Characterization of breast tumors using the FIESTA technique and contrast-enhanced MRI

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Synopsis: In this study we explored the usefulness of the Fast Imaging Employing Steady-State Acquisition (FIESTA) pulse sequence for characterization of breast tumors. Contrast in the FIESTA sequence is related to T2/T1 ratio and FIESTA can be acquired in a 3D format, allowing T2 information to be spatially matched to T1-weighted contrast enhanced MR images (CE-MRI). We performed a preliminary investigation using the combined information from FIESTA and CE-MRI to characterize breast tumors (invasive ductal and lobular carcinomas, DCIS) in a group of 10 patients.

Introduction: CE-MR imaging is highly sensitive for the detection of neoplasms in the breast. CE-MR imaging methods have been developed to characterize tumors according to their contrast enhancement dynamics following injection of a contrast agent [1,2]. T2 weighted sequences are valuable for the demonstration of vessels, cysts and cystic lesions [3] in the breast. Additionally, T2-weighted images of the breast show significant heterogeneity in both tumors and surrounding breast tissue. However T2 has not been found to provide specificity in cancer diagnosis, although this has not been rigorously explored. While other techniques such as the FSE sequence can provide T2 information, they are acquired with a 2D format, making it difficult to correlate T2 and enhancement information. We used the FIESTA pulse sequence to better characterize breast tumor T2. The FIESTA sequence is designed to produce high signal to noise images at very short sequence times (TR). The resulting signal intensity is independent of TR and related to the ratio T2/T1. The advantage of this sequence is that it allows the visualization of T2 information on the same high resolution 3D matrix as T1 and contrast-enhancement information, allowing a pixel-to-pixel comparison of T1, T2 and enhancement values. We undertook this study to better understand the relationship between tumor vascularity as measured by CE-MRI, and tumor characteristics (water content, density of membranes, fibrotic content, overall heterogeneity) provided by the T2 information in FIESTA. The goal of our study is to better characterize normal and diseased breast tissue for application to treatment response assessment.

Materials and Methods: We acquired breast MR data from 10 women participating in a neoadjuvant treatment response study, (29-72 years, mean age 47.3 years). A pathology report was available for all patients showing 6 patients with invasive ductal carcinoma, 2 with invasive lobular carcinomas and 2 with DCIS. MR imaging was performed on a 1.5T Signa scanner (General Electric Medical Systems, Milwaukee, WI) using a bilateral phased array breast coil. A 3D fat suppressed FIESTA pulse sequence was acquired followed by a fat suppressed T1-weighted 3D fast gradient echo sequence, repeated pre-contrast, early post-contrast and late post-contrast. Both FIESTA and CE-MRI sequences were performed using field of view 20 cm, slice thickness 2mm and acquisition matrix of 256x192. The resulting in-plane resolution was approximately 0.78x0.78mm and 60 slices were acquired in the sagittal orientation. For contrast-enhanced studies, gadopentetate dimeglumine (Magnevist, Schering, Berlin Germany) was injected at a dose of 0.1mmol/kg of body weight. ROI signal intensity measurements were made in normal and tumor tissue on FIESTA, pre-contrast T1 and enhanced images, using the first post-contrast image to define tumor. All ROIs were normalized by the average intensity value of chest wall muscle. Intensities from the tumor bed and from the surrounding normal tissue were recorded in the post-contrast image as well as in the FIESTA images. We scored tumor signal intensity on FIESTA images as 1) hypointense; 2) hypointense or 3) isointense to surrounding normal (non-enhancing on CE-MRI) breast tissue. We also qualitatively scored the homogeneity of tumor relative to surrounding normal tissue as: 1) more, 2) less, or 3) as homogeneous.

Results: All tumors demonstrated contrast enhancement on CE MR images. We noted different tumor intensity behaviors in the 3D FIESTA data. Four patients with invasive ductal carcinomas presented a hypointense inhomogeneous tumor region in the FIESTA sequence compared to the surrounding healthy tissue in the same sequence. On the contrary, the 2 invasive lobular cancers in this study presented the opposite pattern on FIESTA, with tumors brighter than normal surrounding tissue. We did not observe a specific pattern for the DCIS cases.

Discussion: In our small population we found that the majority of invasive ductal carcinomas presented as hypointense to surrounding normal tissue, while the two lobular carcinomas studied appeared hyperintense. The hypo- versus hyper- intense appearance of the two histologies may reflect a specific characteristic, specifically its density of membranes. In dynamic MR imaging breast cancers are characterized by a strong enhancement after contrast injection in 85-90% of cases [4]. Our observation in this small population is that FIESTA provides additional and different information from CE-MRI, making it potentially useful for characterizing breast tumors. We intend to apply our scoring on a larger population in order to further explore the value of FIESTA.

References: