Whole Body Diffusion Weighted Imaging and ADC Mapping for Detecting Metastatic Cancer

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INTRODUCTION: The ability to diagnose metastatic disease without radiation would be an advancement in the initial work-up of cancer[1]. Takahara et al [2] employed CNR ratios in WB (whole body) DWI to characterize metastasis, but to our knowledge characterization by WB-quantitative Apparent Diffusion Coefficient (ADC) measurement has not been investigated. Therefore, the purpose of this study was to investigate the potential use of a novel whole body diffusion weighted imaging (WB-DWI) method coupled with ADC mapping for the detection of metastatic disease in patients.

METHODS: Subjects were scanned with WB-DWI using a Siemens 1.5T Avanto MR scanner with Total Imaging Matrix (TIM) with a total scan range of 205cm and a field-of-view of 50cm[3]. Axial fat-suppressed T2 images (TR/TE=5180/88, FOV=28x38cm^2, acquisition matrix= 256x256, slice thickness=4mm) and DWI images (TR/TE=3900/78ms, b=50,300-600 sec/mm^2, acquisition matrix=192x192, FOV=28x38cm^2, slice thickness=4mm) using GRAPPA (acceleration factor=2) were acquired [4]. Total acquisition time was approximately 60min. Metastatic disease on MRI was compared to Tc99m bone scan, and/or PET/CT. Whole body trace ADC maps were constructed for quantitative analysis and ROIs were drawn in regions of normal and abnormal appearing signal intensity in the DWI and were localized to the ADC map. Descriptive and ANOVA statistics are presented as mean and standard deviations.

RESULTS: Seventy two body regions were examined in twelve subjects. Eight volunteers with no known malignancies were initially studied to determine the normal range of expected ADC values. The ADC values for bony structures in volunteers were 78±33x10(-5)mm^2/sec (cervical), 45±22 x10(-5)mm^2/sec (thorax), 104±24x10(-5)mm^2/sec(lumber) and 26±19x10(-5)mm^2/sec(pelvis). In patients with metastatic disease in bone, ADC values were 126±20x10(-5)mm^2/sec in "lesion" area (cervical), 158±22 x10(-5)mm^2/sec(thorax), 99±24x10^{-5}mm^2/sec(lumbar) and 106±24x10(-5)mm^2/sec(pelvis) and similar results were noted in other regions. Visceral lesions ADC's were 107±21x10(-5)mm^2/sec(liver) vs. normal 33±22x10$^{(-5)}$mm^2/sec. These ADC values were significantly different (p=0.01) between patients and volunteers. Patients (n=4) with malignancy were distributed as follows, breast (n=2), prostate (n=1) and colorectal (n=1). Using WB-DWI, three cases of metastatic disease were detected and one patient did not have metastatic disease by imaging. Figure 1 demonstrates a representative patient with metastatic prostrate cancer to bone and Figure 2 demonstrates visceral metastasis to the liver from colorectal cancer.

DISCUSSION: We have demonstrated the feasibility of using WB-DWI and ADC mapping to identify and potentially characterize both bony and visceral metastasis. There were significant differences in the ADC values in areas of metastatic disease compared to normal subjects. WB-DWI is different than other WB methods that employ anatomical T1/T2 imaging[5-8], here we present "functional" WB-DWI that could serve as a biomarker in oncological studies. In conclusion, our data provides baseline for normal and metastatic ADC values which will serve as a basis for quantitative detection of metastatic disease and could potentially provide a method for assessing therapeutic response. Further studies with more patients are needed to better assess the impact of whole body imaging.

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Figure 1. 64 y/o patient with metastatic prostrate disease **A**) Tc99m bone scan. **B**) DWI (b=300-600s/mm2) of corresponding areas of metastatic sites. Metastatic lesions are seen as in the rib and vertebrae. **C**) Sagittal image showing the whole body coverage.

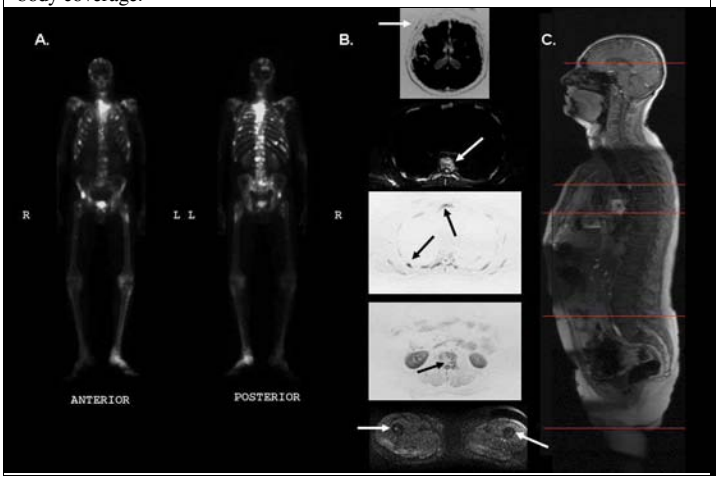

Figure 2. 72 y/o patient with metastatic colorectal cancer. WB_DWI was able to distinguish visceral metastasis to the liver. **A)** Multiple metastatic lesion can be noted in the liver. **B)** Sagittal image showing the whole body coverage.