DIFFUSION-WEIGHTED MRI FOR THE EARLY RESPONSE ASSESSMENT OF NEOADJUVANT CHEMOTHERAPY IN BREAST CANCER: DOES PERFUSION EFFECT INFLUENCE ADC MAP ACCURACY?

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Target Audience

We intend for this to be useful for clinical radiologists and MR physicists with an interest in the field of diffusion-weighted MR imaging in breast cancer.

Purpose

Diffusion-weighted MR imaging (DWI) has shown promise in demonstrating early treatment response in patients receiving neoadjuvant chemotherapy (NACT) for breast cancer[1,2]. Perfusion may confound accuracy of the apparent diffusion coefficient (ADC) value when DWI is acquired with low diffusion b-values[3], although it has been suggested that acquiring DWI after contrast-enhanced sequences (CE-MRI) may suppress this effect[4]. Here, we explore this in the context of early response assessment to NACT, by comparing tumour size changes and ADC values with appropriate selection of diffusion b-values to include/exclude perfusion effects.

Methods

Breast MRI scans were reviewed from patients receiving NACT between October 2008 and January 2012. Patients underwent imaging pre-, mid- (at around three months, after three or four cycles of NACT) and post-treatment (at around six months, after six to eight cycles of NACT and just prior to surgery) on Avanto and Aera 1.5T MRI systems (Siemens, Erlangen, Germany). DWI was acquired with a free-breath single-shot fat-suppressed (SPAIR) echo planar sequence with b-values of 0, 100 and 800 s/mm^2 in three orthogonal directions after a 9-minute CE-MRI sequence. Two ADC maps were calculated using an ADC map plugin[5] within OsiriX; $ADC_{0,800}$ from b-values 0 and 800 s/mm^2 (incorporating potential perfusion) and $ADC_{100,800}$ from b-values 100 and 800 s/mm^2 (excluding potential perfusion). Regions of interest (ROIs), verified by a consultant radiologist, were defined around the largest area of homogeneity in the whole tumour at its largest diameter on T1 contrast-enhanced images, avoiding necrotic/cystic areas and the MRI-compatible coil artifact. ROIs were transferred to the ADC maps and the mean ADC values were measured. Pre to mid NACT changes in mean ADC values and tumour size were compared with eventual radiological response/non-response, defined as >50% reduction in tumour long-axis diameter between pre and post-NACT scans, using a Mann-Whitney U test in IBM SPSS (version 20). Receiver operating characteristic (ROC) curves were calculated for each early response measurement and compared using Vassar Stats[6].

Results

Of the 34 patients (mean age 47.6 years) who underwent MRI scans between these dates, 4 were excluded due to complete radiological response by mid-treatment. Of those remaining, 23 were responders and 7 were non-responders. Pre to mid NACT changes in the mean values for both $ADC_{0,800}$ and $ADC_{100,800}$ were strongly significant between responders/non-responders (p=0.003 and p=0.001 respectively), whereas pre to mid NACT changes in long-axis measurement only just reached significance (p=0.042). ROC area-under-curve values for long axis measurement, $ADC_{0,800}$ and $ADC_{100,800}$ were 0.652, 0.863 and 0.882 respectively. When compared to long axis measurement the ROC curve for $ADC_{0,800}$ just failed to reach significance (p=0.055), whereas the ROC curve for $ADC_{100,800}$ was significantly better than the long axis measurement (p=0.038).

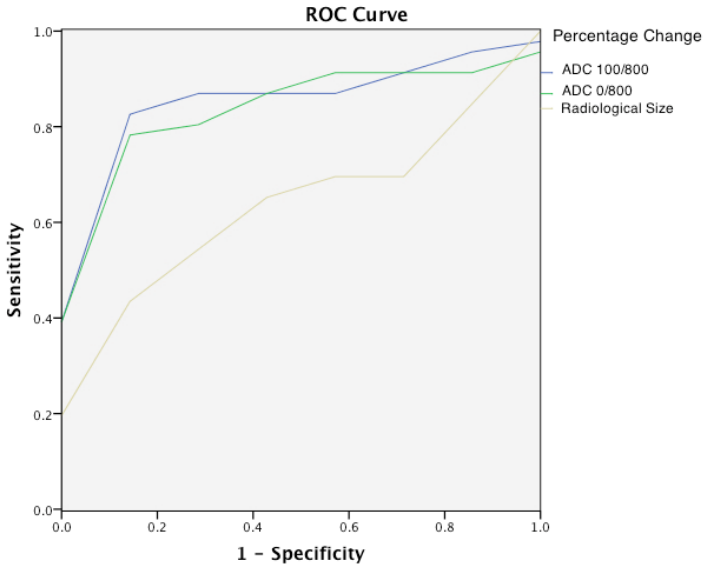

Figure 1 ROC curve showing performance of pre-mid treatment changes in $ADC_{100,800}$, $ADC_{0,800}$ and long-axis size measurements in predicting eventual pre-post treatment radiological response

Discussion

DWI offered a more accurate early response assessment to NACT than long axis measurements in these patients, in line with previous studies[1,2]. Despite reports that residual contrast agent suppresses the perfusion effect on DWI, results here suggest increasing the minimum b-value to avoid perfusion effects may have a small benefit. Limitations of this work include a relatively small sample size, particularly the number of non-responders, and the subjective definition of ROIs to avoid areas of tumour heterogeneity. Increasing tumour heterogeneity during the treatment cycle was also problematic, as our method of ROI generation became increasingly challenging between pre and mid treatment images due to the development of tumour necrosis and fibrosis. Further work is required to explore the most effective high b-value, and to assess the potential impact of perfusion effects when DWI is acquired prior to CE-MRI.

Conclusion

DWI offers a better early response assessment to NACT in breast cancer than tumour size changes. Removing potential perfusion effects by utilising a low b-value of at least 100 s/mm^2 may improve slightly the performance of the fitted ADC value, even when DWI is acquired after CE-MRI.

References

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