Voxel-based Analysis of early DCE-MRI Changes May Predict the Response to Neoadjuvant Chemotherapy in Breast Cancer Patients

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INTRODUCTION To monitor tumor response to neoadjuvant chemotherapy, investigators have begun to employ the quantitative physiological parameters available from dynamic contrast enhanced MRI (DCE-MRI). However, most studies track the changes in parameters obtained from the tumor ROI or histograms, thereby discarding all spatial information on tumor heterogeneity. We have presented and validated a method for the registration of breast MR images obtained at different time points throughout the course of neoadjuvant chemotherapy [1-2]. In this study, we applied this method to longitudinal DCE-MRI data and performed a voxel-by-voxel analysis to examine the ability of early changes in parameters at the voxel level to separate pathologic complete responders (pCR) from non-responders (NR).

METHODS 22 patients with Stage II/III breast cancer were enrolled in an IRB-approved clinical trial where serial breast MRI scans were acquired pre-therapy ($t_1$) and after one cycle of neoadjuvant chemotherapy ($t_2$). Imaging was performed on a 3.0 T Achieva MR scanner (Philips Healthcare, Best, The Netherlands). The DCE-MRI acquisition employed a 3D spoiled gradient echo sequence with TR/TE/α = 7.9 ms/1.3 ms/20°. The acquisition matrix was 192×192×20 over a sagittal (22 cm) FOV with a slice thickness of 5 mm. Each 20-slice set was collected in 16.5 seconds at 25 time points and 0.1 mmol/kg of Magnevist was injected at 2 ml s⁻¹ after the third dynamic scan. Responders (n=11) were defined as those patients who had a pathologic complete response at time of surgery. Non responders (n=11) were defined as patients with residual invasive cancer at the primary tumor site.

The fast exchange regime model (FXR) was applied to the original DCE-MRI data to estimate tumor perfusion and permeability ($K^{\text{trans}}$), extravascular extracellular volume fraction (vₑ), and the average intracellular water lifetime of a water molecule (tᵢ). ROI analysis was performed on the segmented tumor regions in the original DCE-MRI data to obtain three variables: the change of mean, median, and mean of the top 15% parameters. The voxel-based analysis was performed on the registered parametric maps by computing the change of three variables of $K^{\text{trans}}$ obtained by both the ROI and voxel analyses. It shows that the voxel-based analysis yielded significant results ($p < 0.05$) in all three ways of summarizing $K^{\text{trans}}$. Most results for vₑ and tᵢ by both the ROI and voxel analyses, were not significant.

CONCLUSION The results indicate that the voxel-based analysis after longitudinal registration may improve the ability of DCE-MRI to separate pCR from NR after one cycle of therapy when using the FXR model.

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