Kidney Medicine

Pretransplant Cognitive Function and Kidney Transplant Outcomes: A Prospective Cohort Study

Aditi Gupta, Michael J. Grasing, Kate J. Young, Robert N. Montgomery, Daniel J. Murillo, and Diane M. Cibrik

Background & Hypothesis: Cognitive impairment is common in patients being evaluated for a kidney transplant (KT). The association between pretransplant cognitive function and posttransplant outcomes is unclear.

Study Design: We performed a prospective cohort study to assess the association between pretransplant cognitive function and clinically relevant posttransplant outcomes.

Setting and Population: In this single center study, participants from the transplant clinic were evaluated during their pretransplant clinic visits and followed prospectively.

Outcomes: Our primary outcome measure was allograft function. Secondary outcomes were length of hospitalization for KT, hospital readmission within 30 and 90 days, graft loss, graft rejection within 90 days and 1 year, and mortality.

Analytic Approach: We measured cognitive function with the Montreal Cognitive Assessment (MoCA) test. We assessed the association of pretransplant MoCA score with posttransplant outcomes; we used linear mixed effects models to assess the association with the change in estimated glomerular filtration rate, Poisson regression for length of hospitalization, Cox proportional hazard model for graft loss and mortality, and a logistic regression model for readmission and rejection.

Results: We followed 501 participants for 2.7 ± 1.5 years. The mean age of the patients was 53 ± 14 years and the mean pretransplant MoCA score was 25 ± 3. Lower pretransplant MoCA scores did not adversely affect the primary outcome of allograft function or the secondary outcomes. Although higher MoCA scores predicted a higher decline in graft function (β = −0.28, 95% CI: −0.55 to −0.01, $P = 0.04$), the effect was small and not clinically significant. Older age was associated with longer hospitalization, lower likelihood of rejection, and higher mortality. Deceased donor KT (vs living donor KT) was associated with longer hospitalization but better graft function. Longer time receiving dialysis before KT was associated with longer hospitalization. A history of diabetes mellitus was associated with higher mortality.

Limitations: Single center study limiting generalizability.

Conclusions: Pretransplant MoCA scores were not associated with the primary outcome of allograft function or the secondary outcomes.

Complete author and article information provided before references.

Correspondence to A. Gupta (agupta@kumc.edu)

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Cognitive impairment is common in patients with chronic kidney disease (CKD) and kidney failure.[1] A majority of patients being evaluated for kidney transplantation (KT) have cognitive impairment.[2] Although patients with severe cognitive impairment or known dementia are generally not listed for KT, many patients with mild or subclinical cognitive impairment remain undiagnosed during evaluation for KT.[2,3]

Cognitive impairment is associated with poor outcomes in the general population and in patients with kidney failure.[4–7] Cognitive impairment affects the ability to comprehend and comply with instructions, which is important in KT. Management of KT recipients includes complex instructions including dietary advice, care of the incision, monitoring of side effects, taking medications regularly, and frequent change in medications.

KT recipients undergo a thorough evaluation process before being listed for KT. Cognitive function, however, is not routinely assessed. Both cognitive function and post-KT outcomes can be affected by comorbid conditions such as diabetes, hypertension, dyslipidemia, obesity, metabolic syndrome, and physical inactivity. It is thus important to determine whether pretransplant cognitive function affects posttransplant outcomes independent of these confounding variables. Moreover, cognition and CKD associated brain alterations improve after KT[8–12] and the improvement in cognition after KT is independent of pretransplant cognitive function.[13]

It is possible that the improvement in cognition after KT modified the effect of pretransplant cognitive impairment on health outcomes. Thus, it remains unclear whether pretransplant cognitive impairment is associated with poor posttransplant outcomes. In this study, we assessed cognitive function pretransplant and followed these patients prospectively to assess the association between pretransplant cognitive function and posttransplant outcomes. We hypothesized that pretransplant cognitive impairment is not associated with poor clinically relevant posttransplant outcomes.

