Breast Tissue Classifications by CART Analysis of Localized 2D COSY

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Introduction:

Magnetic Resonance Spectroscopy (MRS) allows noninvasive measurements of the concentrations of choline, water, lipids, saturated and unsaturated fatty acids in human breast in vivo (1). Two-dimensional (2D) MRS has improved resolution than one-dimensional (1D) MRS due to the additional J-coupling information in the second dimension and has previously been used in breast cancer detection (2). 2D MRS can detect metabolites in both diagonal and cross peaks, some of the diagonal and cross peak metabolite ratios are significant different between different breast tissues. The purpose of this study is to use classification and regression tree (CART) analysis (3) for classification of the four different breast tissues (malignant tumor, benign tumor, healthy fatty and healthy glandular tissues) non-invasively based on different metabolite ratios from 2D COSY of breast tissues.

Methods:

A total of 31 women participated in this study, including 13 healthy women (mean age 43 year old), 9 subjects with malignant tumor (mean age 51 year old), 9 women with benign tumor (mean age 38 year old). For healthy volunteers, T2 Weighted MRI images were used for 2D COSY localization; for malignant and benign patients, DCE MRI was used for 2D COSY localization. 2D L-COSY data were acquired by using the 2D L-COSY pulse sequence consisted of three slice-selective pulses (90^0-180^0-90^0) to excite the desired voxel, The size of each VOI was $1 \times 1 \times 1 cm^3$ for each acquisition; the total scan time is 12 minutes. All 2D MRS data files were processed using Felix2000 software package (Accelerys Inc., San Diego, CA). The data were zero-filled to 2048 x 96 points, filtered and Fourier-transformed along both dimensions. The 2D L-COSY spectral peaks were displayed using contour plots in the magnitude mode, which were used to evaluate the spectra and to calculate the volume under each detectable peak. Each 2D spectrum contains contributions from the following proton resonances: Water (WAT), (4.8, 4.8)ppm, Fat (FAT) (1.4, 1.4)ppm ; Methyl Fat (FMETD) (0.9, 0.9) ppm ; Olefinic Fat (UFD) (5.4, 5.4)ppm ; Choline (CHO) (3.3, 3.3)ppm ; (UFR) (2.1, 5.4)ppm ; UFL (2.9, 5.4) ppm; Triglyceryl fat cross peak (TGFR) (4.3, 5.3)ppm. 9 diagonal peak metabolite ratios (WAT/FAT, WAT/CHO, WAT/FMETD, WAT/UFD, CHO/FAT, CHO/FMETD, CHO/UFD, FAT/UFD,FAT/FMETD) and 9 cross and diagonal peak metabolite ratios(WAT/UFR, WAT/UFL, WAT/TGFR, CHO/UFR, CHO/UFL, CHO/TGFR, FAT/UFR, FAT/UFL ,FAT/TGFR)were calculated and inputted into the CART analysis software package (Salford System, San Diego, CA), which is used to do classification among the four different breast tissues.

Results:

Out of the 18 different metabolite ratios, 9 metabolite ratios (WAT/FAT; WAT/UFD; CHO/UFD; CHO/FMETD; CHO/UFR; CHO/UFL; FAT/UFR;FAT/UFL;FAT/TGFR) were significant different ($p < 0.05$)to distinguish between 3 different breast tissues. CART selected the combination of 3 diagonal and cross peak ratios: WAT/FAT, FAT/UFR, CHO/UFD as classification features for discrimination among the four different breast tissues. In all the patients and healthy volunteers, there are 11 benign tumors, 18 healthy fatty, 8 healthy glandular breast tissues and 13 malignant tumors. The classification results are shown in Table 1:

Table 1 CART analysis predicated classification of four different breast tissues
Total=50, Overall % Correct = 82.00%

	Predicted Benign	Predicted Fatty	Predicted Glandular	Predicted Malignant	Total
Actual Benign	8(72.7%)	0	2(18.2%)	1(9.1%)	11
Actual Fatty	0	18(100%)	0	0	18
Actual Glandular	1 (12.5%)	0	6(75%)	1(12.5%)	8
Actual Malignant	0	0	4(30.8%)	9(69.2)	13

Discussion and Conclusion:

Two-dimensional L-COSY can identify the many resonances of metabolites and lipids found in human breast tissue by detecting both diagonal and cross peaks. CART can classify four different breast tissues by using the L-COSY peak volumes metabolite ratios. CART is inherently non-parametric statistical analysis method, no assumptions are made regarding the underlying distribution of values of predictor variables(4), the classification result is unbiased because of the cross-validated method. This is the first report that CART analysis was used to classify 4 different breast tissues, it can reach an overall correct rate of 82.0% in discriminating 4 different breast tissues. This method has the potential to be used in clinical for automatic noninvasive breast cancer detections. It needs to be evaluated using a large cohort of breast cancer patients.

References:

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