

Intra and inter-subject reproducibility of fully adiabatic ^{31}P GOIA-1D-ISIS/2D-CSI (goISICS) in calf muscle at 7T.

Marek Chmelik¹, Ivica Just Kukurova^{1,2}, Stephan Gruber¹, Martin Krššák³, Ladislav Valkovic¹, Siegfried Trattnig¹, and Wolfgang Bogner¹

¹MR Centre of Excellence, Dept. Radiology, Medical University of Vienna, Vienna, Austria, ²Department of NMR and MS, Institute of Analytical Chemistry, Slovak University of Technology, Bratislava, Slovakia, ³Department of Internal Medicine III, Medical University of Vienna, Vienna, Austria

Purpose/Introduction

^{31}P -MRS is a non-invasive tool which provides information about energy phosphate metabolites (ATP, PCr, Pi), intracellular pH, intracellular $[\text{Mg}^{2+}]$, and metabolites involved in malignant processes (PME, PDE). Recently, ^{31}P 2D-CSI based on GOIA-1D-ISIS/2D-CSI (goISICS) scheme enabled fully adiabatic acquisition with minimal chemical shift displacement error (CSDE) at 7T [1]. The purpose of our study was to analyze intra- and inter-subject variability of the goISICS sequence in the calf muscle at 7T.

Subjects and Methods

Data from six healthy volunteers (one female, 27±4 years) were acquired on a 7 T MR system (Siemens, Erlangen, Germany). The right calf of the volunteer was positioned on a double-tuned surface coil ($^1\text{H}/^{31}\text{P}$, d=10cm, RAPID Biomedical, Ohio, USA) with the medial head of the right gastrocnemius muscle over the center of the coil. Transversal ^{31}P goISICS data were acquired (FOV: 15x15x2.5cm³, CSI matrix 10x10, TA: 6 min 13 s, TE* = 0.3 ms, TR = 3s, spectral width 5000 Hz, 2048 points, 2.5 ms AHP excitation pulse, 5 ms GOIA-W(16,4)).

For intra-subject reproducibility the same protocol was performed five times in the calf muscle of one of the volunteers including full repositioning of the volunteer.

Three representative spectra (2.5 cm, 5 cm, and 7.5cm distance to coil) of all *in vivo* data sets were automatically quantified using AMARES.

To evaluate the *in vivo* reproducibility, the mean, standard deviation (SD), and coefficient of variation (CV) of all *in vivo* measurements were determined for the SNR, linewidth, CRLB of PCr, pH and the following metabolite ratios: Pi/PCr; γ -NTP/PCr; α -NTP/PCr; β -NTP/PCr; PME/PCr; PDE/PCr.

Results

The inter-subject reproducibility measurements showed comparable high quality spectra for distances 2.5 cm and 5 cm (SNR = 172 ± 35, FWHM = 5 ± 0.47 Hz and CRLB = 1.02 ± 0.13% vs. SNR = 167 ± 38, FWHM = 4.86 ± 0.92 Hz and CRLB = 1 ± 0.14% measured for PCr signal) and lower but still sufficient quality for distance 7.5cm (SNR = 71 ± 23, FWHM = 7.21 ± 0.63 Hz and CRLB = 2.29 ± 0.95%). Similar behavior was shown in intra-subject experiments (Table 1).

The intra-subject reproducibility (CV) was high for pH (0.2%, 0.1% and 0.2% for 2.5cm, 5cm and 7.5cm distance from the coil plane), γ -NTP/PCr (2%, 4% and 15%), α -NTP/PCr (8%, 6% and 23%) and Pi/PCr (5%, 15% and 38%) and lower for β -NTP/PCr (13%, 13% and 117%), PDE/PCr (14%, 11% and 37%) and PME/PCr (34%, 39% and 72%).

Discussion/Conclusion

In our study comparable data quality and inter and intra subject reproducibility was found as for 2.5 cm isotropic single voxel in 3 min 48 s at 7T using a surface coil [2]. Our approach offers multi-voxel localization in only double the measurement time (i.e. ~6min). The metabolite ratios obtained in our study are in agreement with previously published data [3].