METHODS

In this observational study, we analyzed data from the transplant center of a large academic medical center. Our

PLAIN-LANGUAGE SUMMARY

Cognitive impairment (problems with memory and thinking) is common in patients with kidney disease. Cognitive impairment is associated with problems following instructions and remembering to take medications. Medical adherence is important in kidney transplant recipients, and inability to follow instructions and missed doses of immunosuppression increases the risk of rejection of the transplanted kidney. However, kidney transplantation also improves cognition. Hence, transplant centers wonder if cognitive impairment before transplant affects clinical outcomes after kidney transplant. We tried to answer this question by assessing cognitive function before transplantation and examining whether pretransplant cognitive function affects graft function, length of hospitalization, readmission after transplantation, rejection, and death. We did not find any strong link between cognitive function before transplant and these outcomes.

aim was to assess the associations between pretransplant cognitive function and posttransplant outcomes of allograft function, length of hospitalization for KT, hospital readmission after KT, graft loss, rejection, and mortality. The institutional review board approved the project as a quality improvement project and thus waived the need for informed consent. The goals of the quality improvement project were to assess feasibility of cognitive function testing in transplant clinics and to assess whether pretransplant cognitive assessment can identify patients at a higher risk for posttransplant adverse outcomes. The Montreal Cognitive Assessment (MoCA) was administered by trained clinic staff after rooming the patient for the clinic visit. The quality improvement team ran training sessions with all new clinic staff and refresher sessions every 6 months with existing clinic staff members performing these tests. The clinical and research activities being reported are consistent with the Principles of the Declaration of Istanbul as outlined in the "Declaration of Istanbul on Organ Trafficking and Transplant Tourism" and with the Declaration of Helsinki. The results of the cognitive assessment were kept confidential and not shared with the treatment team to prevent the results from influencing the decision about transplant eligibility.

Patient Population

Baseline cognitive assessments were performed on all consecutive patients seen in the evaluation clinic from February 13, 2015, to December 18, 2019, who verbally consented to be tested, did not have severe vision or hearing impairment that could preclude evaluation, and spoke English. MoCA scores were not disclosed to the transplant team and were thus not used in determining transplant eligibility. Patients who underwent a KT before May 2022 were included in the analysis. Patients listed for a dual organ transplant such as liver kidney or kidney pancreas were excluded.

Clinical and Demographic Data

Participant data including age, race, sex, education, ethnicity, marital status, weight, height, calculated panel reactive antibody, Estimated Post-Transplant Survival score, native kidney disease, time receiving dialysis, date of transplant, time on the transplant waitlist, rejection, early rehospitalization, graft function, graft failure, and mortality were collected from their medical records and United Network for Organ Sharing (UNOS) data. Donor data including donor age, Kidney Donor Profile Index, and donor type (living donor, donation after brain death, donation after circulatory death) were obtained from the UNOS data.

Measurement of Cognitive Function

We used the MoCA to assess cognitive function. The MoCA is a 10-minute test that assesses eight domains of cognition and maximum score of 30.[14] The MoCA has better performance in patients with kidney failure than other commonly used tests for cognitive assessment in kidney failure such as the Mini Mental State Examination, the Modified Mini Mental State Examination, the Trail Making Test Part B, the Mini-Cog, and the Digit Symbol Substitution Test.[15] The original MoCA assessment used a cut-off score of 26 for diagnosis of cognitive impairment, but some studies have suggested a lower cut-off score of 24 because the MoCA is more sensitive than some other screening tests for cognitive impairment.[16] For our analysis, we chose to use MoCA score as a continuous variable as a clear cut-off value is not established in patients with CKD. Treating MoCA as a continuous variable also increases statistical power and allows for better estimates of the association between change in MoCA and the outcome variables.[17]

