Metabolite distributions in human aging brain - a study with short-TE whole brain MR spectroscopic imaging

Xiao-Qi Ding[1], Helen Maghsudi[1], Andrew A. Maudsley[2], Mohammad Sabati[2], Sulaiman Sheriff[2], Martin Schütze[1], Paul Bronzlik[1], and Heinrich Lanfermann[1]
[1]Institute of Diagnostic and Interventional Neuroradiology, Hannover Medical School, Hannover, Lower Saxony, Germany, [2]Department of Radiology, University of Miami School of Medicine, Miami, FL, United States

Target audience: Those who are interested in use of MR spectroscopic imaging to study metabolite changes in human brain.

Purpose: To estimate age-related metabolite changes in multiple brain structures by using recently established short TE (17.6 ms) whole brain MR spectroscopic imaging (wbMRSI) (1) on healthy subjects, with the aim to evaluate physiological aging of the adult human brain.

Methods: Sixty healthy volunteers aged between 21 to 70 years (6 males and 6 females per decade) were scanned at a 3T system (Verio, Siemens, Erlangen). Scan protocol included a volumetric Echo Planar Spectroscopy Imaging (EPSI) acquisition (TR/TE = 1550/17.6 ms) and an axial T1-weighted 3D MPRAGE. The EPSI data were analyzed with the Metabolic Imaging and Data Analysis System (MIDAS) package (2) to obtain brain maps of the metabolites N–acetylaspartate (NAA), choline (Cho), total creatine (tCr), glutamine/glutamate (Glx), and myo-Inositol (mI). Local concentrations in ratio to tissue water (presented in institutional units, i.u.) of the metabolites denoted as [NAA], [Cho], [tCr], [Glx], and [mI], respectively, were determined bilaterally at following thirteen brain structures with regions of interesting (ROIs) methods: the frontal (fWM) and parieto-occipital white matter (pWM), hand motor cortex (HC), splenium of the corpus callosum (sCC), centrum semiovale (CS), capsular interne posterior (iCap), putamen (Put), thalamus (Thal), occipital grey matter (oGM), cerebellar white matter (Cbwm) and three ROIs within cerebellar hemispheres (CbGMo, CbGMu, and Cbmix). The values of corresponding left and right hemispheric ROIs were averaged for further analysis. Two-sided t-test with Bonferroni corrections ($\alpha = 0.05/5 = 0.01$) was used to estimate differences between measured data of male and female group, and linear regression analysis ($\alpha = 0.05$) was used to estimate age-dependence of the metabolite concentrations at each ROI.

Results: Significant differences between the data of male and female groups ($p<0.01$) were found at Cbwm for [NAA] and [tCr], putamen for [Glx], and iCap for [mI]. For these data the age-dependence was then estimated separately for males and females, and for metabolite concentrations of all other ROIs the data of males and females were combined for linear regression analyses, which revealed following changes with age: 1) [NAA] decreased at seven ROIs (fWM, SCC, iCap, pWM, oGM, putamen, and thalamus) with Pearson correlation coefficient (R) varying from -0.48 to -0.26; 2) [Cho] increased at ROIs HC and iCap (R = 0.29 to 0.47), and decreased at ROI CbGMo (R = -0.322); 3) [tCr] increased at ROI HC (R = 0.307) and decreased at iCap (R = -0.256); 4) [Glx] decreased only at ROI thalamus (R = -0.287); and 5) [mI] increased at ROIs SCC (R=0.401) and fWM (R = 0.285), in addition, [mI] of males showed a significant age-related increase at iCap (R=0.386).

Discussion/Conclusion: Our results indicate that the age-related changes of brain [NAA], [tCho], [tCr], [mI], and [Glx] are brain regional dependent and metabolite specific, with most changes occurring in cerebrum and for NAA. The observation that [Cho] decreases with aging at CbGMo is quite interesting because until now little has been reported about the metabolite changes in cerebellum. These data could be used as reference data in future studies to identify study of neurodegenerative diseases. With the short TE wbMRSI technique it is possible to study metabolite changes at multiple brain structures with a tractable scan time.

References:

1. Ding XQ, Maudsley AA, Sabati M, Sheriff S, Dellani PR, Lanfermann H. Reproducibility and reliability of short-TE whole-brain MR spectroscopic imaging of human brain at 3T. Magn Reson Med 2014.
2. Maudsley AA, Darkazanli A, Alger JR, Hall LO, Schuff N, Studholme C, Yu Y, Ebel A, Frew A, Goldgof D, Gu Y, Pagare R, Rousseau F, Sivasankaran K, Soher BJ, Weber P, Young K, Zhu X. Comprehensive processing, display and analysis for in vivo MR spectroscopic imaging. NMR Biomed 2006;19(4):492-503.