

Measurements of Relaxation Times of Human Fetus Fixed Tissues at 1.0 T

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Introduction

While ultrasound remains the method of choice for screening of the fetus, MR imaging is playing an increasingly important role in detection and classification of malformations that can not be fully described by traditional means [1]. However there is a lack of information about the fetus normal anatomy and growth that could difficult the task of interpreting MR image, especially in the second trimester of gestation. Our main project is to develop a model of normal growth of the fetal axial skeleton using MR images, building a statistic atlas of normal structures. This project would require fine spatial resolution to describe fetal structures with the maximum of precision, which is quite challenging with classical clinical magnetic field. Therefore we need to optimize all acquisition steps in order to obtain the best contrast and SNR possible prior to image processing.

This project is based on acquiring images of formalin-fixed human fetus. Fixation processes change tissues microstructure, affect water mobility, and vary relaxation times in comparison to *in vivo* tissues [2], making established protocols not suitable to obtain the required image quality. Published results at different fields suggest that T1 and T2 decrease, T2 to a lesser extent, but that effect seems to depend more on fixation time and on tissue type rather than on main magnetic field magnitude [3,4,5]. To our best knowledge, relaxation times of fixed human fetus tissues are not available in literature. Our purpose here is not to address fixation mechanisms but to obtain some data for further improvement of fetus acquisition contrast at 1.0 T.

Material and methods

This project has been approved by Ethical Committees from all institutions. Fetuses come from a Collection of about 300 samples belonging to the Human Embryology Laboratory of the Medical Science Faculty of the Universidad de Santiago de Chile. Normality of all fetuses has been checked, gestational age has been determined by the Dubowitz method. All samples were collected between the years 1976 and 1989, and preserved since then in 10% formalin. As all samples have been fixed for more than 17 years, fixation processes must be stable and similar in all fetuses. Images have been acquired on one 19-weeks old (gestational age) fetus.

Acquisition. Acquisitions were made with a birdcage knee coil on a 1.0T Impact Expert magnet (Siemens, Munich, Germany), using spin echo sequence, with the following parameters: 0.78 x 0.78 x 3 mm³ voxel size, 8 sagittal slices, 112.5 x 150 mm² FOV, 3 repetitions. For T1 determination, acquisitions were done varying TR as [225, 250, 280, 350, 500, 750, 1000, 3000] ms while TE was kept to 15 ms. For T2 measurements TE was varied as [15, 17, 19, 21, 25, 32, 40, 49] ms while TR was kept to 500 ms.

Processing. Data processing was made on Matlab 7.0 (The MathWorks, Natick, Massachusetts, USA). T1 and T2 were obtained by non-linear least-square method using Levenberg-Marquardt algorithm, according to $SI = PD(1 - e^{-TR/T1})e^{-TE/T2}$ where SI stands for signal magnitude, and PD for proton density [6]. Measures were first obtained from a water phantom to validate the procedure, with satisfactory results (not shown).

Results

Figures 1 and 2 present T1- and T2-maps obtained in different slices. Contrast obtained permits to visualize clearly different organs, such as the liver, the lungs, and spinal cord. Measurements of various Regions Of Interest (ROI) are presented in table 1, with T1 ranging from 150 to 2000 ms, and T2 from 30 to 140 ms.

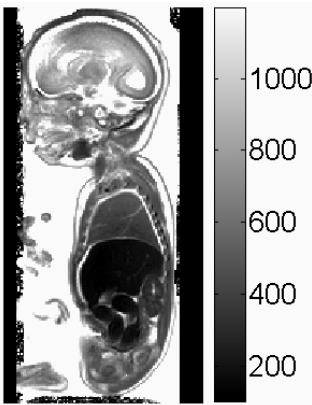


Figure 2 - T1 map (ms)

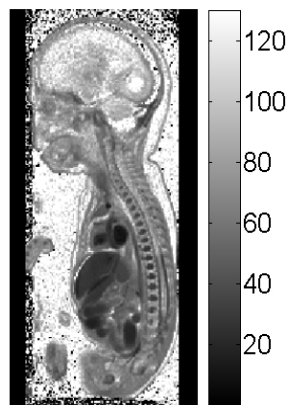


Figure 1 - T2 map (ms)

Discussion and conclusions

Relaxation times have been acquired on one formalin-fixed 19-weeks old (gestational age GA) fetus, at 1.0 T. Few values exist in literature. Comparison with fixed tissues measures is difficult as published studies were done on different structures, on animals, at other magnetic fields, and with various fixation times [3,4,5]. Few values of fetus relaxation times are available *in vivo*, and are available at different gestational age [7]. Formalin fixation cross-links proteins in tissue and it has been suggested that proteins deformation allows for significant increases in the bound water fraction over time [4]. There are still many unknowns about MR contrast with fixed tissues. T1 and T2 maps obtained here still offer good contrast between organs. This study present various advantages, as all fetuses have been fixed for a very long time, no variation in fixation effect should be observed, which will allow averaging between samples. Further measures will be taken on other fetuses of same age, and of different ages, as the Collection contains 300 samples, ranging from 10 to 21-weeks old GA. These relaxation time measurements will allow further acquisition optimization in order to obtain fine spatial resolution with good contrast, for later development of a statistical atlas of axial skeleton normal growth.

References

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| ROI | ROI size (mm ³) | T1 (ms) | T2 (ms) |
|--------------|-----------------------------|------------|----------|
| Bone (spine) | 135 | 924 ± 128 | 73 ± 13 |
| Marrow | 49 | 648 ± 38 | 85 ± 7 |
| White Matter | 380 | 767 ± 82 | 105 ± 16 |
| Liver | 515 | 153 ± 22 | 29 ± 3 |
| Lung | 274 | 442 ± 34 | 62 ± 4 |
| Fat | 100 | 1963 ± 224 | 143 ± 40 |

Table 1 – Relaxation times measured in different ROI