Peritoneal dialysis is associated with better cognitive function than hemodialysis over a one-year course

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Impaired cognitive functioning in patients with end-stage renal disease may reduce their capabilities to adhere to complex medical or dietary regimens and to fully participate in medical decisions. With decreasing renal function, cognitive abilities are likely to decline, with cognitive dysfunction improving after initiation of dialysis and even being generally reversible after successful renal transplantation. However, little is known about cognitive changes particularly regarding different treatment modalities. To gain further insight into this, we focused on a one-year course of cognitive functions, comparing peritoneal to hemodialysis patients. Within the CORETH-project, two validated neurocognitive tests, assessing executive functioning (Trail Making Test-B) and attention (d2-Revision-Test) and the self-reported Kidney Disease Quality of Life Short Form Cognitive Function-subscale, were administered to 271 patients at baseline and after one year. Subsamples were matched by propensity score, adjusting for age, comorbidity, education, and employment status for 96 hemodialysis and 101 peritoneal dialysis patients. The effects of time and treatment modality were investigated, controlling for well-known confounders. Both tests revealed improvement over one year. Peritoneal dialysis was associated with better outcomes than hemodialysis at baseline and follow-up, but comparability between groups may be limited. The opposite pattern applied to self-reporting. Hemodialysis patients had to be excluded from cognitive testing more often than peritoneal dialysis patients. As such, the number of exclusions may have biased the findings, limiting generalizability. Thus, our findings suggest an improvement of cognitive functioning and support previous indications for peritoneal dialysis being associated with better cognitive functions during a one-year course than hemodialysis.

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Cognitive functioning (CF) in patients with end-stage renal disease (ESRD) has become a major concern over the past decades. The term CF covers multiple skill domains including memory, attention, information processing, language, visuospatial skills, and executive functioning (EF). Especially within the subdomains EF and attention, patients with ESRD show a high prevalence of cognitive impairment.[1–5] EF refers to complex cognitive performance–related abilities, including planning and performing activities,[6] and thus is important in the clinical setting. A decline of CF was revealed to be associated with the severity of renal failure.[7] Patients with ESRD are often required to adhere to complex regimens. Impaired cognitive conditions (e.g., a reduced attention span) may hinder the patients' abilities to optimally do so by affecting the efficiency of everyday tasks.[8] Impaired EF has been associated with poor judgment and adherence, functional decline, and mortality in nondemented elderly populations.[9,10] Thus, a cognitive decline may increasingly affect the patients' abilities to understand and process information, to participate fully in making decisions about their health care, to adhere to complex medical regimens, or implement dietary and fluid regulations properly.[11,12] Furthermore, patients with cognitive impairment are at higher risk of hospitalization, mortality, and a poorer quality of life.[1] Consequently, cognitive impairment may considerably worsen disease burden and increase health care expenditures.[11] Given these findings and the relatively advanced age of most ESRD patients, cognitive impairment is increasingly being recognized as a serious problem in this already vulnerable population.[3,13]

Although CF in chronic kidney disease (CKD) has been the focus, most studies are cross-sectional in nature. With respect to longitudinal designs, cognitive function may be fully restored after successful renal transplantation,[14] and several studies indicate better CF after the initiation of hemodialysis (HD) compared with nondialyzed ESRD.[15–17] However, the majority of studies were uncontrolled and did

not adjust for sociodemographic aspects or other cognitive impairment–associated factors[18]; hence, causal inferences regarding CF in dialysis patients remain unclear.

A recent systematic review and meta-analysis[1] indicate that the prevalence of cognitive impairment in HD patients is as high as 70%, with the general population significantly outperforming them in cognitive testing (CT), particularly attention and EF. However, data comparing CF in patients with respect to different dialysis modalities are both too scarce and insufficient to allow for modality-specific conclusions.[1] Some studies have reported better CF in peritoneal dialysis (PD) compared with HD patients, indicating that PD is more beneficial in the management of cognitive impairment,[19] more adequate in reversing uremic encephalopathy,[20] and superior in restoring cognitive capacity.[21] Nevertheless, there is a lack of longitudinal studies observing neurocognitive variances among dialysis patients with different treatment modalities.

