High resolution NMR parameter mapping of a CS23 chemically fixed human embryo at 9.4 T

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INTRODUCTION

Kyoto University has a large collection (~44,000) of chemically fixed human embryos collected from 1961 to 1974 (1). We acquired about 1,200 T_1 weighted 3DSE MR images of the embryos with a 128×128×256 image matrix from 2003 to 2005 at 2.35 T using a super-parallel MR microscope (2). At present, we are planning to construct the next 3D anatomical database with a 256×256×512 matrix. The purpose of this study is to clarify the NMR properties of the chemically fixed embryos to develop the optimum pulse sequences for the next database.

MATERIALS AND METHODS

A chemically fixed Carnegie Stage (CS) 23 human embryo stored in formalin solution was used throughout the experiments. A home-built MRI system using a 9.4 T vertical 54 mm bore superconducting magnet and a 400 MHz digital MRI transceiver (MRTechnology Inc. Japan) were used. A home-built 18 mm diameter eight-rung birdcage coil was used for both RF excitation and signal reception. 3D MR images of the embryo was acquired with T1W 3DSE (TR/TE = 200ms/12ms), PDW 3DSE (TR/TE = 800ms/12ms), T2W 3DSE (TR/TE = 800ms/18ms, 24ms, 36ms), T1W 3DGRE (TR/TE = 200ms/6ms, 10ms) sequences with 256×256×512 image matrices ((60μm)^3 voxel size), and diffusion weighted 3DSE sequences with TR/TE = 400ms/32ms and 6 direction MPG (b = 790 s/mm^2) with 128×128×256 image matrices ((120μm)^3 voxel size). Distributions of T_1, T_2, proton density (PD), ADC, and fractional anisotropy (FA) were calculated from combinations of the reconstructed MR images.

RESULTS AND DISCUSSION

Figure 1 shows mid-sagittal cross sections of T_1, T_2, PD and ADC. Although T_1, T_2, and ADC of the embryo are different among organs and tissues, PD of the embryo seems homogeneous. Figure 2 shows axial cross sections at the eye level of the 3DGRE image, T_1 map, ADC map, and FA map. The small value of the ADC and large value of the FA of the lens are remarkable. Some fibrous structure is also observed in the same cross section as shown by the yellow arrow. Figure 3 shows histograms of T_1, T_2, PD, and ADC. The histograms of the T_1 and T_2 were calculated for the whole embryo and those for PD and ADC was calculated for the embryo and the preservation fluid. The small peaks shown in the T_1 and T_2 histograms correspond to those of the liver. The short relaxation times of the liver are considered to be caused by the presence of iron (paramagnetic) compound because the liver contains a lot of hematopoietic cells at this developmental stage. Two peaks in the PD histogram correspond to PD of the embryo and the preservation fluid. These peaks clearly show that the volume proportion of the NMR visible protons or liquid protons in the embryo is about 30 % of the embryo specimen. In conclusion, physical properties of the CS23 chemically fixed embryo were clarified by the quantitative NMR parameter measurements, which will be utilized for the construction of the next 3D anatomical database of the Kyoto Collection.

REFERENCES: (1) Nishimura H et al, Teratology 1968;**1**:281-290. (2) Matsuda Y, et al. Magn Reson Med Sci 2007;**6**:139-146.

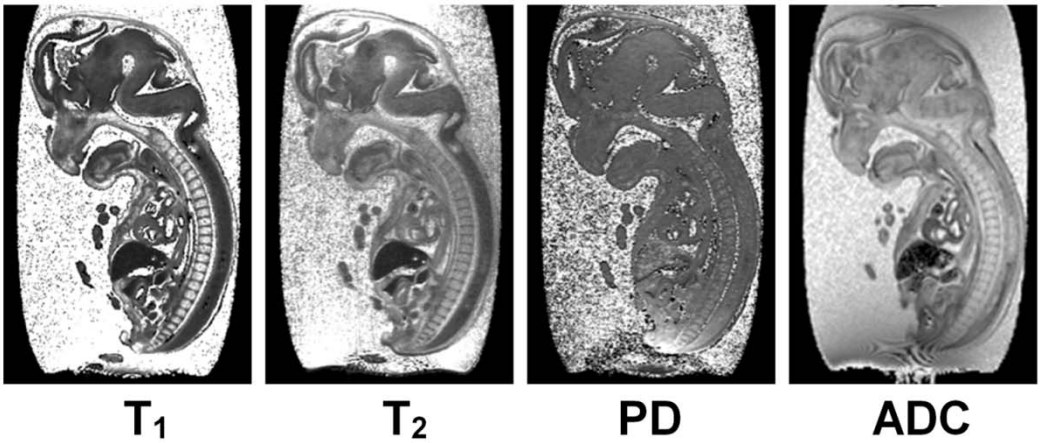

Fig.1 NMR paramaeter maps of the mid-sagittal cross section

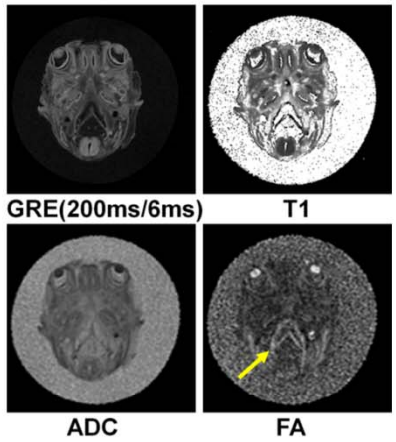

Fig.2 Brain cross section

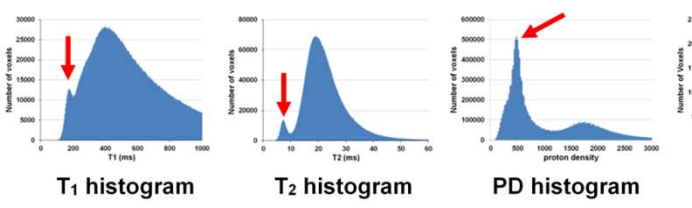

Fig.3 Histogrms of NMR paramaeters

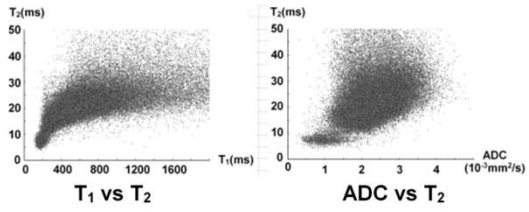

Fig.4 Correlation between NMR parameters