The Burden of Cognitive Impairment in Patients With End-Stage Renal Disease and Impact on Dialysis Modality Choice

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Introduction: Kidney disease is associated with significant cognitive dysfunction. Subjective reports of cognitive ability have not been studied extensively in chronic kidney disease. We investigated the association between objective and subjective cognitive functions in predialysis patients and their association with self-care dialysis modality choice.

Methods: Cross-sectional data from the Barriers to Successful Implementation of Care in Home Haemodialysis study were used for the study of cognition in 220 predialysis patients. The data were used to ascertain the demographics, clinical, laboratory, and neuropsychometric variables. The latter includes Trail Making Tests (TMT) parts A and B, Modified Mini Mental State Examination, and metacognition questionnaire for subjective assessment of one’s cognitive ability. The outcome variable was fully assisted and self-care dialysis modality choice.

Results: Within the study cohort, 90 patients chose fully assisted hemodialysis and 114 patients chose self-care dialysis. The median Modified Mini Mental State Examination, TMT part A, and TMT part B scores were greater for the assisted versus the self-care group. Metamemory was not significantly different between groups, but the metacognition score was significantly worse in the group choosing assisted dialysis. Higher (i.e., better) metacognition scores were significantly associated with the self-care modality choice in the univariate and hierarchical regression analyses. Adjusted and unadjusted analyses showed a significant association between perceived concentration and TMT part B scores ($P < 0.01$). With every 1.6-minute increase in TMT part B score, there was a 1-unit reduction in metacognition score, and the latter was associated with 20% lower odds of choosing self-care dialysis over a fully assisted dialysis modality.

Discussion: Patients’ self-perception of cognitive ability is a significant predictor of self-care dialysis modality choice. Subjective report of “metaconcentration” is also strongly associated with poorer outcome on the TMT part B.

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Chronic kidney disease (CKD) is a worldwide public health issue.1,2 Cognitive deficits in CKD patients are increasingly being recognized as a major problem, with a 3-fold increase in this group compared to that in the general population.3 The management of cognitive deficits very early in the course of CKD is desirable, as more advanced stages of kidney disease are associated with greater impairment of cognitive function.4 In 1 study, participants with mild, moderate, and severe renal impairment were compared, and the authors concluded that for every 10-ml/min decrease in estimated glomerular filtration rate, the risk of cognitive dysfunction increased by 15% to 25%.5 This issue is more of a problem in older individuals and in those established on dialysis, with a prevalence of cognitive impairment in hemodialysis patients estimated to be about 30% to 70%.6 The presence of cognitive impairment in this cohort is also associated with higher mortality.7,8 The pathogenesis of the accelerated cognitive decline in CKD is attributable to vascular injury from traditional risk factors, and from direct neuronal toxicity of uremic retention solutes.9 It is believed that microvascular disease of the brain is responsible for the pattern of cognitive deficits seen in kidney disease and that it is related to the patients’ vascular risk profiles. This is typically manifest as impaired executive brain function.
The focus on cognition in CKD is extremely important, as the notion of self-care dialysis relies on cognitive intactness. Patient participation, patient choice, and patient-led decision making are associated with better outcomes and are therefore considered best clinical practice.10–12 There is greater impetus for self-management of long-term conditions,13,14 but the cognitive context in which such decisions are made by patients is not well understood and merits further research. This applies to both objective cognitive deficits and patients’ assessment of their own cognitive ability (subjective cognitive ability). The latter is grossly underrepresented in kidney disease literature.

Few studies have been published to date, in regard to patients with kidney disease, that specifically seek to examine the association between subjective and objective cognition assessments.15,16 The Kidney Disease Quality of Life (KDQOL)—Cognitive Function subscale with 3 questions was shown to be a limited instrument for accurately assessing subjective cognitive function16 and bore no relationship to the executive function test, which is commonly abnormal in chronic kidney disease.17–19 More recently, a study found modest correlation between subjective and objective assessments; however, the former was a predictor of the patient’s self-reported measure of activities of daily living, although both subjective reports may well be influenced by negative affectivity.1,2,20 In other population groups, subjective assessment of impaired cognition has been associated with poorer health-related quality-of-life, reduced daily functioning,21 and increased risk of hospital attendance,22,23 and is also predictive of future cognitive decline.24–26 In addition, the identification of cognitive impairment is important in order to assist patients in making well-informed treatment decisions, in ensuring treatment compliance, and in helping to prevent functional decline.27 Treatment decision making is multifactorial and includes, among other factors, the patient’s and health care professional’s perception (whether accurate or not) of the patient’s cognitive abilities. The choice of self-care dialysis decisions is expected of patients after information on dialysis modalities is provided to them. Hence, the possibility of the influence of the patients’ assessment of how their memory works, and how they judge their own abilities and effectiveness, may predict their choice of dialysis modality.

