How to achieve a 100% success rate in cardiac 1H MR Spectroscopy

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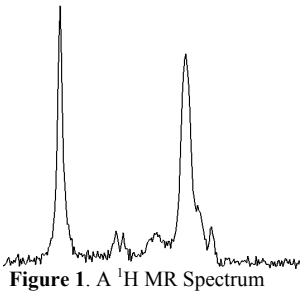

Figure 1. A ^{1}H MR Spectrum from the ventricular septum.

Purpose

Localized cardiac MR-spectroscopy (CMRS) is the only method that facilitates non-invasive localization and quantification of triglycerides stored in the cytosol of the cardiac muscle cells [1], and is therefore an increasingly popular tool for evaluation of the heart metabolism. Cardiac spectroscopy suffers from both cardiac and respiratory motion, as well as susceptibility effects from the lungs and the surrounding blood. All these difficulties frequently reduce the success rate of cardiac MRS to about 50% - 80%. In this work we describe our method for getting a 100% success rate when performing cardiac proton spectroscopy in healthy volunteers.

Outline of Content

Cardiac spectroscopy can be challenging due to motion and susceptibility effects. Many signal averages need to be summarised to obtain large enough signal-to-noise ratio and a variation between separate signal acquisitions will degrade the quality of the final spectrum. A poorly optimised shim leads to peak broadening, a poorly optimised triggering time gives poor signal summation and VOIs including blood will lead to inaccurate quantification and inferior spectral quality.

Our strategy for successful MRS of the human myocardium can be described in a few simple steps. The group verifying the 100% success rate consisted of 23 healthy volunteers; aged 22-60 years, all scanned between the completion of the method development in June and abstract deadline in November. Imaging and localized proton spectroscopy of the human myocardium was performed using a 1.5T Philips Intera/Achieva whole body MRI system equipped with an MRS research package (Philips Medical Systems, The Netherlands). The subjects were scanned in a supine position using the whole body coil for RF transmission and a Philips 5-channel cardiac coil for signal reception. Both imaging and spectroscopy scans were respiratory-triggered at end expiration using a pencil-beam navigator positioned on the diaphragm [2]. From a dynamic scan of the cardiac cycle, so-called cine-imaging imaging, a preliminary cardiac triggering time delay was chosen in end-systole. An anatomical T1-weighted 3D volume (2.1x2.1x2.1 mm voxels) of the heart was reconstructed as short axis, and four chamber images and used for spectroscopy planning. Point resolved spectroscopy (PRESS) was used for volume selection (TE= 35 ms) and the volume of interest (4.5 cm^3) was thoroughly planned to completely fit within the ventricular septum, minimising contamination of ventricular blood. The shimming was optimised using a shimming tool based on field mapping [3]. The shimming scan was also respiratory-triggered using the navigator since our experience is that the level of expiration is likely to alter between breath hold and free breathing with navigator triggering. The cardiac trigging time delay (*td*) was individually optimised by acquiring 16 non-water suppressed spectra (TR=6000 ms) at a few different cardiac triggering time delays in end-systole, starting with the earlier chosen preliminary *td*. The time that resulted in the most repetitive water spectra was then chosen as the final *td* (Fig.2). The water suppressed spectra was acquired (128 signal averages) using individually optimised shim, volume planning and cardiac triggering time delay. These water suppressed spectra were evaluated using the AMARES algorithm in the jMRUI package [4] and the measurement was considered successful when the spectrum showed a clear separation of creatin and TMA making the quantification more user independent.

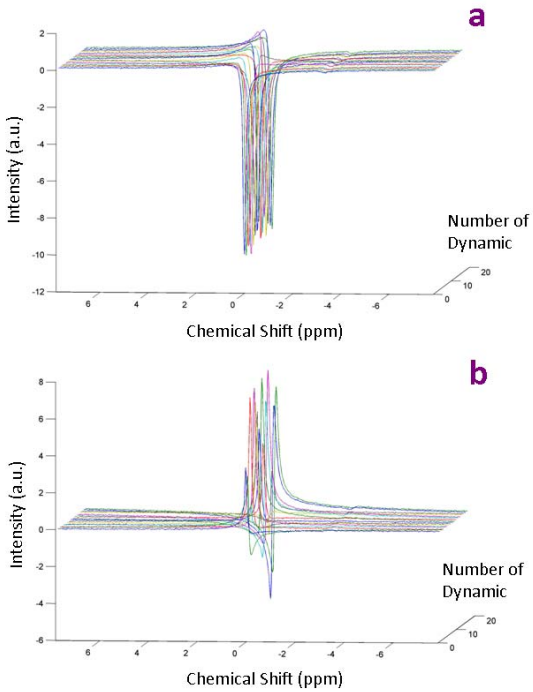

Figure 2. Water spectra from two different cardiac triggering time delays (*td*). **a)** *td* = 30% of full cardiac cycle and **b)** *td* = 33% of full cardiac cycle. The higher repetitiveness in **a** suggests a more efficient signal summation compared to **b**.

Following this strict measurement protocol we have succeeded to keep a 100% success rate in our cardiac spectroscopy measurements, i.e. in all 23 volunteers it was possible to estimate not only the lipid content but also the creatin and TMA content in the ventricular septum.

Summary

It is possible to achieve a 100 % success rate in cardiac proton spectroscopy in healthy volunteers. In order to receive good spectral quality each time one has to follow a strict measurement protocol and optimise every step for each individual. The three most important steps for consistently getting these high quality spectra every single time were:

1. The VOI was carefully planed completely within the ventricular septum to minimize signal contamination from blood.
2. Shimming was optimised using navigator triggered field mapping.
3. The cardiac triggering time delay was individually optimised.

References

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