Simple classification of contrast enhancement curves in DCE MRI correlates to breast cancer survival

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Introduction: Dynamic contrast-enhanced (DCE) MRI derived parameters correlate to response during neoadjuvant chemotherapy in breast cancer patients (1). A range of different analysis methods are commonly applied to DCE-MRI data (2). In a clinical setting, visual assessment of the contrast enhancement curve according to Daniel et al (3) is often used. An improved visual inspection could be obtained by color coding the different types of enhancement curves based on voxel-by-voxel analysis. The purposes of this study was to evaluate the DCE-MRI characterization of locally advanced breast cancer prior to treatment using voxel coding according to different types of enhancement curves, and correlate these characteristics to the clinical status of the patients 5 years after treatment.

Experimental: Patients (n=26) with locally advanced breast cancer receiving neoadjuvant chemotherapy were included in the study. DCE-MRI in the sagittal plane were acquired using a 3D spoiled gradient echo sequence (RF-FAST) with a temporal resolution of 57 sec, using a clinical 1.5T MR system (Picker Inc.). All analyses were performed using in-house software. Region of interest (ROI) encircling the tumour area was defined in each slice. Voxel-by-voxel classification of the DCE-MRI contrast enhancement curves was performed by comparing the enhancement curve of every voxel to each of the five template curves (Figure 1a) and choosing the template which best fitted the sample. To visualize the result, a color map overlay was produced, where the colors yellow, orange and red indicate enhancement curve types 3, 4 or 5, respectively. The volume of tumor tissue classified to enhancement curve type 5 was calculated and used as a predictor for survival 5 years after diagnosis. A receiver operating characteristics (ROC)-curve for this test was produced (Figure 1b), and a Kaplan-Meier survival estimate of patients with a type 5 volume of less than 0.6 ccm was calculated (Figure 1c).

Results and discussion: After 5 years, 15 of the patients were still alive, and 11 had died. Both the breast cancer patients shown in Figure 1d-g had large heterogeneous tumors. An example of a patient still alive after 5 years is shown in Figure 1 d-e, where the color coding demonstrates a small amount of type 5 (red) voxels compared to the larger amount seen in a patient that died before 5 years (Figure 1f-g). The ROC curve (Figure 1b) indicates that the volume of type 5 classified tissue correlates with 5 years survival, with a sensitivity/specificity of 0.4/1.0 at a volume threshold of 0.6 ccm, and 0.74/0.64 at a threshold of 3 ccm. The Kaplan-Meier plot shows a clear difference in survival time between the two groups, however the results should be validated in a larger cohort of patients.

Conclusion: Single voxel classification of contrast enhancement in DCE-MRI resulted in color visualization of voxels with different curve types. The volume of the tissue classified as a type 5 enhancement curve showed correlation to clinical outcome after 5 years.

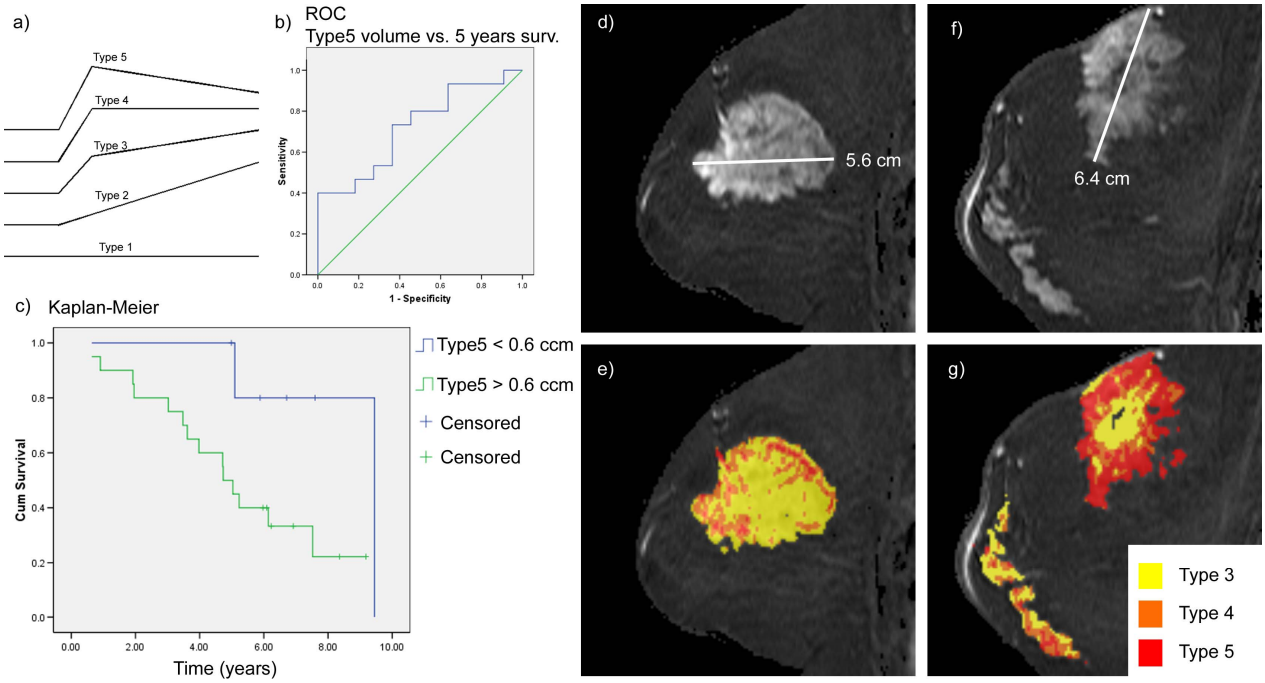

Figure 1 a) Five different template contrast enhancement curves used for single voxel DCE-MRI classification (adapted from Daniel et al (3)), b) ROC-curve for volume of tissue classified as type 5 compared to 5 years survival. c) Kaplan-Meier plot of survival times for patients grouped according to the volume of type 5 curves (threshold 0.6 ccm). d) RSI at 1 minute after contrast injection for a patient alive at 5 years and f) a patient dead within 5 years with color coded overlays (e and g, respectively) based on the enhancement curve classification.

References: 1)Pickles MD et al, Breast Cancer Res Treat 2005, 91: 1-10, 2) Padhani AR et al, Radiology 2006, 239:361-74, 3) Daniel BL et al, Radiology 1998, 209, 499-509.