Small network properity changes in MCI with lacunar infraction

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Target audience: This study could help neurologist to improve understanding about the impairment pattern of lacunar infraction.

Purpose: Little is known about the influence of lacunar infraction on brain network properties in MCI patients. The network derived from resting-state bold has ability to assess the macroscopic damage in MCI patients with lacunar infraction. In this study, we construct the functional networks of human brains by resting-state functional magnetic resonance imaging (rsfMRI) and explore if there has characteristic impairment pattern in MCI patients with lacunar infraction compared with MCI patients without lacunar infraction.

Methods: Consecutive MCI patients with lacunar infraction (LI-MCI)(n=30), and MCI patients without lacunar infraction (noLI-MCI)(n=30) were recruited, and age- and sex-matched normal controls(n=30) were identified. All participants went for neuropsychological testing. The resting-state MRI data were acquired (sequence parameters: TR: 2000ms ;TE: 30ms ;flip angle=90° ;35 axial slices ;voxel size 3mm*3mm*4mm) and preprocessed (using Gretna[1]), and then constructed the functional network by using graph-theoretical analysis.

Results: Compared with NC and noLI-MCI, LI-MCI showed abnormal small-world property with lower σ , ($p < 0.05$, reflecting a less optimal topological organization of the network. In addition, compared with NC and noLI-MCI, LI-MCI showed higher node degree in left hippocampus, bilateral amgydala and left parahippocampus and increased node efficiency in bilateral hippocampus, bilateral amygdala and left parahippocampus($p < 0.05$ = (Fig. 1), corresponding better performance on memory test, suggesting a compensatory mechanism after lacunar infarction in MCI patients.

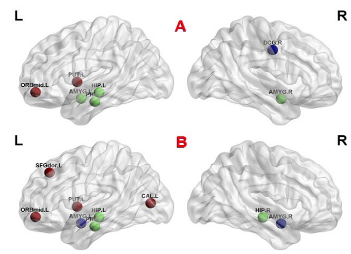

Figure 1: Small-world networks node properties. A: Node degree; B: Node efficiency. Red node : LI-MCI ＞NC ($p < 0.05$); green node : LI-MCI ＞NC & noLI-MCI ($p < 0.05$); blue node : NC ＞ noLI-MCI ($p < 0.05$);

Discussion: In this study, we compared the small-world properties among the MCI patients with or without lacunar infraction and normal aging elderly by applying graph-theoretical analyses. Each group fit $\gamma > 1$,λ=≈1 and $\sigma > 1$,indicating human brain network were consistent with small-world properties in MCI patients and normal aging elderly. However, the σ in LI-MCI group was characterized by lower than NC group and noLI-MCI group, indicating the impairment of lacunar infraction to small-world network topological construction. In addition, a high C_p indicates that the nodes tend to form dense regional cliques, implying that the efficiency in local information transfer and processing are high; a low Lp indicates high transfer speed through the overall network, implying that the network has a high global efficiency. With the increased node efficiency and node degree of several brain region in LI-MCI patients, there might be a compensatory mechanism in LI-MCI patients[2](Fig. 2).

Conclusion: The functional brain networks in all 3 groups showed the property of small-world. However, lacunar infraction showed a more severe impairment on small-world network organization. But there might have a compensatory mechanism on episodic memory in LI-MCI patients, which could explain the different cognitive domain impairment in MCI patients.

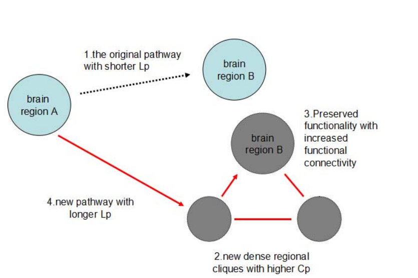

Figure2: Theoretical interpretation of higher C_p and higher L_p in LI-MCI patients. (1) the original

Table 1:Small-world property for node degree

Node degree	NC	LI-MCI	noLI-MCI	ANOVA p value	*	#	&
left middle orbital	6.1±2.2	7.4±2.0	5.8±2.9	P=0.047*	P=0.313	**P=0.021**	P=0.351
left putamen	5.2±2.0	6.7±3.2	5.4±1.9	P=0.049*	P=0.776	**P=0.018**	**P=0.025**
left hippocampus	5.7±3.0	7.9±3.7	6.7±3.0	P=0.048*	**P=0.018**	P=0.233	P=0.190
left parahippocampus	5.7±2.6	7.7±3.1	5.9±2.7	P=0.030*	**P=0.010**	P=0.712	**P=0.030**
Left amygdala	5.4±2.6	7.7±3.4	6.2±3.1	P=0.024*	**P=0.067**	P=0.313	P=0.069
right posterior cingulate	6.9±2.9	7.3±3.2	5.6±2.3	P=0.037*	**P=0.028**	**P=0.040**	P=0.655

* : NC ＜ LI-MCI ; # : NC ＞ noLI-MCI; & : LI-MCI ＞ noLI-MCI

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