Multisequence and multiplanar whole body MRI for detection of cancer metastases

J. Ma[1], C. Costelloe[2], J. Madewell[2], G. Hortobagyi[3], M. Green[3], G. Cao[4], F. Sun[4], and V. Kundra[2]

[1]Imaging Physics, University of Texas MD Anderson Cancer Center, Houston, Texas, United States, [2]Diagnostic Radiology, University of Texas MD Anderson Cancer Center, Houston, Texas, United States, [3]Breast Medical Oncology, University of Texas MD Anderson Cancer Center, Houston, Texas, United States, [4]GE Healthcare, China, People's Republic of

Introduction:

MRI is ideally suited for whole body (WB) cancer detection because it does not use ionizing radiation, has excellent soft tissue contrast, and can provide multi-sequence and multi-planar imaging capabilities for improved diagnostic accuracy. However, the acquisition speed of most MRI sequences is relatively slow. Consequently, the large spatial coverage required in WB imaging often precludes acquiring images of the entire body with a large number of sequences and in different imaging planes. The scan time constraint may be further exacerbated by the need for acquiring separate images at the same locations with and without fat-suppression. In addition, fat-suppression by the frequency selective saturation techniques is difficult to perform consistently in the setting of WB MRI because of the field inhomogeneity or susceptibility artifacts that occur over the large field-of-view (FOV). As a result of these technical challenges, many previous WB MRI studies are limited to acquiring images with a single or very limited number of pulse sequences and in a single or very limited number of imaging planes. The purpose of this study was to develop a WB MRI approach whereby a multi-sequence and multi-planar exam of the entire body can be performed within a standard overall table time of approximately 1 hour. Our approach was based on two fast Dixon techniques and included acquiring T2-weighted images, T1-weighted images (both before and post contrast injection), and diffusion-weighted images of the whole body.

Experiments and Method:

All MR imaging was performed on a 1.5 Tesla whole-body scanner (GE Healthcare, Waukesha, WI) without any customized hardware modifications. WB images were collected in multiple stations with patients lying on a tabletop that was moved automatically between stations. The scanner's built-in body RF coil was used for all body stations, excepted for the T1 and T2-weighted imaging of the chest/abdomen/pelvis stations where breath-hold acquisition and an 8-element torso phased array coil were used. The WBMRI protocol consisted of three different pulse sequences. The essential components and technical enabler of the protocol were two-recently developed fast Dixon sequences: a fast spin echo triple echo Dixon (fTED) sequence [1] and a 3D fast spoiled gradient echo dual echo Dixon (FSPGR-DE) sequence [2]. The third sequence in our WB protocol was a STIR-prepared diffusion-weighted sequence, which provided diffusion-weighted images with background and fat signal suppression and is described by Takahara et. al. [3] and Li et. al. [4]. The fTED and the 3D FSPGR-DE sequences both provided fat-suppressed, non-fat-suppressed and fat-only images in a single acquisition. In our study, we used the fTED sequence for coronal T2-weighted imaging and the 3D FSPGR-DE sequence for axial T1-weighted imaging, both before and after contrast agent injection. A total of 24 breast cancer patients with known distant metastases were enrolled in the study. The total acquisition time and the total table time for each patient were recorded for analyses. The image quality was reviewed by three experienced radiologists.

Results:

Despite having a diagnosis of stage IV metastatic breast cancer, all except one patient tolerated well and completed successfully the WB MRI studies. For the patients who completed the study, the mean total acquisition time of all the sequences (including localizer sequences) and overall patient table time were 46 minutes (range, 40-55; standard deviation, 3) and 68 minutes (range, 61-77; standard deviation, 5), respectively. The overall patient table time included the image acquisition time plus all other additional time such as that needed for system prescanning, injection of contrast agent, and table movement between stations. The mean overall patient table time of 68 minutes was slightly over 1 hour. However, it was considered acceptable for the routine scheduling of a typical body or musculoskeletal MRI examination at our institution. A preliminary reading by three radiologists concluded that the quality of the WB images was consistent between different patients and all WB examinations were diagnostically adequate. Figure 1a-d) shows an example of the coronal fTED non-fat-suppressed T2-weighted, fTED fat-suppressed T2-weighted, sagittal FSPGR-DE fat-suppressed post-contrast T1-weighted, and axial diffusion-weighted images, respectively. When compared to many previous WB MRI studies, these images illustrate superior image quality with uniform fat suppression and minimal motion artifacts.

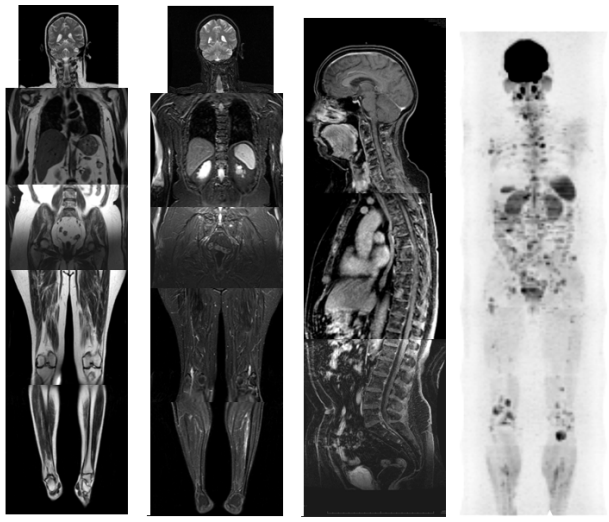

Fig.1. (from left to right) a) coronal fTED T2-weighted image without fat suppression. b) coronal fTED T2-weighted image with fat suppression. c) sagittal 3D FSPGR-DE post-contrast T1-weighted image with fat suppression. d) STIR-prepared diffusion weighted image.

Discussions:

MRI detection of cancer with high confidence requires images of multiple sequences and in different anatomic planes. The essential sequences that are typically acquired for regional MRI include T2-weighted imaging, as well as T1-weighted imaging with and without contrast. Recent reports indicated that diffusion weighted imaging may also provide added values in the setting of WBMRI [3-4]. Our study demonstrated that a complete WBMRI exam including all these sequences can be performed for actual patients on a commercially available 1.5 Tesla clinical scanner within a total table time of approximately 1-hour. We are in the process of validating the diagnostic accuracy of our approach, which requires patient follow-up and comparison to other known WB imaging techniques (such as bone scintigraphy and PET/CT). Nevertheless, we believe that the technical feasibility demonstrated here opens up potential for an appealing "one-stop shop" for WBMRI patient imaging.

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References:

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