The aims of the present study are as follows: (1) to assess metacognition in patients with CKD-5 (pre-dialysis phase of end-stage renal disease) as a measure of subjective cognitive impairment and to explore the association between subjective and objective cognition tests; and (2) to examine associations of dialysis modality choice (fully assisted vs. self-care) with measures of objective (global cognition and executive brain function) and subjective cognition assessments (memory and concentration).

**MATERIALS AND METHODS**

**Participants and Recruitment**

Data for the present study are derived from that ascertained for the Barriers to Successful Implementation of Care in Home Haemodialysis (BASIC-HHD) study.28 The data were prospectively collected for a comprehensive and systematic study of barriers to and enablers of the uptake of self-care dialysis therapy. The study involves 5 centers in the United Kingdom, with variable prevalence rates of home hemodialysis (HD). An integrated mixed methodology (convergent, parallel design) has been adopted for the BASIC-HHD study in a combined cross-sectional and prospective study design. The methodological details and scope of data collected in the BASIC-HHD appear in a published protocol.28 Data presented here are derived from the CKD-5, a predialysis cohort of the BASIC-HHD study. A total of 222 patients were enrolled in this group. Predialysis patients were approached if they fulfilled eligibility criteria and were willing to undertake neuropsychometric assessments and to complete study specific questionnaires.

**Study Registration**

This study was reviewed and approved by the Greater Manchester West Health Research Authority National Research Ethics Service (NRES) (Reference number: 12/NW/0170). The study is on the NIHR portfolio (ID 12346). Written informed consent from participants was obtained for the study. Psychological measures used in this study were part of a compilation of questionnaires. Blood sampling and neuropsychometric assessments were carried out at patients’ routine hospital clinic visits. Visually impaired participants were excluded from this analysis (n = 2).

**Independent Variables**

Independent variables included the following: objective tests of cognition, Trail Making Tests (TMT) parts A and B,29 Modified Mini Mental State Examination (3MS),30 subjective assessment of cognition scales (metacognition questionnaire),31 demographics (age, sex, ethnicity, education, employment, and marital status); clinical variables (Charlson Comorbidity Index [CCI],32 cause of end-stage renal disease [ESRD], diabetes, heart failure, intracranial vascular events, ischemic heart disease, systolic and diastolic blood pressures); laboratory variables (urea, creatinine, phosphate, parathyroid hormone, bicarbonate, albumin, hemoglobin, and medications including angiotensin-converting enzyme inhibitors, central nervous system—influencing drugs, antidepressants, antiplatelet agents, cholesterol-lowering drugs,
Cognitive Assessments

Objective Tests
Tests of cognitive function were assessed by study coordinators across all participating centers after completion of training in the application and procedure for using these tests. Only participants conversant in English language were included in this aspect of the study. The 3MS is a test of global cognitive function that includes assessment of orientation, attention, calculation, language, and short-term memory. The Trail Making Tests are a measure of cognitive abilities such as speed and fluid intelligence; they have been hypothesized to reflect a wide variety of cognitive processes including attention, visual search and scanning, sequencing and set shifting, psychomotor speed, abstraction, flexibility, and ability to execute and modify a plan of action. A 3MS score of <80 is deemed deficient. The timed Trail Making Tests parts A and B are deemed insufficient if the duration exceeds 1 SD from the mean of the present study cohort (>87 seconds in part A and >197 seconds in part B). All 3 variables were treated as continuous variables for the purpose of the univariate and multivariable analysis.

