In vivo proton 1.5-T MR spectroscopy of the breast using the total choline peak integral as a marker of malignancy

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Purpose: The total choline-containing compounds (tCho) spectral profile reflects abnormalities of choline phospholipid metabolism in tumors, as demonstrated with ex vivo studies (1,2). Initially, tCho peak was considered as a dichotomous variable (present or absent) (3). Later, tCho absolute quantification was proposed using either an internal (4) or an external standard of reference (5). Our purpose was to use tCho peak integral as a marker of malignancy in proton magnetic resonance spectroscopy (MRS) of the breast.

Methods and materials: We prospectively enrolled patients with a scheduled diagnostic breast magnetic resonance imaging (1.5 T, Sonata, Siemens). Inclusion criteria: occurrence of one or more contrast-enhancing masses measuring at least 10 mm in the largest diameter. Exclusion criteria: previous or current neoadjuvant chemotherapy or radiation therapy; previous interventional or surgical procedures in the three months preceding the examination. A single-voxel water- and fat-suppressed point resolved spectroscopy (PRESS; TR/TE=1500/136 ms, flip angle 90°, 512 measurements) sequence was acquired. The position and size of the volume of interest (VOI) were chosen to encompass each enhancing lesion limiting as much as possible the inclusion of nonenhancing gland parenchyma and surrounding fat. Postprocessing: signal truncated to 1024 points and then zero-filled to 2048 points; Fourier transform; Hanning filter (width 400 ms; center 3.2 ms); and phase correction. A Gaussian curve fitting between 3.14 ppm and 3.34 ppm was finally applied to measure absolute and normalized tCho peak integral. Reference standard was histology for BI-RADS 4-5 lesions and at least a 2-year negative follow-up for BI-RADS 2-3 findings and normal glands. Mann-Whitney test, ROC analysis and Spearman coefficient were performed.

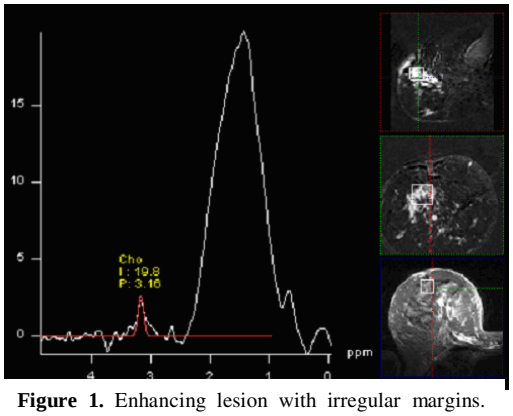

Figure 1. Enhancing lesion with irregular margins. The spectrum (range from 0.00 to 5.00 ppm) is shown with the fitting line for calculating the integral of tCho) is drawn in red. Note the evident peaks of residual lipids on the right, due to the inclusion of fat in the VOI. The position of the volume of interest is shown on the right. Pathology: invasive ductal carcinoma.

Results: Forty-two patients were evaluated for a total of 45 measurements. Eighteen non-malignant tissues showed no detectable tCho, 8 non-malignant tissues showed an absolute tCho peak integral from 0.99 to 9.03 arbitrary units (au) and 19 malignant lesions showed an absolute tCho peak integral from 1.26 to 19.80 au. An example of the tCho peak is shown in Figure 1. The diameter of non-malignant tissues was 16.9±7.4 mm; that of malignant lesions was 15.3±6.9 mm (p=n.s.). At ROC analysis (Figure 2), the optimal threshold was 1.90 au for absolute tCho peak, with 0.90 (17/19) sensitivity, 0.92 (24/26) specificity, and an area under the curve (AUC) of 0.92 (95% confidence interval 0.82, 1.00) while it was 0.85 au/mL for the normalized tCho peak integral with 0.84 (16/19) sensitivity, 0.89 (23/26) specificity, and an AUC of 0.94 (95% confidence interval 0.88, 1.00) (p = 0.470). A negative correlation (r = 0.571; p = 0.011) was found between the VOI and the normalized tCho peak integral of malignant tissues. The whole examination time was < 40 min, including MR imaging and single-voxel proton MRS.

Conclusion: In vivo 1.5-T proton MRS of the breast can be added as a last phase after breast MR imaging. Moreover, we showed that breast MRS using tCho peak integral allows to get high values of sensitivity and specificity, with a ROC-AUC higher than 0.90 also for relatively small tissue samples.

References

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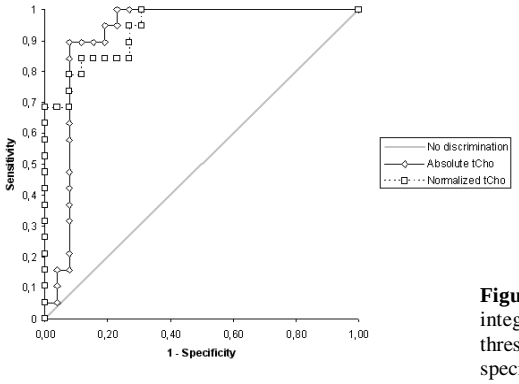

Figure 2. ROC curves. The area under the curves were 0.917 for the absolute tCho peak integral and 0.941 for the normalized tCho peak integral (p=0.470). The optimal threshold was 1.90 *au* for the absolute tCho peak integral (0.895 sensitivity and 0.923 specificity) and 0.85 *au*/mL for normalized tCho peak integral (0.842 sensitivity and 0.885specificity).