Long-term reproducibility of MRS system

A. Polnik[1], M. Wicher[2], T. Banasik[2], A. Kieltyka[2], M. Konopka[3], and M. Sokó[3,4]

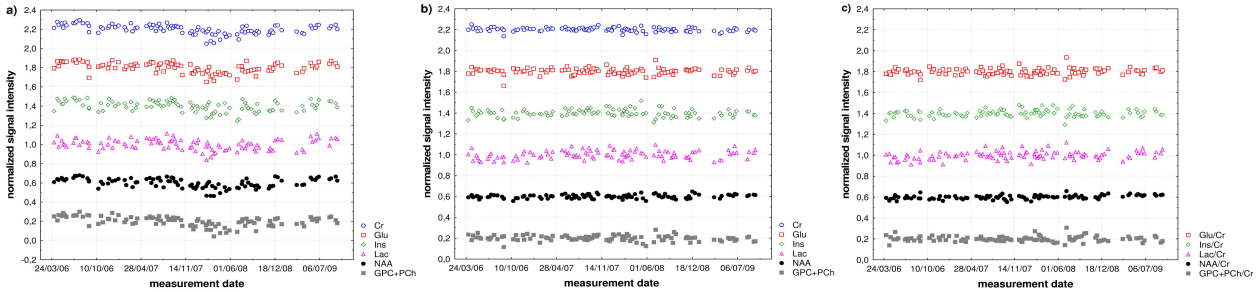
[1]Department of Medical Physics, Maria Sk[3]odowska-Curie Memorial Cancer cenetr and Institute of Oncology, Gliwice, Poland, [2]Helimed Diagnostic Imaging, Katowice, Poland, [3]Helimed Diagnosic Imaging, Katowice, Poland, [4]Maria Sk[3]odowska-Curie Memorial Cancer Center and Institute of Oncology, Gliwice, Poland

Introduction: Proton magnetic resonance spectroscopy (^{1}H MRS) *in vivo* is frequently considered to be a quantitative technique allowing for longitudinal monitoring of disease progression or efficacy of the treatment. However, absolute quantification of the metabolite levels requires several quality control procedures ensuring reliability of the obtained results. One of the main drawback of the so called phantom calibration techniques is the necessity for the temporal scanner instability correction. To achieve this the spectra from a phantom with a known concentration of metabolites should be measured periodically to monitor the time dependent-changes in the scanner performance. The purpose of this work was to assess long-term reproducibility of the scanner.

Materials and methods: ^{1}H MRS measurements were performed on 1.5T GE scanner equipped with a transmit/receive head coil. A standard spherical brain phantom provided by the manufacturer was used. The phantom contains: 12.5 mM N-acetylaspartate (NAA), 10 mM creatine (Cr), 3 mM choline (Cho), 7.5 mM myo-inositol (Ins), 12.5 mM glutamine (Glu), 5 mM lactate, 50 mM potassium phosphate monobasic, sodium hydroxide sodium azide, magnevist. The measurements were performed from April 2006 to September 2009. The spectra were recorded from the volumes of interest located in the center of the phantom using the following acquisition parameters: echo time (TE) 35 and 144 ms, repetition time (TR) 1500 ms, number of signal averages 64, bandwidth 2500 Hz, samples 2048. The total number of spectra measured for TE = 35 ms was 99, while for TE = 144 ms - 96. LCModel software enabling a fully automatic analysis was exploited in the evaluation of the spectra. The metabolite levels were estimated using both a phantom calibration technique and a water scaling method for the sake of comparison. The former method relies on determination of a scaling factor based on measurements of a metabolite solution with a known concentration, while in the latter approach unsuppressed water references are used. The data were not corrected for relaxation. Arbitrarily chosen factor was used to obtain mean NAA concentration of 12.5 mM. The metabolite ratios to creatine were also assessed. Only the spectra with FWHM < 0.03 ppm were taken into account. The results are presented by means of the scatterplots, means, standard deviations and coefficients of variation of the respective spectroscopic parameters.