Subjective Tests
To enable understanding of the patients’ beliefs about their own memory and concentration, the brief metacognition questionnaire was used. This questionnaire has 2 subscales: the metamemory subscale (5 questions) and the metaconcentration subscale (4 questions). Metacognition is highly relevant for sustained independence in older age. This tool has not been validated in the kidney disease population, but the parameters used to assess the outcome, namely independence, was deemed common to both population groups. The responses were given on a Likert scale (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree and 5 = strongly agree) and then summed for each subscale. The range of scores for the metamemory subscale is 5 to 25 and that of the metaconcentration subscale is 4 to 20. A summary of completeness of data provided by the study participants is provided in Table 1.

The TMT part B test data had missing data points that appeared to be missing at both random and not at random. Where patients failed to complete part of the test, the data are considered “missing not at random.” Missing at random data included those items for which participants did not complete any data or for which the administration was deemed incorrect. In 8 cases, the data were imputed to 300 seconds where the administrator explicitly mentioned that the patient “gave up” completing the TMT part B test after persisting for some time (missing not at random data). However, of these 8 imputed cases, only 6 were considered for analysis, for which information on modality choice as the outcome was also available.

Statistical Analyses
Analyses were performed using SPSS 22 and STATA 13. A 2-sided 5% significance level was used throughout the analysis. Baseline characteristics were assessed among the 3 modality choices in the predialysis cohort using $\chi^2$ tests, Fisher exact tests, analyses of variance, and Kruskal–Wallis tests, as appropriate.

Single variable analyses using $\chi^2$ tests, Fisher exact tests, independent t tests, and Mann–Whitney U tests, as appropriate, with modality choice as the outcome, grouped as self-care (peritoneal dialysis [PD] and home dialysis) and hospital, revealed which cognitive, medical, and demographic variables were significant. A hierarchical logistic regression analysis was then carried out for each of the cognitive variables (5 models) with modality choice as the outcome. The differences within the self-care group were investigated to assess the suitability of grouping PD and home HD. The relationships between the subjective and objective cognition variables were investigated using correlations and linear regression.

Sensitivity analyses were carried out involving multiple imputation with chained equations to account for missing data in all of the cognition variables based on variables including CCI, age, sex, ethnicity, education, employment, BDI, scores on other tests of objective cognition, and the outcome variable, namely, modality choice (Appendix S1).

RESULTS

Patient Characteristics
There were 220 participants in all. A total of 90 patients chose hospital hemodialysis and 114 patients chose self-care dialysis (PD and home hemodialysis [HHD]). Of these, 52% (114) of patients expressed their preference
### Table 2. Characteristics of study participants