Outcome Variables

Our primary outcome was allograft function, measured by the change in eGFR, as we have done previously.[18] We used change in estimated glomerular filtration rate (eGFR) instead of the absolute eGFR because the absolute eGFR posttransplant is multifactorial and dependent on donor quality and perioperative events. In addition, older patients and those with multiple comorbid conditions often do not receive the best donor kidneys, resulting in a lower absolute eGFR. The change in eGFR is thus a better predictor of allograft outcomes in KT recipients than the eGFR at a certain timepoint.[19] To calculate the change in eGFR, we used all available eGFR values following KT, except those obtained during the first month posttransplant because transplanted patients may not have reached a steady allograft function during that period. Additionally, we excluded eGFR values when there were ≥3 eGFR values in a

7-day period as they were likely during hospitalization. Our secondary outcomes included length of hospitalization for KT, hospital readmission within 30 days, hospital readmission within 90 days, graft loss, graft rejection within 90 days, graft rejection within 1 year, and all-cause mortality.

Statistical Analysis

We used means and standard deviations to summarize continuous variables and frequency tables for categorical variables. To calculate change in eGFR over time, we used the available eGFR values and fit linear mixed effects models with a random intercept for each patient and a random slope and used time since KT in years as the time variable. To assess the association between pretransplant cognitive function and the length of hospitalization, we used Poisson regression analysis because of the skewed nature of the responses. To assess the association between pretransplant cognitive function and graft loss and mortality, we used a Cox proportional hazard model. To assess the association between cognitive function and readmission at 30 and 90 days and rejection at 90 days and 1 year, we used a logistic regression model. Both unadjusted models and models adjusted for age, level of education, sex, race, history of diabetes, time treated with dialysis before KT, body mass index, and donor type were used. Interactions between age, diabetes, and MoCA scores were also assessed as well as an interaction between MoCA scores and time since KT for the mixed model. As a sensitivity analysis, we also analyzed the data using education as a categorial variable. We split education into ≥4-year degree and <4-year degree. If data for a specific outcome were missing for a patient, then that patient was excluded from that specific analysis.

RESULTS

Table 1 describes the baseline demographics of the 501 study participants. The mean follow-up time was 2.7 ± 1.5 years (minimum 5 days, maximum 6.9 years). Participants were 53 ± 14 years old, 58% male, 73% White, 16% African American, and 9% Hispanic. Diabetes was the most common cause of kidney failure (32%). Patients underwent KT between February 24, 2015, and April 21, 2022.

The mean pretransplant MoCA was 25 ± 3, with 52% of patients scoring <26. The MoCA scores ranged from 12-30. Although MoCA scores generally decreased with increasing age, low-MoCA scores were highly prevalent in younger patients as well (Fig S1A). A higher level of education was associated with higher MoCA scores (Fig S1B).

Our primary outcome measure was allograft function measured as change in eGFR. Table 2 shows the linear mixed effects model for change in eGFR 1 month after KT. An average of 40.6 eGFR values per patient (number of eGFR measurements per patient) were used in the analysis. A higher pretransplant MoCA score was associated with a higher decline in eGFR ($\beta = -0.28$; 95% CI: −0.55 to 0.01; $P = 0.04$). For a one standard deviation higher MoCA score, ie, 3.3 points higher, the expected decline in eGFR was 0.91 mL/min (95% CI: 0.04-1.78) higher. Living donor KT ($P = 0.02$) predicted better allograft function. Time since KT, age at KT, race, education, time receiving dialysis before KT, diabetes, body mass index, and MoCA-by-time interaction were not associated with change in eGFR.

Secondary outcomes included length of hospitalization, readmission at 30 or 90 days, rejection at 90 days or 1 year, graft loss, or mortality. There was no association between MoCA score and any of the secondary outcomes (Tables 3-6). There were 92 readmissions at 30 days and 161 at 90 days. Pretransplant MoCA score was not associated with readmissions. In total, 14 patients had at least one episode of rejection, 18 had graft loss, and 44 died during the study period. Pretransplant MoCA score did not predict rejection, graft loss, or mortality (Tables 5 and 6). However, the total number of events for rejection and graft loss were small (Table 1) to have meaningful results. Older age predicted longer length of hospitalization and higher mortality (Tables 3 and 5). In the Poisson regression analysis for length of hospitalization, older age, longer time receiving dialysis before KT, and deceased donor KT were all associated with longer hospitalization for KT (Table 3). Older age at KT and history of diabetes were associated with higher mortality (Table 5). There were no interactions among age, diabetes, and MoCA scores. Using education as a categorial variable did not alter the results (Table S1).

