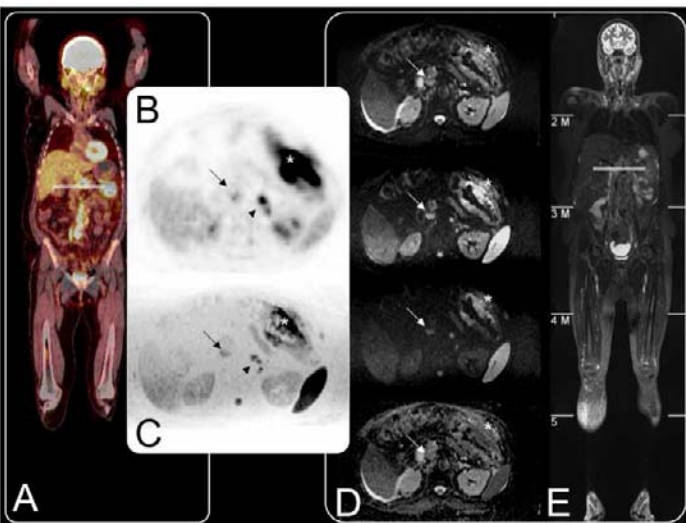
FIGURE

52 a old female patient with advanced melanoma. For tumor staging, whole-body PET-CT ^{18}FDG was performed (A). Pathologic multiple lymph nodes (arrows in B)) and also diffuse metastatic tumor spread within the bowel wall was diagnosed (* in B)). Extensive tumor spread was also confirmed by whole-body MRI (E). Additional DWI scan of the upper abdomen was performed with navigator based respiratory synchronisation. Original DWI images are given D) (from top to bottom: b=0 s/mm^2, b=400 s/mm^2, b=1000 s/mm^2, calculated ADC map based on all 3 b-values (averaged 3-trace-scan)). For better comparison to PET-data, a thin slice maximum intensity projection (slice thickness 20mm) based on images with a b-value of 1000 s/mm^2 was performed (C). A high concordance between increased FDG-uptake and restriction of diffusion is visible in all suspicious lymph nodes and even in the bowel wall.

REFERENCES

[1]   Schlemmer HP, et al.; Invest Radiol 2005;40(2):64-71.
[2]   Takahara T, et al.; Radiat Med 2004;22(4):275-82.
[3]   Yamada I, et al.; Radiology 1999;210(3):617-23.
[4]   Plaks V, et al.; Neoplasia 2004;6(3):224-33.