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Multilayer network analysis in patients with end-stage renal disease: integrating insights into structural and functional layers

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Objectives : The aim of this study was to investigate the alterations of multilayer network combining structural and functional layers in patients with end-stage renal disease (ESRD) compared to healthy controls.
Methods : Thirty-eight patients with ESRD and 44 healthy participants were prospectively enrolled. They exhibited normal brain MRI without any structural lesions. All participants, both patients with ESRD and healthy controls, underwent T1-weighted imaging, diffusion tensor imaging (DTI), and resting-state functional magnetic resonance imaging (rs-fMRI) using the same three-tesla MRI scanner. A structural connectivity matrix was generated using a DSI program, and a functional connectivity matrix was created using an SPM program and CONN toolbox. The multilayer network analysis was conducted based on the structural and functional connectivity matrices using a BRAPH program.
Results : There were significant differences of the global level of the multilayer network between the patients with ESRD and healthy controls. The weighted multiplex participation was lower in the patients with ESRD than that in the healthy controls (0.6454 vs. 0.7212, adjusted $p=0.049$). However, the other multilayer network measures were not different between them. The weighted multiplex participation in the right subcentral gyrus, right opercular part of inferior frontal gyrus, right occipito-temporal medial lingual gyrus, and right postcentral gyrus in patients with ESRD were lower than those in the healthy controls (0.6704 vs. 0.8562; 0.8593 vs. 0.9388; 0.7778 vs. 0.8849; 0.6825 vs. 0.8112; adjusted $p<0.05$, respectively).
Conclusions : This study demonstrates that the multilayer network combining structural and functional layers in patients with ESRD is different from that in the healthy control group. The specific differences in weighted multiplex participation suggest potential disruptions in the integrated communication between different brain regions in patients with ESRD.

Multilayer 1.png

	Patients with ESRD	Controls	Difference	Lower value of the 95% confidence interval	Upper value of the 95% confidence interval	*p*-value	adjusted *p*-value
Weighted multiplex participation	0.6454	0.7212	0.0758	-0.0128	0.0112	0.013	0.049
Persistence	0.4425	0.4526	0.0101	-0.0348	0.0311	0.199	0.337
Average overlapping strength	34.2239	34.5994	0.3755	-1.6153	1.5247	0.241	0.337
Average multiplex participation	0.7454	0.7245	-0.021	-0.0128	0.0112	0.016	0.056
Average multiplex clustering	0.1547	0.1551	0.0004	-0.0095	0.0091	0.353	0.353
Mulilayer modularity	0.3961	0.3804	-0.0157	-0.0147	0.0141	0.036	0.084
Average flexibility	0.5516	0.555	0.0035	-0.0382	0.0353	0.347	0.353

Multilayer 1.png