T1 determination with rapid 2D Gradient Echo Imaging also applicable in cardiac MRI

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Introduction: Cardiac mouse MRI is a wildly used method to study and characterize intrinsic tissue structure and physiology with e.g. determination of T1 and T2 relaxation time constants, diffusion coefficients or kinetic parameters of contrast agent uptake in cardiovascular diseases [1]. As exact T1 values are so far only derived from time-consuming 3D experiments [2], we want to present a tool to calculate images with quantitative T1 values out of a flip angle varied 2D gradient echo experiment like FLASH or IntraGate™ under the consideration of the excitation pulse profile of the slice selection pulse.

Methods: Measurements were performed on a 7T (PharmaScan, cryogenic 4 element array receive-only or 30mm ^{1}H planar receive-only surface coil, 72mm transmit-only volume coil, Bruker Biospin) small animal MRI system. Utilizing 2D gradient echo sequences and the T1Gator Tool (Arno Nauerth; https://IntraGators.com), we achieved images with quantitative T1 values for $CuSO_4$ x $2H_2O$ phantoms with and without gadobenate dimeglumine (Gd-BOPTA, MultiHance™).

Results/Discussions: Our T1Gator Tool enables us to calculate T1 values for 2D Gradient Echo type of experiments: The signal of a 3D experiment is depending on the applied flip angle and the TR. In 2D, the RF profile correction of the applied slice selection pulse has to be taken into account (RfProfileGator Tool, A. Nauerth: https://IntraGators.com). Exemplary the expected signals of a T1 of 400ms (green) and of 1000ms (blue), at TR of 10ms and flip angles from 0 to 90 degrees are shown in Fig.1. The highest dynamic corresponds to low flip angles. T1 calculation of a sample with a T1 of about 100ms, acquired with the flip angles 1.5, 8, 11, 18 and 25 degrees at a TR of 10ms is shown in Fig. 2 and Fig. 3, the graphs on the right show the measured values in black and the theoretical ones in blue. Fig. 3. Fig. 4 shows the profile of the applied excitation pulse.

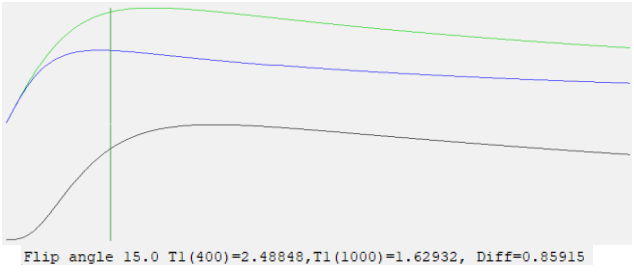

Fig. 1: Expected signal for two different T1 values. Black curve indicates the difference between the two expected signals at 400 ms and1000 ms.

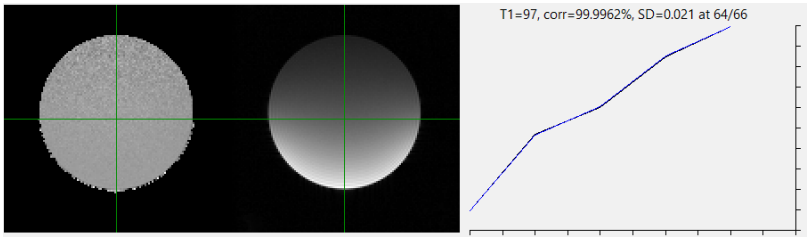

Fig. 2: T1 calculation. Left image shows the calculated T1 image, the right one is the image taken at a flip angle of 8 degree, at the crossing of the green lines a T1 of 97 ms was calculated with a correlation of 99.996% of the theoretical value with a standard deviation of 0.021ms

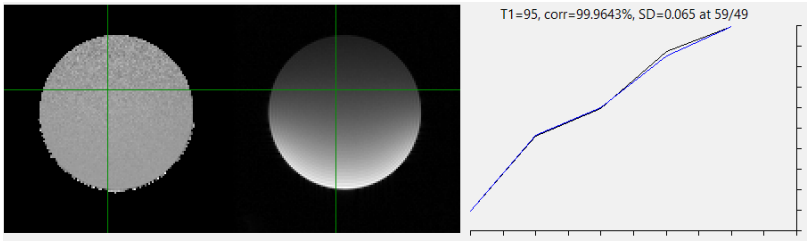

Fig. 3: Visualisation of the deviation between measured (black) and theoretical (blue) values.

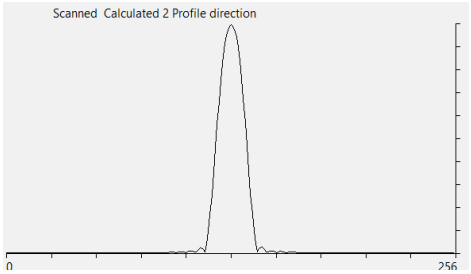

Fig. 4: Visualization of the calculated excitation pulse profile.

Conclusion: We have successfully established a quantitative T1 determination for 2D Gradient Echo types of experiments.

References:

[1] Wu YL "2021: "Cardiac MRI Assessment of Mouse Myocardial Infarction and Regeneration" Methods Mol Biol 2158:81-106.
[2] Coolen BF, et al. (2011) "Three-dimensional T1 mapping of the mouse heart using variable flip angle steady-state MR imaging" NMR Biomed. 24(2):154-62