|                          | Facility-based HD (n = 90) | PD (n = 78) | Home HD (n = 36) | P value |
|--------------------------|---------------------------|------------|-----------------|---------|
| **TMT B, median (IQR)**  | 102.0 (76.5–132.3)        | 90.0 (63.0–118.0) | 94.0 (64.5–122.5) | 0.11*   |
| **TMT A, median (IQR)**  | 49.0 (32.0–62.0)          | 41.5 (30.0–60.0) | 42.8 (31.2–55.9) | 0.086*  |
| **3MS, median (IQR)**    | 93.0 (88.5–97.0)          | 95.0 (91.0–98.0) | 92.5 (88.0–98.5) | 0.066*  |
| **MCQ1 (metamemory), mean (SD)** | 17.7 (3.8)    | 18.2 (3.3) | 17.4 (4.5) | 0.53    |
| **MCQ2 (metaconcentration), mean (SD)** | 13.9 (2.4)    | 15.1 (2.8) | 14.6 (2.9) | 0.016*  |
| **Age, mean (SD)**       | 62.6 (12.3) | 58.3 (12.9) | 53.6 (13.0) | 0.001*  |
| **Sex, female**          | 36 (40.0%) | 28 (35.9%) | 15 (41.7%) | 0.80    |
| **Education, post high school** | 19/87 (21.8%) | 20/76 (26.3%) | 12/35 (34.3%) | 0.36    |
| **Employment**           |                          |            |                 |         |
| Retired                  | 51 (56.7%) | 36 (46.2%) | 12 (33.3%) | 0.053   |
| Unemployed               | 19 (21.1%) | 13 (16.7%) | 7 (19.4%) | 0.063   |
| Salaried/self-employed   | 20 (22.2%) | 29 (37.2%) | 17 (47.2%) | 0.001   |
| Ethnicity, nonwhite      | 12 (13.3%) | 3 (4.4%) | 5 (13.9%) | 0.079   |
| Marital status           |                          |            |                 |         |
| Married or partner       | 56 (62.2%) | 53 (67.9%) | 23 (63.9%) | 0.71    |
| Single                   | 20 (22.2%) | 13 (16.7%) | 7 (19.4%) | 0.71    |
| Divorced or separated    | 6 (8.7%) | 3 (8.8%) | 4 (11.1%) | 0.99    |
| Widowed                  | 8 (8.9%) | 9 (11.5%) | 2 (5.6%) | 0.99    |
| **Cause of ESRD**        |                          |            |                 |         |
| Systemic                 | 50 (55.6%) | 29 (37.2%) | 13 (36.1%) | 0.081   |
| Renal                    | 17 (18.9%) | 24 (30.8%) | 13 (36.1%) | 0.081   |
| Other/Unknown            | 23 (25.6%) | 25 (32.1%) | 10 (27.8%) | 0.009   |
| **Diabetes**             | 5.0 (4.0–7.0) | 4.0 (3.0–6.0) | 4.0 (3.0–5.0) | 0.009   |
| **Heart failure**        | 4 (4.4%) | 4 (5.1%) | 1 (2.8%) | 0.99    |
| Ischemic heart disease   | 18 (20.0%) | 18 (23.1%) | 6 (16.7%) | 0.72    |
| IVE                      | 9 (10.0%) | 5 (6.4%) | 2 (5.6%) | 0.59    |
| **Urea, median (IQR)**   | 22.6 (16.8–28.2) | 23.1 (16.8–29.4) | 23.1 (19.7–26.0) | 0.066   |
| **Creatinine, median (IQR)** | 377 (338–459) | 428 (343–524) | 429 (383–500) | 0.046   |
| **Hb < 9**               | 3/89 (3.4%) | 2/76 (2.6%) | 0/35 (0%) | 0.77    |
| **Alb < 30**             | 4/89 (4.5%) | 2/76 (2.6%) | 0/35 (0%) | 0.65    |
| **Bic <22**              | 37 (44.0%) | 32 (42.7%) | 17 (48.6%) | 0.99    |
| **>28**                  | 4 (4.8%) | 4 (5.3%) | 1 (2.9%) | 0.99    |
| **PTH, median (IQR)**    | 23.6 (14.0–35.2) | 22.2 (12.3–35.1) | 32.3 (17.5–48.3) | 0.061   |
| **Phosphate**            | 4/88 (4.5%) | 9/76 (11.8%) | 1 (2.9%) | 0.10    |
| **SBP, mean (SD)**       | 143.7 (19.2) | 137.5 (21.4) | 140.1 (17.5) | 0.14    |
| **DBP, >85**             | 16/89 (18.0%) | 15/76 (19.7%) | 6 (16.7%) | 0.92    |
| **DBP, mean (SD)**       | 76.3 (11.1) | 77.1 (11.4) | 73.4 (11.9) | 0.26    |
| **ACEi or ARB**          | 41 (45.6%) | 47 (60.3%) | 21/34 (61.8%) | 0.098   |
| **Folic acid**           | 10 (11.1%) | 11 (14.1%) | 5/34 (14.7%) | 0.80    |
| No. of antihypertensive drugs, median (IQR) | 3.0 (2.0–4.0) | 2.5 (2.0–4.0) | n = 34 | 0.28    |
| **EPO**                  | 31 (34.4%) | 30 (38.5%) | 8/35 (22.9%) | 0.27    |
| **CNS**                  | 7 (7.8%) | 7 (9.0%) | 4/34 (11.8%) | 0.78    |
| **Antidepressants**      | 18 (20.0%) | 10 (12.8%) | 3/34 (8.8%) | 0.22    |

(Continued on next page)
for self-care dialysis, 36 patients preferred HHD, and 78 patients preferred PD. The characteristics of these participants are presented in the Table 2. Among the 3 groups overall, significant differences were observed in regard to age, CCI, BDI score, and STAI-S, which were higher in patients choosing fully assisted dialysis. Metaconcentration scores were lowest in participants choosing hospital HD. Parathyroid hormone was significantly higher in the cohort choosing HHD. Within the self-care group, no significant differences were observed in any dependent variable category, including tests of cognition, between participants who chose PD versus HHD.

