1H MRS SIGNAL CALIBRATION IN CLINICAL CONDITIONS USING A NON-SYNCHRONIZED REFERENCE SIGNAL (ERETIC II)

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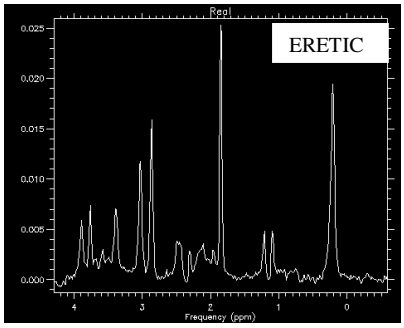

Fig1: ERETIC peak in the spectrum

Introduction

Calibration is one of the main problems faced in proton MR spectroscopy. Some of the current methods use external phantoms with known metabolite concentrations for referencing, yielding e.g. a coefficient of variation for NAA (N-Acetyl-Aspartate) of 6% to 15% at 1.5Tesla in the human brain.

The ERETIC method (Electronic REference To access In vivo Concentrations) consists of adding a pseudo-FID (Free Induction Decay) into the signal which can be used to calibrate the acquisition tools (coils, amplifiers, analog to digital converters, etc.). This pseudo-FID is a synthesized NMR reference produced by an electronic device. The ERETIC peak is not depending on any physical parameters. The ERETIC method developed by Barantin *et al.*[1,2], uses data synchronization of the ERETIC signal and NMR metabolite signals. Here, we present a method ERETIC-II not requiring any synchronization of the NMR hardware and the device generating the ERETIC signal.

Materials and Methods

Ten ^{1}H-MRS experiments were performed on a GE clinical 1.5 Tesla scanner (Signa HDx) using an eight-channel phased array and a quadrature head coils. The localized single voxel ^{1}H MR spectra were acquired using the PRESS based probe-p sequence with TE=35 ms, TR=1500 ms and 8 excitations (NEX=8). All tests were performed with the GE MRS sphere which contains metabolites such as NAA, Cr or Cho in known concentrations. The phantom was put on a support holder in order to obtain good reproducibility of the location inside the coil. The ERETIC peak (a sinus outside the range of main frequency resonance e.g. outside [1ppm;4ppm] see Fig1) was produced by an arbitrary waveform generator, Tektronix AFG3102.

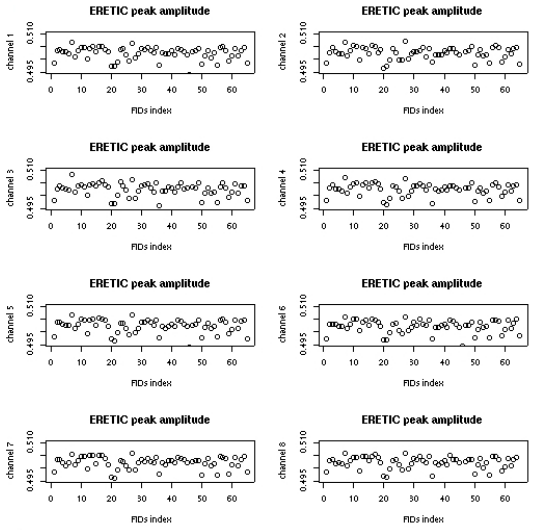

Fig2 : ERETIC peak per channel

The ERETIC signal was continuously sent without synchronization and apodization through a copper coil fixed inside the scanner room. Unprocessed MR spectra were acquired and stored in full temporal resolution without averaging the FIDs (acquisition in a special mode : the averaging was turned off and each FID is recorded).

FIDs were separately analyzed with a home-written program (in Scilab©INRIA-ENPC, open source), named SCI-MRS-LAB. An exponential method was used to suppress the residual water peak. The ERETIC peak was fitted using an exponential function $\exp(a_0+a_1t)$ and its amplitude was estimated by Re ($\exp(a_0)$).

Results

In order to quantify the precision of the calibration procedure, two types of parameters were studied : the intra-recording variability and the inter-recording variability. The intra-recording variability for one acquisition is measured by the mean coefficient of variation of estimated signal amplitudes. The inter-recording variability is measured by the standard deviation of the mean amplitude of each recording.

The estimated amplitude of the ERETIC peak per channel is shown in Fig 2. For each acquisition the intra-variability coefficient of variation (CV) was found to be 0.5%. The inter-recording CV was to be around 0.2% in various recordings.

Discussion and Conclusion

The acquisition tools calibration may decrease the overall variabilities. Nevertheless, the ERETIC peak must be calibratedand compensated to reach a constant value in spectra.

Molinier *et al.*[4] have implemented the ERETIC method (on a Bruker spectrometer) by acquiring the ERETIC signal and the sample signal in two different acquisitions in order to make a phase correction of both signals before adding them. In that implementation the ERETIC method gave a precision of 2% for phantom experiments. For Akoka *et al.*[3] the accuracy of ERETIC method was reported to be slightly better than a calibration method with an internal reference. For *in vitro* studies, the mean error was found to be lower than 3%.

ERETIC stability poses a crucial problem for using it as a calibration. This study has shown improved intra-acquisition variability of less than 1% compared to previously published results. The reproducibility over a period of two weeks with a CV of about 0.2% was also found to be significantly better than the published results : Akoka *et al.*[3] found CV about 0.76% for a 56-hour study between CH_3 of Lactate and ERETIC. We think that this improvement of the estimation of ERETIC amplitude signal is due to the non-synchronization. In fact, the introduction of a non-synchronized signal detection and the fully time resolved signal processing, allow for corrections of synchronization errors, which is not possible with averaged data.

The proposed method impresses by its simplicity compared to earlier implementations, decreases intra- and inter-acquisition variability of ERETIC signal amplitude and allows to avoid difficulties of signal synchronization. The only limitation is that the raw file is bigger (each FID is recorded) and signal processing is more intensive, especially in CSI where our method could also be applied.

The ERETIC-II method, allows detection of problems with individual RF channels and provides a simple tool for quality control on the acquisition chain (analog to digital converter). By controlling the quality of the acquisition chain we hope to improve quantification of biological variability in pathologies.

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References:

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