DISCUSSION

This study showed that low pretransplant MoCA scores are not associated with adverse posttransplant outcomes of allograft function, length of hospitalization, early hospital readmission, graft loss, or all-cause mortality. A higher MoCA score predicted worse allograft function, but this small association may not be clinically significant. These findings are clinically relevant for the evaluation for KT eligibility and care of patients after KT.

Our primary outcome was allograft function. To assess allograft function, we used change in eGFR because it is a more accurate estimate of allograft function after KT than the absolute eGFR.[19] Change in eGFR is less dependent on donor quality, intraoperative factors, and postsurgical complications. We found a small association between pretransplant MoCA score and posttransplant allograft function, in which a higher score was associated with a higher decline in eGFR. However, the estimated effect was less than a one unit decrease in eGFR for a one standard deviation increase in MoCA score.

We did not find an association between pretransplant cognition and any of our secondary variables: length of hospitalization for KT, hospital readmission, graft loss, graft rejection, and mortality. In addition, this study confirmed associations that have been shown previously.

Table 1. Demographic and Clinical Characteristics of Participants by Baseline Cognitive Function Scores

	MoCA < 26 n = 258	MoCA ≥ 26 n = 243	All Participants n = 501
Clinical Characteristics			
Age at KT (y)	54.3 ± 13.2	50.8 ± 14.7	52.6 ± 14.0
Female sex	97 (38)	111 (46)	208 (42)
Race			
White or Caucasian	169 (66)	195 (80)	364 (73)
Black or African American	53 (21)	26 (11)	79 (16)
Other	36 (14)	21 (9)	57 (11)
Ethnicity			
Hispanic, Latino, or Spanish Origin	26 (10)	17 (7)	43 (9)
Marital status			
Married	166 (64)	156 (64)	322 (64)
Single	61 (24)	64 (26)	125 (25)
Other	31 (12)	23 (9)	54 (11)
Education			
Did not graduate from high school	19 (7)	9 (4)	28 (6)
Has high school diploma, no college	70 (27)	56 (23)	126 (25)
Some college	94 (36)	87 (36)	181 (36)
Has 4-y degree	51 (20)	50 (21)	101 (20)
Has attended graduate school	21 (8)	38 (16)	59 (12)
BMI (kg/m^2)	30.6 ± 5.9	30.0 ± 6.5	30.3 ± 6.2
Follow-up time (y)	2.6 ± 1.5	2.8 ± 1.5	2.7 ± 1.5
Pre-KT MoCA score	22.5 ± 2.6	27.6 ± 1.3	25.0 ± 3.3
EPTS score (%)	41.7 ± 28.0	34.9 ± 25.2	38.4 ± 26.9
CPRA	16.7 ± 31.7	19.5 ± 35.5	18.1 ± 33.6
Native kidney diagnosis			
Diabetes mellitus	90 (35)	70 (29)	160 (32)
Glomerulonephritis	57 (22)	64 (26)	121 (24)
Polycystic kidney disease	32 (12)	39 (16)	71 (14)
Other	71 (28)	60 (25)	131 (26)
History of diabetes	96 (37)	77 (32)	173 (35)
Length of hospitalization (d)	5.1 ± 3.0	4.8 ± 2.5	5.0 ± 2.8
Time on waitlist (d), median (IQR)	473.0 (146.0-908.8)	466.0 (160.0-933.0)	467.0 (153.0-927.0)
Time receiving dialysis (y)	2.4 ± 2.2	2.2 ± 2.5	2.3 ± 2.4
KDPI	45.6 ± 25.9	45.7 ± 27.1	45.7 ± 26.4
Donor type			
Donation after brain death	137 (53)	120 (49)	257 (51)
Donation after circulatory death	68 (26)	64 (26)	132 (26)
Living	53 (21)	59 (24)	112 (22)
Number of events, n (%)			
Readmitted within 30 d	53/258 (21)	39/243 (16)	92/501 (18)
Readmitted within 90 d	90/258 (35)	71/243 (29)	161/501 (32)
Rejection within 90 d	4/245 (2)	5/235 (2)	9/480 (2)
Rejection within 1 y	6/218 (3)	8/207 (4)	14/425 (3)
Graft loss (excluding deaths)	11/258 (4)	7/243 (3)	18/501 (4)
Graft loss within 1 y of KT	4/222 (2)	2/209 (1)	6/431 (1)
Graft loss within 3 y of KT	8/91 (9)	5/111 (5)	13/202 (6)
Deceased	24/258 (9)	20/243 (8)	44/501 (9)
Deceased within 1 y of KT	7/226 (3)	7/214 (3)	14/440 (3)
Deceased within 3 y of KT	20/104 (19)	14/120 (12)	34/224 (15)