Results and discussion: Figures 1 and 2 present the dependency of the normalized signal intensities and ratios on the date of measurement for TE 35 ms and 144 ms, respectively. The normalization was achieved by dividing each value of the spectroscopic parameter by the mean value of this parameter. The scatterplots for various metabolites are presented with vertical scale offsets to facilitate interpretation of the plots. The coefficients of variation presented in tables (figures 1, 2) confirm that the greatest variability is observed for the phantom calibration technique. Tables present also means and standard deviations of the metabolite levels and ratios. The results of the analysis of the dataset acquired for TE = 35 ms prove intuitive trend that the metabolites characterized by the highest SNR (Cho, Cr, NAA) are described by the lowest variability. Of note, coefficients of variation do not exceed the value of 6% for any metabolite over three years of the experiment.

Conclusion: The analysis of the results confirm relatively good long-term stability of the scanner over the evaluated period of time. Knowledge about the ranges of signal variability in the normal work of the scanner seems to be of crucial importance in detection of subtle metabolic changes.

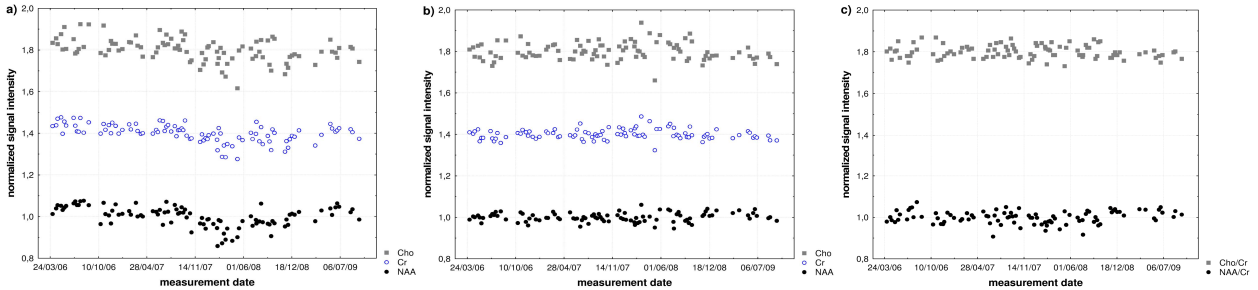


	Cho	Cr	NAA	Glu	Ins	Lac
mean	3.02	10.19	12.5	11.67	6.73	5.86
standard deviation	0.15	0.5	0.61	0.62	0.37	0.32
coefficient of variation	5.08	4.89	4.89	5.28	5.43	5.49

	Cho	Cr	NAA	Glu	Ins	Lac
mean	3.02	10.19	12.5	11.67	6.73	5.86
standard deviation	0.08	0.19	0.23	0.35	0.24	0.24
coefficient of variation	2.7	1.88	1.82	3.04	3.56	3.56

	Cho/Cr	NAA/Cr	Glu/Cr	Ins/Cr	Lac/Cr
mean	0.3	1.22	1.14	0.66	0.58
standard deviation	0.008	0.02	0.04	0.02	0.02
coefficient of variation	2.63	1.9	3.13	3.31	3.96

Fig. 1. Temporal variability of (a) normalized metabolite levels determined with the use of a phantom calibration technique, (b) normalized metabolite levels determined with the use of a water scaling technique, (c) normalized metabolite ratios to creatine. Tables presenting mean metabolite levels (mM), standard deviations and coefficients of variation for (a) phantom technique, (b) water scaling technique and (c) metabolite ratios are also shown. The data were measured for TE equal to 35 ms.



	Cho	Cr	NAA
mean	1.99	8.83	12.5
standard deviation	0.11	0.37	0.6
coefficient of variation	5.53	4.19	4.81

	Cho	Cr	NAA
mean	1.99	8.83	12.5
standard deviation	0.08	0.21	0.27
coefficient of variation	1.35	1.77	2.63

	Cho/Cr	NAA/Cr
mean	0.23	1.41
standard deviation	0.007	0.04
coefficient of variation	3.11	2.99

Figure 2. Temporal variability of (a) normalized metabolite levels determined with the use of a phantom calibration technique, (b) normalized metabolite levels determined with the use of a water scaling technique, (c) normalized metabolite ratios to creatine. Tables presenting mean metabolite levels (mM), standard deviations and coefficients of variation [%] for (a) phantom technique, (b) water scaling technique and (c) metabolite ratios are also shown. The data were measured for TE equal to 144 ms.