1H-MRS of Human Pancreas Grafts: Relaxation Times and Metabolite Concentrations

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Target Audience

This study is determined to the researchers involved in pancreas MR spectroscopy and transplantation.

Introduction

Transplantation of pancreas or insulin produced islets of Langerhans are the treatments of choice for the patients whose pancreas does not make enough, or sometimes any insulin. Increased pancreatic fat content is contraindication for transplantation because fatty pancreas is difficult to procure. Extensive fatty infiltration is also associated with an increased risk for complications after surgery. In the present work, we applied ^{1}H-MRS to pancreas grafts during the cold preservation. Our aim was to measure pancreatic water, total choline (tCho) and fat $(-CH_2-)_n$ relaxation times T_1 and T_2 and estimation the absolute concentration of tCho and fat.

Methods

Pancreas grafts from 8 human donors were measured. Informed consent was obtained from all families. The study was approved by The Regional Ethical Review Board. Each pancreas was perfused in situ with histidine-tryptophan-ketoglutarate (HTK) solution and placed into transport container filled with HTK solution. Temperature inside container was maintained at 4±1 ^oC by cooling ice-elements (Fig. 1). Median donor age was 69 years (range: 24-82) and mean body mass index was 27±4.3kg/m^2 (range: 22.2-31.9). Experiments were performed on a 1.5 T clinical scanner (Philips, Achieva) using a transmit-receiver head coil. Single-voxel spectra were acquired using PRESS sequence (spectral bandwidth 1000 Hz, 1024 points). Typical voxel size was 10x10x20 mm^3. Voxel was placed within the body of the pancreas (Fig. 1). Water T_1 and T_2 relaxation times were computed using spectra acquired at ten TRs (range: 300-5000 ms, number of scans (NS) 16, TE 30 ms), and eight TEs (range: 30-200 ms, TR 3000 ms, NS 16). The T_1 values of tCho and lipid line $(-CH_2-)_n$ were estimated from the spectra measured at TE 25 ms and TRs between 550, and 1600 ms (NS 128). T_2 values of tCho and $(-CH_2-)_n$ resonances were estimated using the spectra measured at TE range 30-150 ms (TR 1500 ms, NS 128). Fat and tCho content were quantified using the spectra acquired with TR/TE 5000/30 ms and NS 64. Spectra were processed in time domain using MRUI software package[1]. Spectral intensities were fitted to Lorentzian line shapes (Fig. 2). Relaxation times were estimated by monoexponential fitting of the spectral intensities (Fig. 3) by a software package ORIGIN (OriginLab, Northampton, MA). Lipid and tCho content was estimated from relaxation corrected spectral intensity ratios to unsuppressed water line[2]. Reference concentration 38 300 mM of "NMR-visible" water in the pancreas was used for this purpose. We assumed that pancreas contains 0.71 g H_2O per 1 g wet weight (ww) tissue[3] and its density is 1.08 g/cm^3. Furthermore, it was assumed that 10% of tissue water is "NMR-invisible". Absolute lipid concentration was quantified using $(-CH_2-)_n$ intensities[2]. Lipid content was also expressed as the ratio of fat $-(CH_2)_n-$ over water spectral intensity (f/w∗100%).

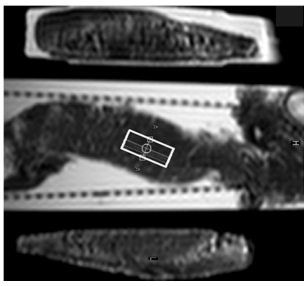

Fig. 1: Voxel position in transport container and two cooling ice-elements.

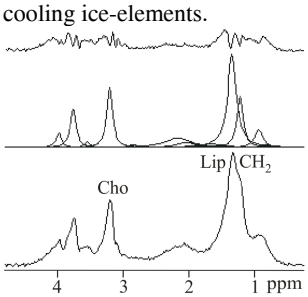

Fig. 2: The spectrum, fits and residue.

Results

Grafts from 5 donors were used for relaxation times estimations. Relaxation times are reported for water (T_1, 670±69 ms; T_2, 77±17 ms), tCho (T_1, 876±147 ms; T_2, 103±22 ms), and lipid $(-CH_2-)_n$ (T_1, 287±60 ms; T_2, 27±4.4 ms). tCho was detectable in the spectra of six grafts. Mean tCho concentrations was 12.4±3.1 mmol/kg ww (range: 8.2-16.6). Median f/w spectral intensity ratio and total fat concentration were 2.0 % (range: 0.3-21.7), and 22.8 mmol/kg ww (range: 3.1-248.1), respectively. Spectral interval 3.5-4.2 ppm (Fig. 2) was empirically fitted by three Lorentzians. This range contains a large number of signals with high degree of overlap (glucose, glycerol, amino acids, etc.)[5].

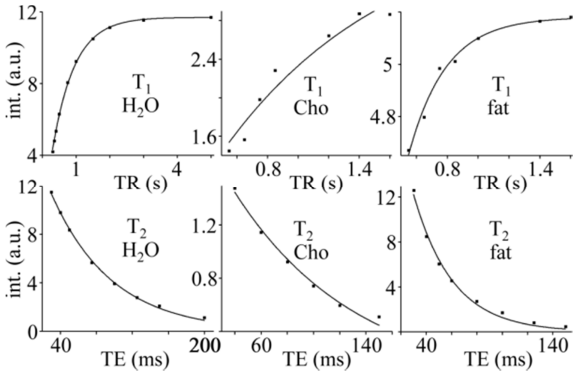

Fig. 3: Mono-exponential fits of spectral intensities vs. TR and TE.

Discussion

This is the first ^{1}H-MRS of human pancreas grafts. In vivo estimation of pancreatic water T_1 (584±14 ms) and T_2 (46±6 ms) was performed by de Bazelaire et al[4]. Our longer T_2 can be explained by the fact that the blood was replaced by HTK solution. To our knowledge, there are no previous T_1, T_2 estimates of tCho and fat $-(CH_2)_n-$ at 1.5 T that can be compared with our results. tCho concentration and f/w ratio are in line with in vivo 3T results[3].

Conclusion

Knowledge of the relaxation times enables quantification of pancreas graft metabolite concentrations using water as the internal concentration reference. From clinical point of view is pancreatic fat content useful for inspection the pancreas graft quality prior to transplantation or islet of Langerhans isolation. Assessment of tCho concentration is important in differentiation between normal and malignant tissue.

References

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