Abbreviations: BMI, body mass index; CPRA, calculated panel reactive antibody; EPTS, estimated posttransplant survival score; KDPI, kidney donor profile index.

For example, similar to the findings in our study, it has previously been shown that older age is associated with a longer hospitalization for KT, lower likelihood of rejection, and a higher mortality.[20,21] Living donor transplant was associated with shorter hospitalization and better allograft function. Similarly, diabetes was associated with higher mortality. These associations previously identified in both the general population and the kidney failure

Table 2. Association Between Pretransplant Cognitive Function and Posttransplant Allograft Function Measured by the Change in Estimated Glomerular Filtration Rate

	Estimated linear effect[a]	Standard error	95% CI	*P* Value
Unadjusted Analysis				
Pretransplant MoCA score	−0.24	0.13	−0.49 to 0.01	0.06
Time since KT (y)	0.97	2.53	−4.02 to 5.95	0.70
Pretransplant MoCA score time since KT (y)[a]	0.02	0.10	−0.18 to 0.21	0.87
Adjusted Analysis				
Pretransplant MoCA score	−0.28	0.14	−0.55 to −0.01	0.04
Time since KT (y)	0.97	2.53	−4.01 to 5.95	0.70
Pre-KT MoCA score[b] time since KT (y)	0.02	0.10	−0.18 to 0.21	0.88
Age at KT (5 y)	−0.27	0.16	−0.58 to 0.05	0.09
Race (Ref: White)	−1.32	0.99	−3.26 to 0.62	0.18
Years of education	0.23	0.20	−0.17 to 0.62	0.27
Diabetes (Ref: no diabetes)	1.63	0.95	−0.25 to 3.48	0.09
Time receiving dialysis (y)	0.18	0.19	−0.20 to 0.55	0.36
BMI (kg/m^2)	0.08	0.07	−0.06 to 0.22	0.25
Donor type (Ref: living)	2.55	1.09	0.41 to 4.70	0.02

Abbreviations: BMI, body mass index; CI, confidence interval; KT, kidney transplant; MoCA, Montreal Cognitive Assessment; Ref, reference.
[a]Estimates are based on the estimated fixed effects from a linear mixed effects model with a random intercept and a random time effect for patient. n=489.
[b]Although this is an unadjusted model, time since KT is included to account for the variation between measurements collected for each individual.

population.[22,23] However, pretransplant cognitive function did not affect any of these posttransplant outcomes.

Our findings are similar to studies in the pediatric population in which cognitive impairment and intellectual disabilities do not affect posttransplant outcomes.[24–26] Our results also support findings from a Canadian study that shows that pretransplant cognitive function does not affect length of hospitalization or delirium.[27] Further, Bozhilov et al[28] showed that lower MoCA scores do not predict death on the KT waitlist. Our results are in contrast with the findings of Thomas et al[29] that indicate higher all-cause graft loss with poor pretransplant cognitive function.

