Detection of the local volumes of white matter lesions in type 2 diabetes mellitus by an automatic measurement method

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Introduction Type 2 diabetes mellitus (T2DM) has been associated with poor cognitive performance and dementia. The exact mechanisms underlying the cognitive dysfunction in DM remain unclear. The association between T2DM and white matter lesions (WMLs) is a topic of some controversy, which had been believed to be influenced by the methodologies assessing the lesion severity, including relative crude visual rating scales, the more comprehensive visual rating scales and the automated segmentation methods. Since some recent studies had showed good consistency between visual score and volume of WMLs, and meanwhile proved that the volumetric measures with automated segmentation methods provide the detailed, precise and repeatable advantages. The aim of this study is to assess the volumes of WMLs in patients with T2DM using an automatic quantification method, and explore the relationship of T2DM and WMLs, and if there is some characteristic change of WMLs.

Methods ***Subjects:*** 26 patients with T2DM hospitalized in endocrinology were enrolled in T2DM group, and 28 healthy persons from medical examination center were included as control group, excluding poor cognitive performance, hyperlipidemia, cardiovascular disease, mental disorder, brain injury. Clinical details of both groups were showed in **table 1**. ***MRI acquisition***: Morphological brain MRI of T2DM and control groups including T1WI and FLAIR sequence were obtained on 1.5T MRI equipment (Philips, Achieva:T1WI:TR/TE/TI=1963/10/800ms, matrix=256x192, FLAIR:TR/TE/TI = 6000/120/2000ms, matrix=240×180, slice thickness=6mm. *Image analysis*: WMLs were detected by a coarse-to-fine mathematical morphology method[1]. 3 steps were proceeded from the beginning of brain and white matter segmentation, and then the mathematical morphology, finally the segmentation of white matter lesions. The statistical differences of WMLs volumes in different brain regions and total of them between T2DM and control group were analyzed. The relationship between the volumes of WMLs including different brain regions and the total of them, as well as clinical indexes including age，sex, disease course, blood pressure, blood glucose, HbA1c, BMI, blood lipid were analyzed in T2DM group . Statistical difference was reached when $P<0.05$.

Table 1 Demographic data of case and control group

Demographics	Diabetes (n=26)	Control (n=28)	*P* value
Age(y)	57.70±10.48	53.93±10.34	0.071
gender(F/M)	9/17	8/20	0.746
BMI(kg/m2)	24.65±3.89	24.72±3.28	0.517
Glu(mmol/l)	11.40±5.96	5.16±1.16	<0.001
HbA1c(%)	7.61±2.03	3.20±2.86	<0.001
Systolic BP(mmHg)	121.73±12.96	125.37±14.27	0.392
Diastolic BP(mmHg)	78.73±7.94	79.97±11.68	0.709
TG(mmol/l)	2.14±1.85	1.34±0.53	0.168
TC (mmol/l)	4.44±0.72	4.65±0.79	0.359
LDL(mmol/l)	2.55±0.62	2.94±0.76	0.03
HDL(mmol/l)	1.04±0.75	1.34±0.29	0.001
Disease Course(mon)	92.52±80.27	-	-
History of hypertension	11	3	0.014

Results There were no WMLs found in bilateral infratentorial regions both in diabetes and control group. Various volumes of WMLs assessed by this automatic measurement method demonstrated in the 10 supratentorial regions in both groups, ranging from 22.58 to1128 mm^3 in diabetes group and 9.33 to 901 mm^3 in control group . The volumes of WMLs in bilateral frontal lobes (right P =0.006,left P =0.016) and right parietal lobe (P =0.03), and the total WMLs volume (P=0.017) in T2DM group were significant larger than those in control group, (showed in **Fig. 1**). In T2DM group , WMLs in bilateral frontal and parietal lobes had been found no significance between each other, but were larger than the other brain regions ($P<0.05$). Moreover, HbA1c was correlated with the WMLs volume in right frontal (r=0.43, P =0.05) and bilateral parietal lobe(right :r=0.47, P=0.03;left: r=0.49, P=0.02) , right temporal lobe (r=0.47,P=0.03) and the total brain regions (r=0.43, P =0.04) in the T2DM group. Systolic BP were correlated with the WMLs volume in right frontal(r=0.44, P =0.04) and bilateral parietal lobe (right: r=0.49, P =0.02;left: r=0.45, P =0.04) and right basal ganglia(r=0.45, P =0.03). Diastolic BP was correlated with the WMLs volume in bilateral frontal (right: r=0.65, P =0.00;left: r=0.51, P =0.02) and parietal lobe (right: r=0.58, P =0.00;left: r=0.64, P =0.00)and the total WMLs volume(r=0.65, P =0.00) .

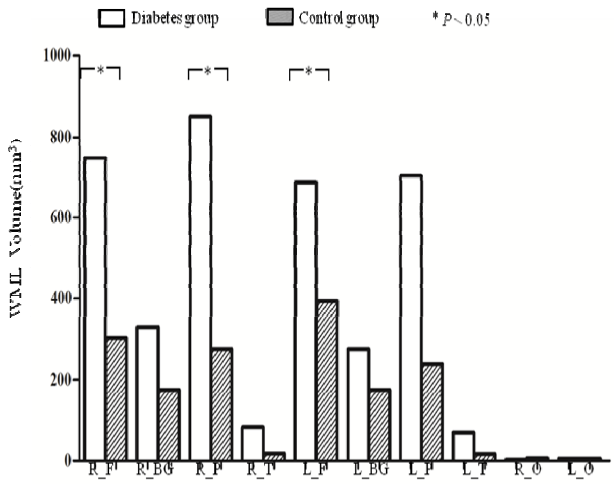

Fig.1 Comparison of WMLs volume in each brain region between diabetes and control group
Notes: R=right, L=left, F=Frontal, BG=Basal Ganglia, P =Parietal, T= Temporal, O= Occipital

Discussion Various techniques have been developed to assess the white matter hyperintensity, ranging from semiquantitative to quantitative volumetric measures. Direct comparisons between visual rating scales and volumetry indicate that several rating scales do correlate well with measured lesion volume, particularly in those with more detailed grading method. However, the ability of rating scales to discriminate between absolute volumes of white matter hyperintensity is limited. Volumetric measure provides greater detail and more reliability. In this study, an automatic quantification method had been proved to have reliable WML segmentation results. Using this automatic computational method, varieties of volumes of WMLs were only found supratentorialy both in this diabetes and control group. The total volume of WMLs of all brain regions in diabetes group were larger than in control group, giving more evidence to white matter injury in T2DM as described by many studies. In diabetes group, WMLs in bilateral frontal and parietal lobes had been found larger than the other brain regions, suggesting that WMLs predominantly located in frontal and parietal lobes in T2DM. This finding has some similarity with a previous study[2], which might be a potential feature for the structural change in T2DM. The frontal and parietal lobe may be particularly vulnerable by microvascular damage in T2DM. In addition, SBP and DBP were correlated with WMLs volumes in some regions, which might suggest that vascular damage may play a role affecting the WMLs in T2DM. HbA1c was correlated with the WMLs volumes in some regions and the total WMLs volume, which was consist with the previous studies[3].

Conclusions This study showed that brain white matter changes in T2DM may have its own characteristics preferring in the frontal and parietal lobes, which may be associate with the cognitive dysfunction.

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References

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