Outer-volume suppression pulses to improve in-vivo 2D MR spectroscopy

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Introduction: Outer volume suppression (OVS) pulses have long been used to improve localization properties of MRS acquisition sequences. For saturation pulses, there is no need to reach 180° and there is no phase requirement for the crushed signal. Therefore, they can be constructed to feature steep profiles and high bandwidth providing reduced chemical shift artifacts (CSA) [1]. These properties have been put to use e.g. to suppress nearby lipid signals or even to define the localized ROI in MRS. The CSA from localization pulses along different directions has also been recognized as the cause for reduced sensitivity for lactate (Lac) in PRESS localization at intermediate TE [2], the reason being that the refocusing pulse in the PRESS sequence is not extending to the A-part of the AX_3 spin system in parts of the selected volume, which leads to partial J-refocusing. OVS has been combined with PRESS to improve Lac sensitivity [3]. The same effect is also relevant in 2DJ spectroscopy – or any 2D sequence involving coherence transfer or refocusing by slice selective pulses. Extending a 2DJ sequence with OVS makes spin evolution homogeneous in space. It is shown that this leads to 1) spectra that are closer to those from ideal simulation, normally used in 2D fitting [4] and 2) better cross peak yield, which makes it more sensitive.

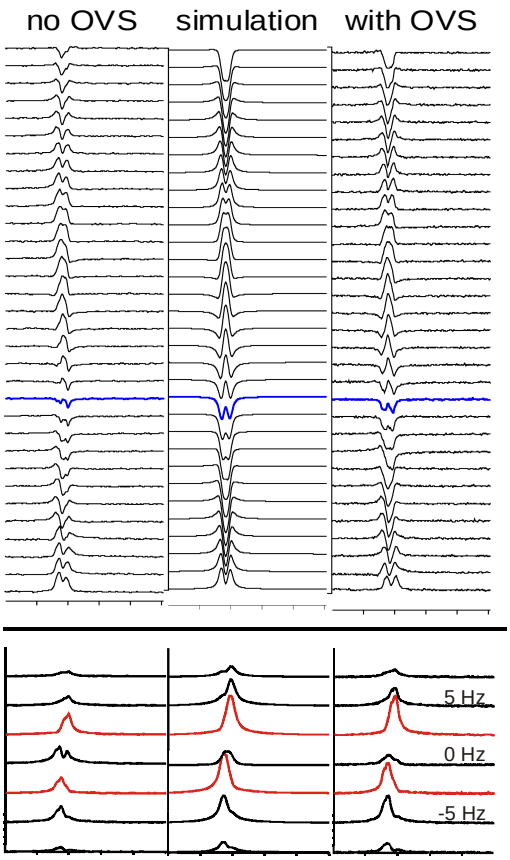

Fig 1. *Lactate doublet as obtained with 2DJ-PRESS without and with OVS in comparison to a simulation with ideal pulses (and no T_2-decay). plotted before (**top**, TE 21 - 408.5 ms,) and after (**bottom**, center excerpt as magnitude) FFT along the 2nd dimension.*

Methods: All data was acquired on a clinical 3T scanner (Siemens, Trio). The 2D-J sequence was based on the product PRESS sequence using Mao pulses for slice refocusing (~ 1200 Hz bandwidth, exact value depending on coil load). Product outer volume suppression pulses were used to improve ROI definition (over-prescribed PRESS, i.e. PRESS volume enlarged to enable homogeneous refocusing, while ROI dimension is reduced to the prescribed size by OVS pulses). Spectra were acquired from a Lac solution, a metabolite mixture (NAA, Lac, glutamate (Glu), myo-inositol, creatine, creatinine, choline), and in vivo from occipital and parietal brain. Minimum TE 21ms, 2DJ with 32 steps, delta TE of 10-12.5 ms. Data evaluation using jMRUI. Spectral simulation used GAVA [5] with ideal hard pulses. The implemented 2DJ sequence also offers full echo sampling [4] to further improve sensitivity.

Results and Discussion: Fig. 1. illustrates the non-ideal J-evolution for the Lac doublet in a plain 2DJ sequence in comparison to the simulation. Eliminating signal from those parts of the ROI where the coupling partner is not subjected to the 180° refocusing pulse leads to more complete evolution, particularly evident at TE's around 1/J in blue, and increased crosspeak intensity after FFT (red). Fig. 2 shows that the Glu pattern is also affected by the CSA, but differences are more subtle than for Lac because coupling partners have a smaller chemical shift difference. If 2DJ spectra are not fitted, but evaluated as TE-averaged PRESS, addition of OVS pulses guarantees better cancellation of unwanted signals. Main disadvantages of OVS are the potential for incomplete removal of lipid peaks in neighboring tissue – particularly for inhomogeneous B_1 –, increased power deposition, and temporal restrictions for water presaturation.

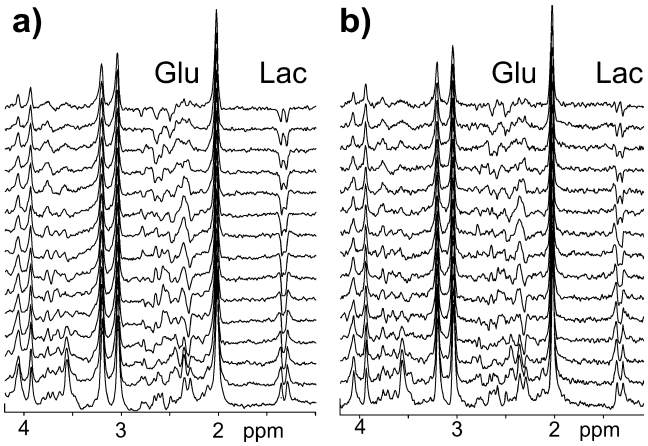

Fig 2. *2DJ raw data (TE 21 to 161 ms) of a metabolite solution acquired with (**a**) and without (**b**) OVS.*

Conclusions: Addition of OVS pulses to reduce CSA effects on spin evolution improves cross-peak yield and fitting accuracy for in vivo 2D spectroscopy.

References: **1.** Tran TK et al MRM 43:23 (2000); **2.** Yablonskiy DA et al MRM 39:169 (1998); **3.** Edden RAE et al MRM 56:912 (2006); **4.** Schulte RF et al NMRB 19:255 & 19:264 (2006); **5.** Soher BJ et al JMR 185:291 (2007).

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