Table 3. Association Between Pretransplant Cognitive Function and Length of Hospitalization for Kidney Transplant

	Risk Ratio[a]	95% CI	*P* Value
Pretransplant MoCA score (unadjusted)	0.99	0.97-0.99	0.02
Adjusted analysis			
Pretransplant MoCA score	0.99	0.98-1.01	0.28
Age at KT (5 y)	1.02	1.01-1.04	0.01
Race (Ref: White)	1.01	0.92-1.11	0.82
Years of education	1.01	0.91-1.03	0.29
Diabetes (Ref: no diabetes)	1.10	1.01-1.20	0.03
Time receiving dialysis (y)	1.04	1.03-1.06	<0.001
BMI (kg/m^2)	1.00	0.99-1.01	0.99
Donor type (Ref: living)	1.21	1.08-1.35	<0.001

Abbreviations: BMI, body mass index; CI, confidence interval; KT, kidney transplant; MoCA, Montreal Cognitive Assessment; Ref, reference.
[a]Estimates are based on the results of a Poisson regression model with the length of hospitalization (in days) as the outcome variable. Estimated risk ratios estimate the risk of being hospitalized one day longer compared with the reference group. A risk ratio >1 indicates longer hospitalizations. n=501.

These differences could be because of different tests used. Thomas et al[29] used the Modified Mini Mental Scale Examination, a test that may be less sensitive in patients with kidney disease than MoCA. This might explain the low prevalence (10%) of cognitive impairment in their study compared with ours (>50% with MoCA score <26). After censoring for death, even Thomas et al[29] did not see an association between pretransplant cognitive impairment and graft loss. Similar to the results of our study, Thomas et al[29] also did not see a difference in graft loss between the deceased donor transplant groups with and without cognitive impairment. Further, our study includes other outcomes.

We used MoCA to assess cognitive function. Validated tools for screening of cognitive impairment rather than clinician perception are more accurate in determining cognitive status.[30] MoCA has been determined as the most reliable screening test for cognitive impairment in kidney disease because it is more sensitive for executive function than other commonly used tests.[15] The MoCA only takes 10 minutes to administer, making it practical for use during a busy transplant evaluation. We used MoCA scores as a continuous variable, thus avoiding specific cutoffs and allowing us to assess patients across the entire spectrum. More detailed neuropsychological tests, especially for individuals who scored poorly on the MoCA, could be beneficial, but not without additional burden to the patients.

The pragmatic design of the study gives more accurate and real-world representation of data. Assessment of consecutive patients seen in the clinic with minimal exclusion criteria is more inclusive than traditional clinical trials. We also had granular clinical information by combining data from patients' medical records and UNOS.

Table 4. Association between pretransplant cognitive function and hospital readmission within 30 and 90 days

	Hazard Ratio[a]	95% CI	*P* Value
Within 30 d of KT			
Pretransplant MoCA score (unadjusted)	1.01	0.97-1.05	0.71
Adjusted analysis			
Pretransplant MoCA score	1.001	0.96-1.05	0.97
Age at KT (5 y)	1.002	0.95-1.06	0.94
Race (Ref: White)	0.78	0.55-1.10	0.16
Years of education	1.01	0.94-1.08	0.89
Diabetes (Ref: no diabetes)	1.26	0.92-1.72	0.15
Time receiving dialysis (y)	1.04	0.98-1.10	0.26
BMI (kg/m^2)	1.001	0.98-1.02	0.94
Donor type (Ref: living)	0.80	0.56-1.15	0.23
Within 90 d of KT			
Pretransplant MoCA score (unadjusted)	1.01	0.97-1.05	0.75
Adjusted analysis			
Pretransplant MoCA score	1.001	0.96-1.05	0.97
Age at KT (5 y)	1.004	0.95-1.06	0.88
Race (Ref: White)	0.79	0.56-1.12	0.19
Years of education	1.003	0.94-1.07	0.92
Diabetes (Ref: no diabetes)	1.25	0.91-1.71	0.17
Time receiving dialysis (y)	1.03	0.97-1.10	0.28
BMI (kg/m^2)	1.002	0.98-1.03	0.90
Donor type (Ref: living)	0.81	0.57-1.16	0.25

