Quality control for 1HMRS longitudinal studies

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1. Introduction.

Proton magnetic resonance spectroscopy is a promising method to diagnose and track the progression of neuro-degenerative diseases such as Alzheimer's disease and multiple sclerosis. In our hospital some longitudinal studies have been performed[1]. Such studies require longitudinal measurements over periods of months to years, and require great stability (few percent, if possible) of scanner output. To assure the coherence of data we planned a quality assurance protocol for spectroscopy acquisition. We present a simple, non computational expensive and closely related to clinical acquisition quality control protocol.

2. Materials and methods.

All measurements were performed on a GE signa LX 1.5 T MRI scanner (General Electric Medical Systems, Milwaukee, WI, USA) using a standard quadrature transmit/receive volume resonator and the GE brain MRS phantom MRS-HD sphere (see table 1). PRESS pulse sequence was used with different TE and TR, number of points (spectral resolution)=2048, bandwidth=4000 Hz and phase cycling=8, number of average = 128. Data processing was performed with the scanner build-in PROBE/SVQ reconstruction. In addition each set of FID was processed on a SGI workstation using a dedicated software package SAGE (General Electric Medical Systems, Milwaukee, WI, USA) as well as using a home-made software based on the same algorithms of commercial software[2]. In all figures the data presented are elaborate via PROBE/SVQ reconstruction.

Table 1: GE brain MRS phantom MRS-HD

Metabolite	*Concentration*
N-acetyl-L-aspartic acid (NAA)	12.5 mM
Creatine hydrate (Cr)	10 mM
choline chloride (Cho)	3 mM
myo-inositol (mI)	7.5 mM
L-glutamic acid	12.5 mM
DL-lactic acid	5 mM
sodium azide	0.1%
KH_2PO_4	50 mM
sodium hydroxide	56 mM
Gd-DPTA (Magnevist)	1 ml/l

3. Results

The quality assurance protocol include: ***a) SNR*** To characterize SNR in *in vivo* spectra of patients with neuro-degenerative diseases we chosen area of creatine peak divided by spectrum noise (SNRCr). We defined noise, in our software and in macro written in SAGE/IDL[3] environment, as standard deviation of residual signal (signal minus fit of data). Also PROBE/SVQ provides SNRCr, but, as described by other authors[4], noise level determined by PROBE/SVQ showed large variations (see figure 1: linear regression of PROBE/SVQ SNRCr vs. TE in two measures at 6 months) while the variations measured with the other methods stayed below ± 2%. However PROBE/SVQ SNRCr is very useful in order to provide a quality index as an inferior limit (e.g. in AD patients must be greater of 20) immediately available after patients examination. ***b) Signal linearity.*** We performed this measure in order to check the metabolic signal linearity vs. volume of volume of interest (VOI) and SNRCr vs. VOI volume in phantom and in human (to determine minimum volume acceptable). In figure 2 we show the linear regression of signal intensity (in arbitrary units) for ◊ NAA, ∇ Cr, Δ Cho, ▷ mI vs. volume (in cm^3). Figure 3 shows the relationship between SNRCr PROBE/SVQ and volume of VOI:

$$SNR_{Cr} \propto \sqrt{Volume}$$

Figure 1

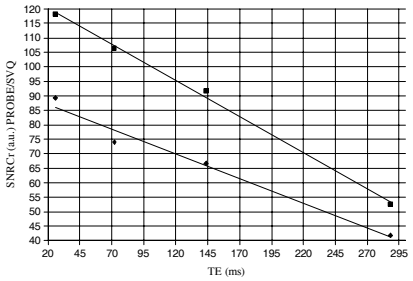
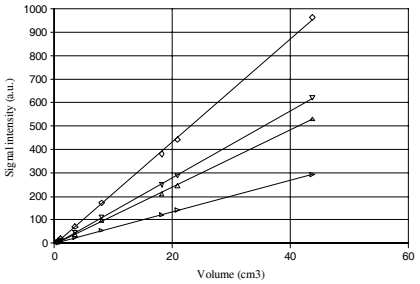


Figure 2



c) T2 relaxation. In figure 4 we show the measurement of T2 decay for all metabolites, the deviations of mono-exponential decay is due to overlap of peaks (e.g.: N-acetyl-L-aspartic acid and L-glutamic acid). T2 decay for all metabolites is very sensitive to scanner stability. In figure 5 two measures at one year are presented, the signal intensities are expressed, as usual in clinical application, in form of ratio with creatine signal intensity. For 50 ms < TE < 80 ms we have the maximum for the long term stability for all metabolite: < 1% for NAA/Cr, < 2% for Cho/Cr, < 5% for mI/Cr (using PROBE/SVQ reconstruction). ***d) T1 minimum acceptable.*** Measurement of T1 decay for all metabolites is useful to determine the minimum TR. For TR > 2000 ms the maximum increase in signal intensity for all metabolites is smaller of 1% **e)** ***Spectra quality vs. VOI position***. To check the influence of fields homogeneity in quality of spectrum we perform measures choosing VOI in different regions in the phantom.

In annual quality control we repeat all measures to characterize long term stability, for short term stability (every month) we repeat a) and c) only.

4. Conclusion

Proton magnetic resonance spectroscopy is a promising method to track the progression of neuro-degenerative diseases, but due to high sensitivity to scanner instability or initial set-up mistake longitudinal studies (over periods of months to years) are difficult. In this study we describe the results of a quality assurance program adopted to guarantee the coherence of the data in 1HMRS longitudinal studies.

Figure 3

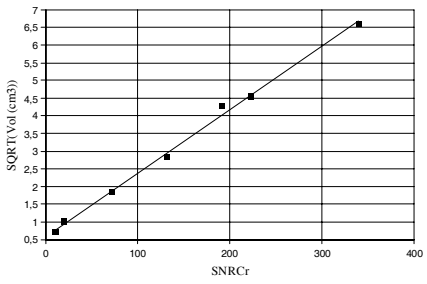


Figure 4

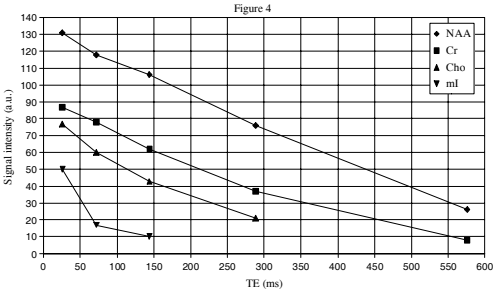
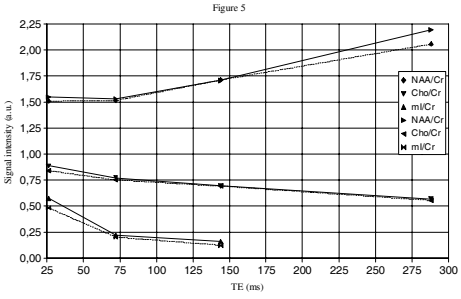


Figure 5



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[2] Operator Manual for SAGE software, GE Medical Systems, WI, USA

[3] IDL, ITT Visual Information Solutions, Pearl East CircleBoulder CO, USA

[4] Hancu I et al., Proceedings of the ISMRM 2004, p. 305 and Schirmer T et al. Proceedings of the ISMRM 2005, p. 2504