Cognition Burden in ESRD
In the study cohort, based on the cut-off for identification of objective cognitive deficit (3MS < 80, TMT parts A and B > 1.5 SD from the mean for the study groups), the numbers and proportions of participants with cognitive deficits in the 3 groups are as shown in Table 3.

Univariate Analysis
In the single-variable analysis of the association of key variables of interest with modality choice (Table 4), variables significantly ($P < 0.05$) associated with self-care dialysis modality (PD+HHD) choice, include lower TMT part B scores, lower TMT part A scores, higher metaconcentration scores, lower age, being in employment, “renal-limited” cause of end-stage renal disease, lower CCI, use of drugs such as angiotensin-converting enzyme inhibitors, higher serum creatinine, lower BDI, and lower STAI-S/T scores.

Hierarchical Regression Analysis of Predictors of Self-Care Modality Choice
In the hierarchical regression analysis (Table 5), significant predictors of self-care dialysis modality choice across all models of cognition tests include white ethnicity, lower BDI scores, and lower CCI, after adjustment for other variables in the model. The test of subjective cognitive ability, the metaconcentration subscale, but not the metamemory subscale, was highly significantly associated with self-care modality choice ($P < 0.01$). TMT parts A and B and 3MS were not statistically significant predictors of modality choice after adjustment for CCI (age is factored into CCI), BDI, employment, ethnicity, and sex, although the direction of effect suggests that better scores on tests of cognition are associated with the choice of self-care dialysis modality.

Association Between Objective and Subjective Cognitive Assessments
In the adjusted analysis (adjusted for CCI, BDI, and education) (Table 6) of the association among TMT parts A and B, 3MS, and the metamemory and metaconcentration subscales, a significant association was noted between TMT part B and the metaconcentration scale ($P < 0.01$). A parameter estimate of $-0.10$ suggests a small (0.1-unit) change in metaconcentration score with a 1-second increase in TMT part B. Therefore, with every 1.6-minute increase in TMT part B, there is a 1-unit reduction in metaconcentration score, and this is associated with 20% lower odds of choosing a self-care modality over HHD.

| Table 2. Characteristics of study participants (Continued) |
|------------------------------------------------------------|
| **Facility-based HD (n = 90)** | **PD (n = 78)** | **Home HD (n = 36)** | **P value** |
| Antiplatelet agents | 39 (43.3%) | 24 (30.8%) | 13/34 (38.2%) | 0.24 |
| Statins/EZE | 53 (58.9%) | 41 (52.6%) | 24/34 (70.6%) | 0.20 |
| Pill burden, mean (SD) | 7.5 (2.6) | 6.9 (2.5) | n = 34 | 8.2 (3.4) | 0.069 |
| BDI, median (IQR) | n = 82 | 12.0 (5.8–22.3) | n = 70 | 7.0 (4.0–12.3) | n = 28 | 9.0 (6.0–14.5) | 0.009 |
| STAI State, median (IQR) | n = 80 | 39.5 (29.3–47.8) | n = 66 | 32.0 (26.0–40.0) | n = 28 | 33.0 (25.3–46.0) | 0.026 |
| STAI Trait, median (IQR) | n = 79 | 41.0 (30.0–47.0) | n = 63 | 34.0 (29.0–46.0) | n = 28 | 35.0 (27.0–42.8) | 0.093 |

BDI, Beck Depression Inventory; CCI, Charlson Comorbidity Index; CNS, central nervous system; DBP, diastolic blood pressure; EPO, erythropoietin; ESRD, end-stage renal disease; EZE, ezetimibe; HHD, hemodialysis; IVE, intracranial vascular event; IQR, interquartile range; MCI, Metacognition Questionnaire; PD, peritoneal dialysis; PTH, parathyroid hormone; SBP, systolic blood pressure; STAI, State and Trait Anxiety Inventory; TMT, Trail Making Test; 3MS, Modified Mini Mental State Examination.