Abbreviations: BMI, body mass index; CI, confidence interval; KT, kidney transplant; MoCA, Montreal Cognitive Assessment; Ref, reference.
[a]Estimates are based on the results of two Cox proportional hazards models with the day of readmission as the outcome. In the first model, patients who were not readmitted within 30 days are considered censored, and in the second, patients who were not readmitted within 90 days are considered censored. n=501.

Table 5. Association Between Pretransplant Cognitive Function, Graft Loss, and Mortality

	Hazard Ratio	95% CI	*P* Value
Graft loss[a]			
Pretransplant MoCA score (unadjusted)	0.90	0.79-1.02	0.10
Adjusted analysis			
Pretransplant MoCA score	0.95	0.83-1.09	0.46
Age at KT (5 y)	1.07	0.89-1.29	0.45
Race (Ref: White)	1.41	0.53-3.79	0.49
Years of education	0.86	0.68-1.08	0.20
Diabetes (Ref: no diabetes)	0.76	0.26-2.27	0.63
Time receiving dialysis (y)	1.04	0.86-1.23	0.62
BMI (kg/m^2)	0.99	0.91-1.08	0.80
Donor type (Ref: living)	5.41	0.68-43.29	0.11
Mortality[a]			
Pretransplant MoCA score (unadjusted)	0.90	0.83-0.98	0.01
Adjusted analysis			
Pretransplant MoCA score	0.93	0.84-1.02	0.11
Age at transplant (5 y)	1.43	1.22-1.68	<0.001
Race (Ref: White)	0.97	0.49-1.92	0.93
Years of education	1.01	0.88-1.17	0.84
Diabetes (Ref: no diabetes)	2.35	1.24-4.44	0.01
Time receiving dialysis (y)	1.04	0.94-1.14	0.47
BMI (kg/m^2)	1.00	0.95-1.05	0.89
Donor type (Ref: living)	1.17	0.53-2.59	0.69

Abbreviations: BMI, body mass index; CI, confidence interval; KT, kidney transplant; MoCA, Montreal Cognitive Assessment; Ref, reference.
[a]Graft and mortality were modeled using a Cox proportional hazard model. Patients who did not experience a graft loss before their last follow-up day are considered censored in the first model. In the second model, all patients who survived to their last follow-up day are considered censored. n=501.

For example, we had an average eGFR value of 40.6 per patient to assess the change in allograft function. Another strength is accounting for comorbid conditions; cognitive impairment in CKD is complex and often confounded by other comorbid conditions.[31]

Limitations of the study include a single center study that can limit generalizability and its observational nature. Only patients who underwent KT were included in the analysis. It is possible that pretransplant cognitive function could have affected posttransplant outcomes in a subgroup of patients (had they been transplanted) who were deemed "ineligible" by the transplant selection committee. Pretransplant cognitive function was assessed at the time of evaluation, and there was a gap between pretransplant testing and KT. However, assessment of cognitive function during evaluation visit is also more practical for transplant centers. Further, performance in cognitive assessments can be affected because of anxiety about KT whether assessments are performed during the admission for the transplant surgery. Also, the number of rejections and graft losses were small in our cohort, which can affect the reliability of results of the analysis for these specific outcomes.

