Electronic reference for absolute quantification of brain metabolites by 1H-MRS on clinical whole body imager.

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Since in SRM the peak area is proportional to the concentration of the corresponding metabolite, the individual and the absolute metabolite concentrations can be estimated if at least one metabolite concentration is known (used as a reference concentration). Many strategies for absolute quantification have been proposed among which the ERETIC™ (Electronic Reference To access *In vivo* Concentration) method (1). Originally this method implies that the reference signal is transmitted during the reception of the NMR signal. It is therefore necessary to use a second radiofrequency channel capable of transmitting while the principal channel is in the reception configuration. However, most clinical scanners have only one RF channel. To overcome this difficulty we developed another approach consisting in the transmission of the ERETIC signal during a different acquisition from the localized spectroscopy acquisition (just before or just afterwards). The ERETIC sequence sent a rectangular pulse of 5 ms duration 5 ms after the onset of sampling period (Figure 1a). This signal was transmitted by the body coil.

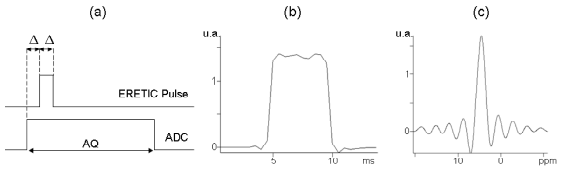

Figure 1: The sequence used to produce the ERETIC signal (a). The real part of the ERETIC signal (b) and its Fourier transform (c). (Δ = 5 ms).

MATERIALS AND METHODS

All measurements were carried out using a 1.5 T whole-body MR system (Sonata, Siemens AG, Erlangen, Germany) with a CP head coil. Water-suppressed and water ^{1}H-MRS were performed using PRESS sequences with an echo time (TE) of 30 ms and a repetition time (TR) of 3000 ms. The water and metabolite concentrations were measured in a phantom containing NAA, creatine, myo-inositol, glutamate, choline in phosphate buffer. We acquired the proton brain spectra of ten volunteers, who gave their informed consent. This investigation was in compliance with our Institutional Research Review Board. An ERETIC reference signal was acquired at the beginning of the examination of each volunteer. Calibration acquisition was carried out at the beginning of each half-day.

Table 1: Concentrations (mM) measured on phantoms ± std calculated over 5 measurements. (a) measured in high resolution NMR, (b) measured using water as reference and (c) measured using ERETIC.

	Water	NAA	Cho	Cr
H.R. [a]	39.8 ± 0.1	11.49 ± 0.09	2.57 ± 0.01	8.27 ± 0.05
Ref. Wat [b]		11.0 ± 0.2	2.7 ± 0.8	7.5 ± 0.2
Ref. Eret. [c]	39.7 ± 0.3	11.1 ± 0.1	2.7 ± 0.5	7.6 ± 0.2

Table 2: Concentrations (mmol.kg^{-1}ww) ± std calculated over the ten volunteers. (a) measured using water as reference and (b) measured using ERETIC.

	Water	tNAA	Cho	Cr
Ref. Water [a]		13.0 ± 2.2	1.7 ± 0.2	6.8 ± 0.9
Ref. Eret. [b]	33.9 ± 1.1	12.3 ± 2.0	1.6 ± 0.2	6.5 ± 0.9

RESULTS

Table 1 shows the results on phantoms using the ERETIC signal as reference, water as reference and the concentrations measured by high resolution NMR. The means and standard deviations were calculated over five experiments. Table 2 shows the metabolite concentrations of the ten volunteers using the ERETIC technique as well as water reference technique. A good linear correlation was observed between the results of both techniques: ($C^{Eret.} = 0.94\ C^{Water} + 0.02$ with $R^2 = 0.997$).

DISCUSSION AND CONCLUSION

The metabolite concentrations that were calculated by the ERETIC™ method were close to those obtained by high resolution NMR (for phantoms) or values found in the literature (for volunteers) (2). Because the *in vivo* measurements were performed on volunteers, the water signal as reference did not induce any bias and it can therefore be concluded that both methods gave accurate results. Furthermore, with the ERETIC™ technique the water content can be measured as an additional parameter for pathology evaluation.

The constraints of using the ERETIC method are the need (i) to perform a calibration acquisition on a phantom with known concentrations and (ii) to measure the ERETIC signal at the beginning of each volunteer (or patient) examination. However, the frequency actually needed has yet to be evaluated. Concerning the ERETIC measurement, it takes less than one minute so does not lead to a significant increase in the total examination time.

We have therefore demonstrated that the ERETIC™ method can be used on clinical MR scanners comprising only one RF channel. Our preliminary results, obtained on a small population of volunteers, confirm the reliability of this technique.

REFERENCES

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