*Kruskal–Wallis test.
*One-way analysis of variance.
*Pearson $\chi^2$ test.
*Fisher exact test.


Table 4. Univariate analysis of study variables with modality choice as outcome

| Facility-based HD (n = 84) | Self-care, Home HD or PD (n = 114) | P value |
|---------------------------|-----------------------------------|---------|
| TMT B, Median (IQR)       | n = 84                            | n = 93  |
|                           | 102.0 (78.5–132.3)                | 90.0 (63.0–119.0) |
| TMT A, Median (IQR)       | n = 83                            | n = 110 |
|                           | 49.0 (32.0–62.0)                  | 42.0 (30.0–56.3) |
| 3MS, Median (IQR)         | n = 85                            | n = 108 |
|                           | 93.0 (88.5–97.0)                  | 94.5 (91.0–98.0) |
| MCQ1 (metamemory)        | n = 89                            | n = 111 |
| Mean (SD)                 | 17.7 (3.8)                        | 17.9 (3.7) |
| MCQ2 (metacognition)      | n = 88                            | n = 110 |
| Mean (SD)                 | 13.9 (2.4)                        | 14.9 (2.8) |
| Age, Mean (SD)            | 62.6 (12.3)                       | 56.8 (13.1) |
| Gender, Female            | 36 (40.0%)                        | 43 (37.7%) |
| Education, post-high school| 19/87 (21.8%)                     | 32/111 (28.8%) |
| Employment                | Retired 51 (56.7%)                | 48 (42.1%) |
|                           | Unemployed 19 (21.1%)             | 20 (17.5%) |
|                           | Married or partner 56 (62.2%)     | 76 (66.7%) |
|                           | Single 20 (22.2%)                 | 20 (17.5%) |
|                           | Widowed 8 (9.8%)                  | 11 (9.6%) |
| Cause of ESRD             | Systemic 50 (55.6%)               | 42 (36.8%) |
|                           | Renal 17 (18.9%)                  | 37 (32.5%) |
|                           | Other/Unknown 23 (25.6%)          | 35 (30.7%) |
| CCI, Median (IQR)         | 5.0 (4.0–7.0)                     | 4.0 (3.0–6.0) |
| Diabetes                  | 32 (35.6%)                        | 32 (28.1%) |
| Heart failure             | 4 (4.4%)                          | 5 (4.4%) |
| Ischaemic Heart Disease   | 18 (20.0%)                        | 24 (21.1%) |
| IVE                       | 9 (10.0%)                         | 7 (6.1%) |
| Urea, Mean (SD)           | n = 89                            | n = 111 |
|                           | 23.3 (7.7)                        | 24.0 (6.8) |
| Creatinine – Median (IQR) | n = 89                            | n = 111 |
|                           | 377 (338–459)                     | 428 (348–613) |
| Hb, <9                    | 3/89 (3.4%)                       | 4/112 (3.6%) |
|                           | >9                               | 48/89 (45.5%) |
| Alb, <30                  | 2/112 (1.8%)                     | 21/122 (1.8%) |
|                           | >30                              | 48/89 (4.8%) |
| Bic                       | n = 84                            | n = 110 |
|                           | <22                              | 37 (44.0%) |
|                           | 22–28                            | 43 (51.2%) |
|                           | >28                              | 4 (4.8%) |
| PTH, Median (IQR)         | n = 86                            | n = 112 |
|                           | 23.6 (14.0–35.2)                  | 25.2 (13.2–38.2) |
| Phosphorus                | n = 88                            | n = 111 |
|                           | <1.1                             | 11 (12.5%) |
|                           | 1.1–1.7                          | 61 (76.3%) |
|                           | >1.7                             | 16 (18.2%) |
| SBP, <=115                | 4/89 (4.5%)                       | 10/112 (8.9%) |
| SBP, Mean (SD)            | n = 89                            | n = 112 |
|                           | 143.7 (19.2)                     | 138.4 (20.2) |
| DBP, >85                  | 168/89 (18.0%)                    | 21/112 (18.8%) |
| DBP, Mean (SD)            | n = 89                            | n = 112 |
|                           | 76.3 (11.1)                      | 75.9 (11.6) |
| ACEI orARB                | 41 (45.6%)                        | 68/112 (60.7%) |
|                           | Number of antihypertensive drugs, Median (IQR) | 3.0 (2.0–4.0) |
|                           | <0.05                            | 3.0 (2.0–4.0) |