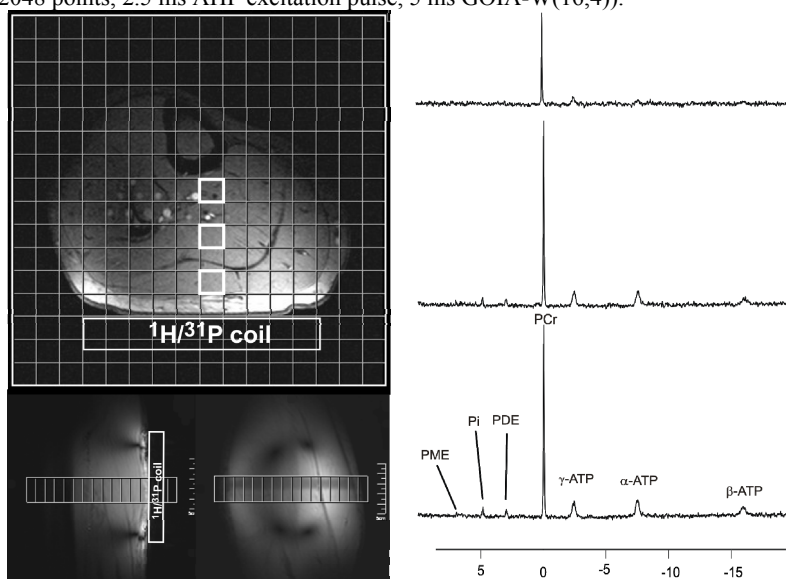


Fig.1. *In vivo* example of goISICS localization in the human calf muscle at 7T. Localizer with CSI grid and position of the surface coil (left). White boxes depict voxels used for quantification at approx. distance of 2.5 cm, 5 cm, and 7.5 cm from the coil center. Corresponding spectra are displayed on the right side.

Table 1. Intra-subject reproducibility of ^{31}P goISICS MRS in the calf muscle of one healthy volunteer (age 31 years) measured five times after complete repositioning.

	~ 2.5cm	~ 5cm	~ 7.5cm
FWHM	5.54 ± 0.49 (9%)	6.29 ± 0.32 (5%)	7.00 ± 2.29 (33%)
CRLB	1.03 ± 0.09 (9%)	1.19 ± 0.03 (2%)	2.38 ± 0.44 (18%)
SNR	148 ± 21 (14%)	133 ± 19 (14%)	63 ± 15 (23%)
pH	7.08 ± 0.01 (0.2%)	7.09 ± 0.01 (0.1%)	7.09 ± 0.01 (0.2%)
Pi/PCr	0.13 ± 0.01 (5%)	0.13 ± 0.02 (15%)	0.08 ± 0.03 (38%)
γ NTP/PCr	0.31 ± 0.01 (2%)	0.32 ± 0.01 (4%)	0.30 ± 0.05 (15%)
α NTP/PCr	0.27 ± 0.02 (8%)	0.26 ± 0.01 (6%)	0.11 ± 0.03 (23%)
β NTP/PCr	0.18 ± 0.02 (13%)	0.15 ± 0.02 (13%)	0.10 ± 0.11 (117%)
PDE/PCr	0.14 ± 0.02 (14%)	0.14 ± 0.02 (11%)	0.13 ± 0.05 (37%)
PME/PCr	0.02 ± 0.01 (34%)	0.02 ± 0.01 (39%)	0.03 ± 0.02 (72%)

Three representative voxels at distance of 2.5 cm, 5 cm and 7.5 cm from the coil plane were quantified. FWHM, CRLB and SNR of the PCr resonance are presented. Mean, SD and CV were calculated.

References

- [1] Chmelik et. al. ISMRM 2011
- [2] Bogner et. al. MRM 2011;66(4):923–930.
- [3] Kemp et al. NMR Biomed 2007; 20(6):555-565