Differentiating between benign and malignant breast tumors using the choline concentration as determined by chemical shift imaging

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Purpose Most MRS studies of breast tumors published to date used semi-quantitative measures such as the visibility or signal-to-noise ratio of the choline (Cho) peak as markers of malignant breast lesions. It has been known, however, that benign lesions and normal breast tissues also contain detectable levels of Cho (**1-6**). In this study quantitative chemical shift imaging is used to determine the Cho concentrations in benign and malignant breast lesions. The purpose is to determine whether or not Cho concentration can be of clinical use in the differentiation between benign and malignant lesions.

Methods The MRS protocol included 2D-CSI with point resolved spectroscopy (PRESS) double spin-echo with phase-encoding gradients between the slice selective 90º pulse and the first slice-selective optimized 180º pulse. 2D-CSI of the breast was performed twice, first without suppression of the water and fat signals to serve as a reference measurement, next with suppression of the water and fat signals (TR 1500ms, TE 135ms) to be able to detect Cho (**6**). The field of view was 8x8 cm to roughly cover the transverse cross section of the examined breast, subdivided into 144 phase encode steps at the used slice thickness of 1 cm (acquisition time 4:46 min). In this hybrid CSI technique the volume of interest on which the automated adjustments of B_0-field (shimming), frequency, transmitter gain and receiver attenuation were performed, was smaller than the field of view (3x3x1 cm) in order to end up with essentially measuring the watery part of the breast (glandular breast tissue, pathology). Unwanted water and lipid signals were suppressed by band selective inversion with gradient dephasing (BASING).
The final diagnosis of the 25 breast lesions larger than 1 cm diameter (from 24 consecutive patients aged 32-69 years, assessed as BIRADS 3 of 4 by mammography) which were examined by MRS, was confirmed by pathology.

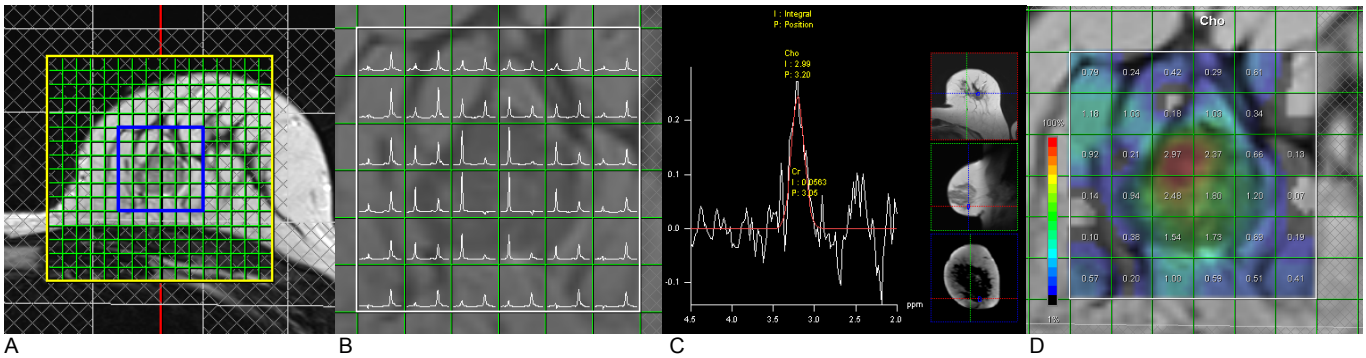
Results Fourteen out of 25 breast lesions were malignant. The mean and the highest Cho concentration in the breast lesions, measuring 2-10 MRS voxels each, were determined. The mean Cho concentration in benign lesions varied between 0.3 and 1.3 mM (0.84 ± 0.32 SD), that in malignant lesions between 1.3 and 9.5 mM (3.10 ± 2.21 SD). The respective highest Cho concentrations in benign and malignant lesions were 0.4 - 1.5 mM (1.19 ± 0.33 SD) and 1.7 - 11.8 mM (4.08 ± 2.81 SD). Mean and highest Cho concentrations in benign and malignant breast lesions differed significantly:

Means and standard deviations for chemical shift and concentration of Cho in benign and malignant lesions

	Benign lesions (n=11) Mean (SD)	Malignant lesions (n=14) Mean (SD)	P-value
Cho peak position (ppm)	3.24 (0.07)	3.18 (0.05)	0.04
Mean Cho concentration (mM)	0.84 (0.32)	3.10 (2.21)	0.02
Highest Cho concentration (mM)	1.19 (0.33)	4.08 (2.81)	0.02

Discussion Most of the studies published to date use single-voxel MRS methodology suffering from limitations inherent to the method used. The remainder are multivoxel studies using qualitative or semiquantitative measurements for the detection of Cho (i.e. detectability or Cho signal-to-noise ratio) (**1-5**). In our study a recently published multivoxel MRS method based on quantitative measurement was used (**6**). The significant difference between the Cho concentrations in benign and malignant breast lesions strongly indicates that the lesion Cho concentration in mM offers a diagnostically meaningful test, i.e. a cut-off point of 1.5 mM. Quantitative multivoxel MRS may thus be applied to reliably exclude benign breast lesions such as fibroadenomas from biopsy or other invasive procedures.
In agreement with an observation made by Stanwell et al. (**7**) in benign tumors the -$N(CH_3)_3$ resonance of Cho tended to have a higher chemical shift than in malignant tumors.

References **1.** Roebuck JR et al. Radiology 1998;209:269-275. **2.** Kvistad KA et al. JMRI 1999;10:159-164. **3.** Bolan et al. MRM 2003;50:1134-1143. **4.** Bartella et al. Radiology 2006;239;686-692. **5**. Bartella et al. Radiology 2007;245:80-87. **6**. Sijens PE et al. Magn Reson Imaging 2010;28:314-319. **7**. Stenwell et al. Eur Radiol 2005;15:1037-43.



A B C D

Volume of interest (36 voxels of 0.25 cm^3 each) centered on an invasive ductal carcinoma in the left breast of a 38 year old patient (A), and spectral map showing intense water and minor fat peaks in the lesion (B). After application of water and fat suppression, an intense Cho peak is detected in the tumor (C) showing up as hyperintense in the Cho map (D).