(Continued)

Table 4. Characteristics of study participants (Continued)

| Facility-based HD (n = 90) | Self-care, Home HD or PD (n = 114) | P value |
|---------------------------|-----------------------------------|---------|
| EPO                       | 31 (34.4%)                        | 38/113 (33.6%) |
| CNS                       | 7 (7.8%)                          | 11/112 (9.8%) |
| Antidepressants           | 18 (20.0%)                        | 13/112 (11.6%) |
| Antipsychotics            | 39 (43.3%)                        | 37/112 (33.0%) |
| Statins/EZE               | 53 (58.9%)                        | 65/112 (58.0%) |
| Pill burden, mean (SD)    | 7.5 (2.6)                         | n = 112 |
|                           | 7.3 (2.9)                         |         |
| BDI, median (IQR)         | n = 82                            | n = 98  |
|                           | 12.0 (5.8–22.3)                   | 7.5 (4.0–13.0) |
| STAI State, median (IQR)  | n = 80                            | n = 94  |
|                           | 39.5 (29.3–47.8)                  | 32.0 (26.0–42.3) |
| STAI Trait, median (IQR)  | n = 79                            | n = 91  |
|                           | 41.0 (30.0–47.0)                  | 35.0 (29.0–45.0) |

ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker; CCI, Charlson Comorbidity Index; CNS, central nervous system; DBP, diastolic blood pressure; EPO, erythropoietin; ESRD, end-stage renal disease; EZE, ezetimibe; HD, hemodialysis; IQR, interquartile range; MCQ, Metacognition Questionnaire 1; PD, peritoneal dialysis; PTH, parathyroid hormone; SBP, systolic blood pressure; STAI, State and Trait Anxiety Inventory; 3MS, Modified Mini Mental State Examination.

*aMann–Whitney U test.
*bIndependent-samples t test.
*cPearson χ² test.
*dFisher exact test.
*eFisher linear trend test.

Our study has attempted to explore the association between measured cognitive deficits and self-care dialysis modality choice. The influence of patients’ assessment of how their memory works, and how they judge their own abilities and effectiveness, may predict their choice of dialysis modality; therefore, a pragmatic brief tool to measure subjective cognitive capacity has been studied here. This is the first study of its kind in the dialysis choice context. The data completeness rate for all aspects of the study combined is excellent.

Our findings suggest that greater cognitive ability is associated significantly with greater self-care dialysis...
Table 5. Characteristics of study participants (Continued)

| Variable                                      | Odds ratio (95% CI) | P value |
|-----------------------------------------------|---------------------|---------|
| **Table 6. Association of metacognition scales with objective tests of cognition**
| Objective cognition test                      | n                  | Parameter estimate (95% CI) | P value |
| Adjusted (for CCI, BDI, and education) regressions with metacognition as the outcome | 144                | -0.09 (-0.19, 0.02)         | 0.097   |
| TMT B (per 10-s increase)                    | 180                | -0.15 (-0.39, 0.08)         | 0.19    |
| TMT A (per 5-s increase)                     | 179                | 0.33 (-0.66, 1.33)          | 0.51    |
| 3MS (per 10 score increase)                  | 141                | -0.10 (-0.17, -0.03)        | 0.004   |
| TMT B (per 10-s increase)                    | 177                | -0.10 (-0.26, 0.06)         | 0.21    |
| TMT A (per 5-s increase)                     | 176                | 0.43 (-0.26, 1.12)          | 0.22    |

BDI, Beck Depression Inventory; CI, confidence interval; CCI, Charlson Comorbidity Index; OR, odds ratio; s, second; TMT, Trail Making Test; 3MS, Modified Mini-Mental State. *OR >1 = Self-care modality choice.

modality choice. Patients’ self-reported metacognition however, is highly significantly associated with self-care dialysis modality choice. None of the 3 measures of objective cognition assessments, however, is statistically significant in the regression models. The objective tests of cognition lack statistical power. The data that are systematically missing because of patients’ inability to complete the test indicates that there could potentially have been a statistically significant association if patients had persevered and completed the tests. However, it is to be noted that recruitment and retention of patients in studies of cognition is difficult and may pose a major limitation with respect to practical clinical utility.

