REVEALING PHYSIOLOGY BY TRIPLE QUANTUM MAGNETIC RESONANCE *IN VIVO*.

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Triple quantum (TQ) signals are unique features for potassium and sodium nuclei, as they both have spin=3/2. These ions interact with the electric field gradients of the surrounding macromolecules. *In vivo* these molecules are mainly proteins. The interaction needs sufficient duration to create a TQ signal, and *in vivo* this is usually around several milliseconds. Thus, TQ signals represent a particular pool of the total ions *in vivo*. These signals can serve as a specific "window" to monitor *in vivo* cell functioning through changes in ion homeostasis and cellular energy metabolism.

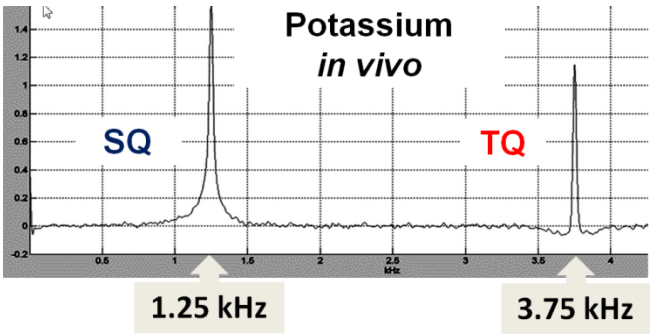

Fig. 1. Single quantum signal (SQ) and triple quantum (TQ) *in vivo* MR signals in rat head at 21.1 T. The TQ peak appeared at 3x times more frequency relative to SQ signals. The TQ signals represent potassium in a bound state, while the SQ signals represent the total amount of ions.

In the bound state the behavior of the nuclear magnetization after application of the RF pulse cannot be described by a classical vector model. The appearance of the multiple quantum effects can be described by irreducible tensors, and orientation dependence can be visualized by corresponding spherical harmonics [1].

The beneficial value of the *in vivo* TQ signals is still under investigation. After calibration, the TQ signal can detect changes in the intracellular sodium concentration in a rat heart and sensitively detect cellular status after a variety of interventions [2]. The difference in concentration of intracellular and extracellular ions (i.e., gradient) for potassium and sodium is an important indicator of cellular energy metabolism [3].

The ultra-high magnetic field of 21.1 T offers a capability to detect the low intensity MR signal of potassium and to compare it with sodium TQ signals. SQ and TQ signals for both potassium and sodium demonstrate the effect of the stronger attraction of potassium relative to sodium ions for the same binding places. The values of the TQ signals indicate that *in vivo* up to ~65% of sodium and ~31% of potassium ions are free or experience a binding with very short correlation times.

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Category: MR
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