We have previously shown that mild to moderate CKD (that is usually seen in KT recipients) is not associated with cognitive impairment[32,33] or brain atrophy.[34] Changes in cognitive function because of severe CKD are largely reversible with KT.[8-11,13] This might explain why pretransplant cognitive function may not affect posttransplant outcomes. Given these data, pretransplant cognitive

Table 6. Association Between Pretransplant Cognitive Function and Allograft Rejection at 90 Days and 1 Year

	Odds Ratio[a]	95% CI	*P* Value
Rejection at 90 d (n=480)			
Pretransplant MoCA score (unadjusted)	1.09	0.88-1.39	0.48
Adjusted analysis			
Pretransplant MoCA score	1.003	0.80-1.29	0.98
Age at KT (5 y)	0.72	0.54-0.93	0.02
Race (Ref: White)	0.33	0.02-2.03	0.32
Years of education	1.14	0.82-1.58	0.45
Diabetes (Ref: no diabetes)	2.70	0.45-15.03	0.25
Time receiving dialysis (y)	0.77	0.44-1.14	0.29
BMI (kg/m^2)	1.03	0.93-1.12	0.60
Donor type (Ref: living)	1.338	0.28-7.51	0.72
Rejection at 1 y (n=425)			
Pretransplant MoCA score (unadjusted)	1.11	0.94-1.36	0.26
Adjusted analysis			
Pretransplant MoCA score	1.02	0.84-1.25	0.88
Age at KT (5 y)	0.68	0.53-0.84	<0.001
Race (Ref: White)	0.22	0.01-1.24	0.16
Years of education	1.11	0.84-1.46	0.48
Diabetes (Ref: no diabetes)	2.97	0.65-12.99	0.14
Time receiving dialysis (y)	0.73	0.45-1.06	0.16
BMI (kg/m^2)	1.02	0.93-1.10	0.70
Donor type (Ref: living)	1.02	0.29-3.74	0.97

Abbreviations: BMI, body mass index; CI, confidence interval; KT, kidney transplant; MoCA, Montreal Cognitive Assessment; Ref, reference.
[a]Estimates are based on two logistic regression models with rejection at 90 days and at 1 year as the outcome variables.

screening as part of the KT evaluation process may not be needed. Future studies should try to identify patients with reversible cognitive impairment who can benefit from KT despite poor (perceived) cognitive function pretransplant. Studies are also needed to determine the factors that contribute to posttransplant cognitive impairment and its effect on posttransplant outcomes. We were not able to assess the effect of change in cognitive function or posttransplant cognitive function on outcomes because all our patients did not have a posttransplant MoCA available for this analysis. Moreover, patients who had a posttransplant MoCA had a large variation in the timing of MoCA assessments after KT. Additionally, studies are needed to address patient-centered outcomes such as posttransplant functional status, quality of life, and care giver burden pre- to posttransplant.

In conclusion, poor performance in clinic-based screening tests for cognitive impairment does not predict worse posttransplant outcomes.

SUPPLEMENTARY MATERIALS

Supplementary File (PDF)

Figure S1: Scatterplots of pretransplant MoCA score and (A) age and (B) level of education.

Table S1: Models With Education as a Categorical Variable.

ARTICLE INFORMATION

Authors' Full Names and Academic Degrees: Aditi Gupta, MD, MS, Michael J. Grasing, MD, Kate J. Young, PhD, Robert N. Montgomery, PhD, Daniel J. Murillo, MD, and Diane M. Cibrik, MD, MS.

Authors' Affiliations: Division of Nephrology and Hypertension, Department of Internal Medicine and Neurology (AG, MJG, DMC), Department of Biostatistics and Data Science (KJY, RNM), and Department of Surgery (DJM), University of Kansas Medical Center, Kansas City, KS.

Address for Correspondence: Aditi Gupta, MD, MS, Division of Nephrology and Hypertension, Departments of Internal Medicine and Neurology, University of Kansas Medical Center, 3901 Rainbow Blvd, Kansas City, KS 66160. Email: agupta@kumc.edu

Authors' Contributions: study conception and design: AG; data interpretation: AG; supervision/mentorship: AG; data analysis and interpretation: KY, RM. Each author contributed important intellectual content during manuscript drafting or revision and accepts accountability for the overall work by ensuring that questions pertaining to the accuracy or integrity of any portion of the work are appropriately investigated and resolved.

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