Within the framework of the Choice of Renal Replacement Therapy (CORETH) project, we addressed this issue to improve description and evaluation of CF in dialysis patients. We monitored the course of CF in the domains of EF and attention as well as through self-reported CF in HD versus PD patients over 1 year. We focused on the course of CF with respect to treatment modality while adjusting for well-known CF-related factors. Additionally, we estimated the prevalence of cognitive impairment relating to the general population.

RESULTS

Sample characteristics

Sample characteristics are shown in Table 1. After propensity score matching, there were no differences regarding age, comorbidity, education, or employment status between patient subgroups. A previous neurological/cerebrovascular disease (e.g., stroke) was present in 9 patients in the matched sample with no differences between both subgroups. Psychotropic drug intake was documented for 29 patients (matched sample) with no differences between HD and PD patients. At follow-up, psychotropic drug intake was documented for 11 PD and 33 HD patients in the unmatched sample ($P = 0.03$) and for 11 PD and 16 HD patients in the matched sample ($P = 0.24$).

Descriptive data of cognitive indicators

Figure 1 illustrates the course of CF for the Trail Making Test B (TMT-B[23]), the Test d2-Revision (d2-R[24]), and the subscale Cognitive Function from the Kidney Disease Quality of Life Short Form (KDQOL-CF[25]) for the matched sample. Detailed descriptive statistics for all cognitive indicators of the matched and unmatched samples as well as the CT results of the baseline sample including loss to follow-up are provided in Supplementary Table S1. Performance in both types of CT improved over time, with PD patients showing better CF in the CTs than HD patients. In contrast, HD patients reported higher CF than PD patients. Self-reported CF scores were lower at follow-up, indicating a perceived reduction of CF over time. The degree of change within each cognitive indicator is presented in Supplementary Figure S1.

The course of CF and effects of treatment modality

To estimate effects of time and treatment modality on CF, a linear mixed model was used, adjusting for age, comorbidity, education and employment status, depression level, psychotropic drug intake, and time on dialysis. Correlations (Pearson coefficients) between the d2-R score with the TMT-B score inverted were moderate at baseline ($r = 0.61$, $P < 0.001$)

Table 1 | Characteristics of the total sample and the subsamples (HD vs. PD)

	Unmatched sample					Matched sample				
Characteristics	Total ($N = 271$)	PD ($N = 108$)	HD ($N = 163$)	*z* difference	*P* value	Total ($N = 197$)	PD ($N = 101$)	HD ($N = 96$)	*z* difference	*P* value
Age, mean (SD), yr	56.6 (14.9)	56.0 (14.7)	57.0 (15.0)	0.07	0.56	53.8 (14.9)	55.7 (14.7)	51.9 (15.9)	−0.26	0.08
Sex, %										
Female	30.3	34.3	27.6	−2.40	0.24	30.5	35.6	25.0	−3.23	0.11
Male	69.7	65.7	72.4	2.40		69.5	64.4	75.0	3.23	
Education level, %										
Lower	28.1	24.1	30.9	2.49	0.01	23.9	25.7	21.9	−1.25	0.41
Medium	47.4	41.7	51.2	0.99		47.2	42.6	52.1	2.67	
High	24.4	34.3	17.9	−6.29		28.9	31.7	26.0	−1.76	
Employment status, %										
Working	26.7	32.4	22.8	−3.57	0.08	33.0	29.7	36.5	2.03	0.31
Nonworking/retired	73.3	67.6	77.2	3.57		67.0	70.3	63.5	−2.03	
CCI, mean (SD)	4.7 (2.2)	4.4 (2.1)	4.9 (2.3)	0.23	0.04	4.2 (2.0)	4.4 (1.9)	4.1 (2.1)	−0.15	0.30
Time on dialysis, mo, mean (SD)	14.8 (5.3)	14.9 (7.2)	14.8 (5.7)	−0.02	0.93	14.6 (6.3)	14.7 (7.2)	14.5 (5.4)	−0.03	0.82
Neurological/ cerebrovascular disease, %	4.8	6.5	3.7	−2.16	0.29	4.6	5.9	3.1	−1.88	0.34
Psychotropic drug intake, %	16.6	13.0	19.0	2.65	0.19	14.7	13.9	15.6	0.67	0.73

CCI, Charlson Comorbidity Index; HD, hemodialysis; PD, peritoneal dialysis.
A *t* test was performed for continuous variables, and a χ^2 test was performed for categorical variables. *z* Differences referring to Kuss[22] were used to measure the balance of covariates in a matched propensity score analysis.