The metacognition questionnaire captures patients’ beliefs about their memory and concentration components of the cognition process, and it is important, as not every functional area of the brain is affected equally in patients. In an otherwise healthy group of elderly patients, 1 study reported that individuals lacking in self-concept show less problem solving, perhaps because they do not think it is worth trying. If cognitive decline is consciously perceived by individuals, they may no longer practice their cognitive skills and may rely on external assistance. Our study does show a statistically significant association of the metacognition measurement with tests of executive function (TMT B), consistent with another study in the dialysis population. This is not surprising, and it raises the possibility of the metacognition measurement as an effective proxy/complement to objective tests of executive brain function. This remains to
be validated, and so does the metacognition question
naire in the population with renal disease.

Other predictors of hospital-based modality choice
after adjustment of cognitive status include nonwhite
ethnicity and higher BDI and CCI scores. The latter
variables are known to be associated with and to
adversely affect both executive and global cognitive
functions. 40 - 43

Cognitive impairment and/or depressive mood in
patients with ESRD can affect patient behaviors, atti
tudes, and compliance. 44,45 In a routine clinical
consultation of the predialysis patient in the UK,
patients spend considerable lengths of time being
assessed physically in preparation for commencement
doctor as being cognitively impaired. 36 In the same study,
doc
tors could not identify 25.5% of patients who were
depressed, and 45% of those depressed were also found
to be cognitively impaired. This knowledge is impor
tant not only for the decision-making phase but
thereafter for dialysis. Unidentified cognitive deficits
may explain nonadherence with diet and fluid man
agement, and also disruptive behaviors on the dialysis
unit. Many CKD patients also report sleep disturbances,
and these can directly affect memory and concentra
tion. 47 In 1 study of CKD-4/5 patients, sleep-disordered
breathing was detected in 49.1% of patients. 48 This
group also scored poorly on tests of working and
verbal memory, attention, and psychomotor speed.

There is also evidence from literature linking age,
cognition, and other individual characteristics with
health literacy in advanced age. 49 The finding that
impaired health literacy in older age is in part a func
tion of cognitive decline even among persons without
dementia necessitates interventions to reduce cognitive
demands, particularly complex reasoning abilities and
memory from patients, inherent in the health literature
materials and decision-making aids used by patients
with even milder degrees of cognitive impairment.
The question of cognition assessment is therefore
important today from a research perspective to answer
several questions regarding pathophysiology, potential
pharmacological and nonpharmacological interven
tions, the timing of commencement of these inter
ventions, the appropriate manner of monitoring, and
the ideal combination of tests, among other factors,
notwithstanding the implications of negative tests on
patient behavior and the health care team’s practice.

Our study has several limitations. The cross
sectional study design does not confirm the causal
impact of cognition on the reported choice of modality.
The limited data on TMT part B demonstrated the
difficulty of lack of “effort” on the patients’ and the
administrator’s part to “try hard” at the neuropsych
logical tests, making the results of our study show a
relatively smaller proportion of predialysis patients as
having significant cognitive impairment. Despite the
limitations, the study highlights some important prac
tice points. There may be a role for subjective cognition
assessment as a measure of patients’ ability to under
take self-care tasks. These patients may well need extra
support to cope with the burden of the disease.

In conclusion, patients’ own perception of their
cognitive ability has an important association with self
care modality choice. This may offer a reliable assess
ment tool in clinical practice to understand patient
phenotype. The subjective report of “metaconcentra
tion” is significantly associated with poorer outcome on
the Trail Making Test part B, a test of executive brain
function. Several areas of unmet need in understanding
cognition in kidney disease should provide the basis
for future research.

DISCLOSURE

All the authors declared no competing interests.

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SUPPLEMENTARY MATERIAL

Table S1. Hierarchical regression of multiple imputation
data.
Supplementary material is linked to the online version of
the paper at http://www.kireports.org.

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