Evaluation of computer aided 3D parametric analysis of MR-mammography for follow-up assessment of malignant lesions under primary systemic therapy

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Introduction:

According to the annual statistics of the American Cancer Society, apart from non-melanoma skin cancer, breast cancer is currently the most common cancer type among women and the second most common cause of cancer death. In case of multricentric or inoperable tumor manifestation neoadjuvant chemotherapy is used for preoperative tumor size reduction. Hence, the assessment of early treatment response is an inevitable issue in primary systemic therapy. Within the last few years computer aided detection systems have evolved to be an important tool in the evaluation of the contrast enhancement of breast lesions, by means of their contrast kinetics. The aim of this study was to evaluate a 3-dimensional (3D) parametric analysis CAD system in dynamic MR mammography for (a) volume determination and analysis of (b) contrast kinetic and (c) pharmacokinetic changes of malignant lesions under neoadjuvant chemotherapy.

Material and Methods:

60 patients with histopathologically proven breast cancer were enrolled in this study. Dynamic contrast-enhanced MR mammography was performed on a 1.5T scanner (Magnetom Espree, Siemens Medical Solutions) (a) before and (b) on average 12 weeks after the initiation of systemic chemotherapy. Six dynamic T1 weighted gradient echo sequences were collected with an average acquisition time of 2 minutes (TR 11 ms, TE 4,76 ms, flip angle 15°, FOV 370 mm, matrix 384×384, slice thickness 2 mm). Contrast media (Gadobutrol, 0.2 mmol / kg body weight) was injected 3 minutes after the start of the first dynamic T1w GRE sequence. The contrast kinetics of all malignant lesions were analysed quantitatively on a pixel by pixel basis using a computer-aided detection system (iCAD, Nashua, NH, USA). The signal enhancement pattern was coded by different color intensities and different color hues. The initial signal increase was coded by three different color intensities: slow signal enhancement (<50%) was coded dark, an enhancement of 50-100% was coded medium, fast enhancement was coded bright. The postinitial signal pattern was coded by different colors: postinitial enhancement increase was coded blue, plateau was coded green and fast wash out was coded red. Changes of tumor size were analysed. Furthermore, pharmacokinetic changes were evaluated based on the Tofts model including vascular permeability and extracelullar volume fraction. The parametric changes were compared by Wilcoxon signed rank test. A p-value < 0,05 was determined to be statistically significant.

Results:

In comparison to the baseline MR mammography, follow-up mammographies showed a significant tumor size reduction of 62% on average. The CAD evaluation of the signal enhancement patterns of the lesions revealed a significant decrease of all intensities of the color red, as well as the total of red and the total of green ($p < 0,05$). By means of contrast kinetics, this indicates a significant decrease of malignant enhancement patterns under neoadjuvant chemotherapy (Fig. 1). Furthermore, a decline of the inhomogeneous tumor configuration could be depicted (Fig. 2). The assessment of the pharmacokinetic changes under therapy revealed a statistically significant decrease of the vascular permeability ($p < 0,05$). However, extracellular volume fraction changes revealed only a slight decrease under chemotherapy (mean decline of 18%).

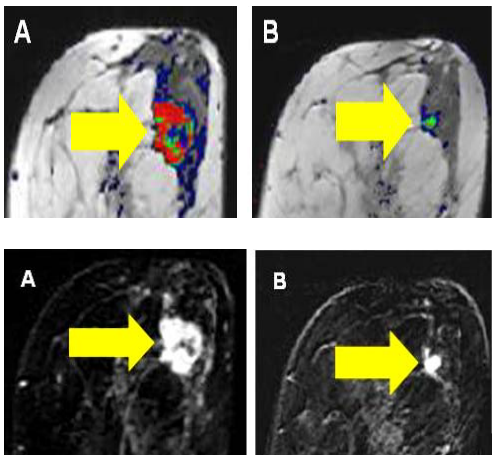

Fig.1 CAD imaging of an invasive ductal carcinoma before CTX (A) and in the follow up MR mammography (B) demonstrating therapy response by colour change from red (A) to blue areas (B).
Lower hand side: Concomitant subtraction imaging.

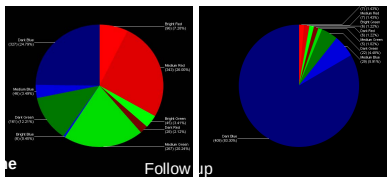

Fig.2: Contrast kinetic changes under primary systemic therapy, demonstrating the decrease of malignant enhancement patterns (red and green) and progressive fibrosis of the tumor (blue). The tumor shows a homogenization of its signal pattern.

Discussion:

Our results demonstrate the high diagnostic potential of computer aided analysis in therapy monitoring under neoadjuvant chemotherapy. The parametric analysis provides a fast and reliable evaluation of tumor size, contrast kinetics, vascular permeabilitiy and extracellular volume fraction. Thus, CAD analysis of contrast kinetic and pharmacokinetic parameters provides a valid assessment of early treatment response.

References

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