Chin Med Sci J
June 2017

Vol. 32, No. 2
P. 75-82

CHINESE
MEDICAL SCIENCES
JOURNAL

ORIGINAL ARTICLE

Abnormal Alterations of Cortical Thickness in 16 Patients with Type 2 Diabetes Mellitus: A Pilot MRI Study△

Zhiye Chen[1,2], Xiujuan Zang[3], Mengqi Liu[1,2], Mengyu Liu[1], Jinfeng Li[1], Zhaoyan Gu[4], and Lin Ma[1]*

[1]Department of Radiology, Chinese PLA General Hospital, Beijing 100853, China
[2]Department of Radiology, [4]Department of Endocrinology, Hainan Branch of Chinese PLA General Hospital, Sanya, Hainan 572013, China
[3]Department of Radiology, The Fifth People's Hospital, Shizuishan, Ningxia 753000, China

Key words: type 2 diabetes mellitus; brain; cerebral cortex; cortical thickness; magnetic resonance imaging

Objective The aim of this study is to investigate the cerebral cortical thickness changes in type 2 diabetes mellitus (T2DM) using a whole brain cortical thickness mapping system based on brain magnetic resonance imaging (MRI).

Methods High resolution three-dimensional T1-weighted fast spoiled gradient recalled echo MR images were obtained from 16 patients with T2DM, as well as from 16 normal controls. The whole brain cortical thickness maps were generated, and the cortical thickness of each brain region was calculated according to gyral based regions of interest (ROI) using an automated labeling system by the Freesurfer software. We compared mean cortical thickness at each brain region by the analysis of covariance with age and sex as covariates. The regional difference of the cortical thickness over the whole brain was compared by the analysis of surface-based cortical thickness.

Results Mean cortical thicknesses analysis showed bilateral cerebrum in the patients with T2DM (left: 2.52±0.07 mm; right: 2.51±0.08 mm) were significant thinner than those in the normal controls (left: 2.56±0.09 mm; right: 2.56±0.09 mm) (both $P<0.05$). Regional cortical thinning in T2DM was demonstrated in the paracentral lobule, postcentral gyrus, lateral occipital gyrus, lingual gyrus, precuneus, superior temporal gyrus, middle temporal gyrus, inferior temporal gyrus and posterior cingulate gyrus, compared to the normal controls. The cortical thickness of left middle cingulate and right inferior temporal gyrus were negatively correlated with the disease course.

Conclusion A widespread cortical thinning was revealed in patients with T2DM by the analysis of brain cortical thickness on MR. Our finding supports the idea that T2DM could lead to subtle diabetic brain structural changes.

Chin Med Sci J 2017; 32(2):75-82. DOI:10.24920/J1001-9294.2017.010

Received for publication September 9, 2016.

*Corresponding author Tel: 86-10-66939592, E-mail: cjr.malin@vip.163.com.

△Supported by the Foundation for Medical and Health Sci & Tech innovation Project of Sanya (2016YW37) and the Special Financial Grant from China Postdoctoral Science Foundation (2014T70960).

DIABETES is a common metabolic disease with progressive damage in peripheral and central nervous systems caused by chronic hyperglycaemia. Cognitive dysfunction has been observed in patients with type I diabetes mellitus[1] or T2DM. It has been reported that patients with diabetes mellitus have a greater risk of cognitive function decline than healthy people.[2] Some longitudinal studies provided compelling evidence to support the view that type 2 diabetic patients were at increased risk of developing cognitive impairment in comparison to the general population.[3] Therefore it is necessary to evaluate the brain structure in T2DM in order to understand the changes in diabetic brains.

In some studies, the brain atrophy was investigated through visual assessment and rating scales on conventional MR images in patients with T2DM.[4-6] However, it is difficult to evaluate subtle brain structural changes using these methods. Voxel-based morphometry (VBM) is an automatic technique for brain structural evaluation. A study using VBM has demonstrated the atrophy of gray and white matter in the right temporal lobe in patients with T2DM.[7] Although VBM can be used in detecting subtle gray matter volume changes over the whole brain, it is not an ideal technique for the delineation of cortical structure, because it is a kind of statistical method at voxel level rather than a measurement of the cortical thickness.

Cortical thickness measurement provides us with a methodological innovation for assessing subtle changes of cortical thickness in human brain. Combining the image information and geometry constraints, the surface of gray and whiter matter can be reconstructed, and then the cortical thickness can be measured based on identification of the morphometric features of cortex.[8] In the past few years, many novel methods have been proposed to focus on cortical thickness measurement, including coupled surface method,[8,9] closest point method,[10] Laplace method[11] and voxel-based cortical thickness.[12] Subsequent studies[13,14] using these techniques have shown that cortical thickness measurement could potentially provide more valuable information than volume measurement in neurodegenerative and psychological diseases. In a study[15] using Laplace methods to investigate the cortical thickness of diabetic brain, however, only regions of interest (ROI) statistical analysis was performed. Herein, surface-based cortical thickness analysis may provide more information of structural alteration for diabetic brains.

In this study, we used a whole brain cortical thickness mapping technique aiming at detecting possible alteration of cortical thickness over whole brain in patients with T2DM.

MATERIALS AND METHODS

Subjects

Patients from the diabetes outpatient clinic at PLA General Hospital who met one of the following inclusion criteria were eligible for the study:[16] fasting plasma glucose (FPG) level>7.0 mmol/L; 2-hour plasma glucose level >11.1 mmol/L during oral glucose tolerance test (OGTT); or a prior diagnosis of T2DM. The exclusion criteria were as follows: a history of dementia, macrovascular complications (definite cerebral infarction or malacia), cranium trauma, inflammatory diseases of the central nervous system, or use of psychoactive drugs or hormones. In addition, we evaluated brain atrophy and white matter lesions (WMLs) of the candidates on conventional MR images using ten-level grading scales.[17] Patients with brain atrophy of grade 0 (normal ventricular size) or grade 1(presumably normal ventricular size), and WMLs in grade 0 (normal white matter) or grade 1 (barely detectable white matter changes) were enrolled in this study. Finally, sixteen patients with T2DM were included.

Normal controls were recruited from our hospital staffs or their relatives with gender matched evenly. The same exclusion criteria were applied to the normal controls, and none of the controls had a history of hypertension. There were sixteen normal controls enrolled in the study. All the subjects were right-handed and underwent Mini Mental State Examinations (MMSE)[18] in order to exclude the possibility of dementia.

Written informed consents were obtained from all participants according to the approval of the ethics committee of the local institutional review board.

MRI acquisition

High resolution structural images were obtained from a 3.0 T MR system (SIGNA EXCITE, GE Healthcare, Milwaukee, WI, USA) with a conventional eight-channel phased array head coil. Conventional axial fast fluid-attenuated inversion recovery (FLAIR) images were acquired firstly, and the parameters were as follows: TR (repetition time)= 8802 ms, TE (echo time)=124.3 ms, TI (invertion time)= 2200 ms, slice thickness=4 mm, gap=1 mm, matrix= 256×256, FOV (field of view) = 24 cm×24 cm, NEX (number of acquisition)=1. The structural images were generated from the high resolution three-dimensional T1-weighted fast spoiled gradient recalled echo (3D T1-FSPGR) sequence. The parameters were as follows: TR=6.3 ms, TE=2.8 ms, flip angle=15°, FOV=24 cm×24 cm, Matrix=256×256, in-plane resolution was 0.9375 mm× 0.9375 mm, NEX=1.