Monitoring treatment response to neoadjuvant chemotherapy in breast cancer by 3D proton magnetic resonance spectroscopy imaging

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Introduction: Breast cancer is the most common cancer in women worldwide. Over half a million women died of breast cancer in 2004. Early detection and treatment of breast cancer is crucial to lower the mortality. For breast tumors of large size and high grade neoadjuvant chemotherapy is applied before surgery. However, not all patients are responders to this treatment. Thus it is important to monitor the response to neoadjuvant chemotherapy in order to allow modification and changes to the treatment planning. [1]H-MR Spectroscopy may offer substantial advantage over standard MR imaging for the monitoring of treatment [1]. With three dimensional magnetic resonance imaging (3D-MRSI) a large fraction of the breast can be covered within one measurement and provide metabolic information. [2]

Materials and Methods: In total treatment response in 11 patients with confirmed cancer (via biopsy) was monitored over six cycles of chemotherapy. All measurements were performed on a 3T MR system (Siemens Tim Trio) using a four channel breast coil with patients in prone position. Written informed consent and approval of the local review board was obtained from all patients. A routine clinical protocol that include a three-dimensional, T_1 weighted, turbo, fast low-angle shot sequence (FLASH), a T_2 weighted, short inversion time inversion-recovery sequence (STIR) and dynamic contrast-enhanced MRI (DCE-MRI) was used. Additionally a 3D-MRSI sequence with PRESS pre-selection was performed (TR/TE = 750/145 ms). The T_1 weighted image was reconstructed to slices in all three dimensions to perform an accurate positioning of the MRSI volume. The Field of View (FOV) was 12 x 12 x 12 cm^3. 3D-MRSI was performed before contrast agent injection to avoid any influence of the contrast agent on the detected choline signal. To avoid noise contributions or aliasing for 3D-MRSI the contra-lateral reception coil was deactivated. The sequence included weak water suppression and spectral fat suppression and spatial outer volume suppression. Nominal voxel size was set to $1\times1\times1cm^3$ in all measurements. Weighted k-space sampling was used (5 averages) resulting in measurement time of approx. 12 min. Before processing, the data were zero filled from $12 \times 12 \times 12$ to $16 \times 16 \times 16$ voxels. A Hamming-filter (100%) was applied. SNR values were calculated for each lesion using spectral postprocessing software based on Matlab in the frequency domain.

Results: Data from 11 histology proven cancer patients were successfully acquired. Nine invasive ductal carcinomas (IDC) and two invasive lobular carcinomas (ILC) were examined. The age of the patients was between 33 and 69 years (mean = 52). The response to the chemotherapy was evaluated by a physician based on different imaging modalities. The mean value of the choline SNR decreased by 94% for the excellent, 84% for the good and 21% for the poor or non-responder after chemotherapy, see Figure 1. The number of voxels which contained choline decreased by about 92% for excellent, 70% for good and 38% for poor or non-responders after chemotherapy, see Figure 1. In Figure 2, a spectrum from the same position of a 47 years old patient is displayed before and after chemotherapy. The SNR value of choline decreased about 90 %.

Figure 1: The left Boxplot illustrates the distribution of SNR values before and after chemotherapy for different classes of responders (excellent, good, poor/non). The right Boxplot illustrates the numbers of voxels containing choline for the same classes.
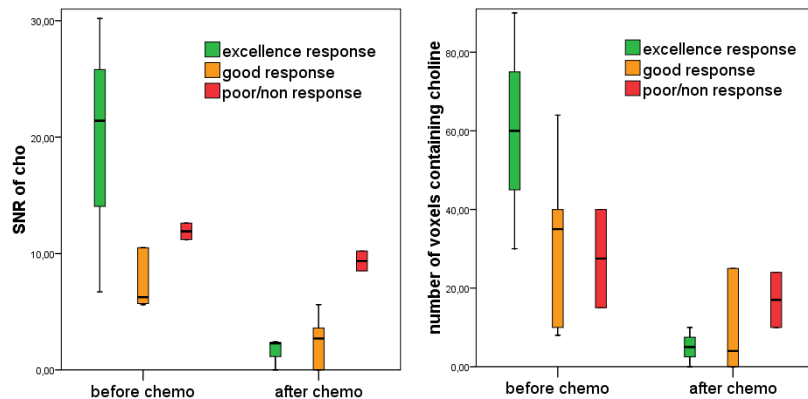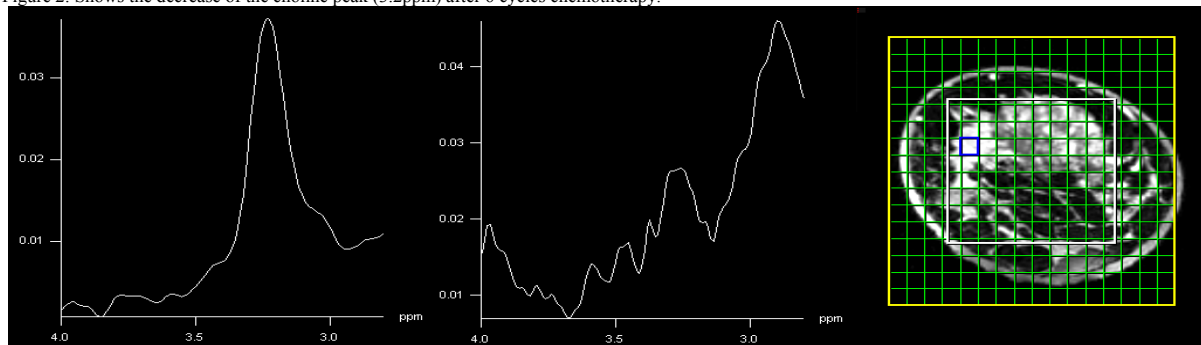

Figure 2: Shows the decrease of the choline peak (3.2ppm) after 6 cycles chemotherapy.

Discussion and Conclusion: In this study the treatment response to neoadjuvant chemotherapy by ^{1}H-MRSI was evaluated. Our results show that 3D-MRSI may improve early monitoring of treatment response in breast cancer. By using 3D-MRSI not only the SNR values for Cho , but also the number of choline containing voxels could be a helpful marker for treatment response. We conclude that 3D-MRSI at 3T is a flexible tool which can be applied for monitoring treatment response in a clinically feasible measurement time.

References: [1] Bartella et all, W. Proton (1H) MR spectroscopy of the breast. *Radiographics : a review publication of the Radiological Society of North America, Inc.* 2007;27 Suppl 1:S241-52. [2] Hu et all., An improved 1H magnetic resonance spectroscopic imaging technique for the human breast: preliminary results. *Magnetic resonance imaging.* 2005;23(4):571-6.