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Frailty, Age, and Postdialysis Recovery Time in a Population New to Hemodialysis

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Key Points

- Nearly three-quarters of participants recovered within an hour, 20% required between 1 and 6 hours, and 5% reported recovery times >12 hours.
- Frailty and younger age were associated with prolonged recovery time.
- Younger frail participants were more likely to report longer recovery times.

Abstract

Background Frailty, a phenotype characterized by decreased physiologic reserve and the inability to recover following confrontation with a stressor like hemodialysis, may help identify which patients on incident hemodialysis will experience longer postdialysis recovery times. Recovery time is associated with downstream outcomes, including quality of life and mortality. We characterized postdialysis recovery times among patients new to hemodialysis and quantified the association between frailty and hemodialysis recovery time.

Methods Among 285 patients on hemodialysis enrolled in the Predictors of Arrhythmic and Cardiovascular Risk in End Stage Renal Disease (PACE) study, frailty was measured using the Fried phenotype. Self-reported recovery time was obtained by telephone interview. We estimated the association of frailty (intermediately frail and frail versus nonfrail) and postdialysis recovery time using adjusted negative binomial regression.

Results Median time between dialysis initiation and study enrollment was 3.4 months (IQR, 2.7–4.9), and that between initiation and recovery time assessment was 11 months (IQR, 9.3–15). Mean age was 55 years, 24% were >65 years, and 73% were Black; 72% of individuals recovered in ≤1 hour, 20% recovered in 1–6 hours, 5% required 6–12 hours to recover, and <5% required >12 hours to recover. Those with intermediate frailty, frailty, and age ≤65 years had 2.56-fold (95% CI, 1.45 to 4.52), 1.72-fold (95% CI, 1.03 to 2.89), and 2.35-fold (95% CI, 1.44 to 3.85) risks, respectively, of longer recovery time independent of demographic characteristics, comorbidity, and dialysis-related factors.

Conclusions In adults new to hemodialysis, frailty was independently associated with prolonged postdialysis recovery. Future studies should assess the effect of frailty-targeted interventions on recovery time to improve clinical outcomes.

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Introduction

Patient-centered outcomes are increasingly important in patients on hemodialysis (1–3); one important outcome is the length of time required to recover from a dialysis session (4). Prolonged recovery time is associated with poor health-related quality of life (HRQoL) and increased risk of both hospitalizations and mortality (5). The question of "how long does it take you to recover from a dialysis session?" is a validated patient-centered tool that captures important information about patient health status as well as resilience to hemodialysis (4). Recovery time, however, has only been studied in patients on prevalent hemodialysis with significantly longer recovery times (5). These results are likely not generalizable to those new to hemodialysis because physical and cognitive declines while on dialysis and mortality rate are high in the first year of dialysis (6).

In community-dwelling older adults, frailty is a phenotype characterized by decreased physiologic reverse and the inability to recover following confrontation with a stressor (7). Among patients with ESKD, hemodialysis represents a major physiologic stressor. Furthermore, frailty is highly prevalent among patients of all ages who are undergoing hemodialysis, with prevalence as high as 73% (8). Frailty prevalence increases with age, and it is associated with increased mortality risk, hospitalizations, falls, and reduced HRQoL (9–13). Nonfrail individuals, regardless of age, may have resiliency when confronted with the stressor of hemodialysis. Whether this resiliency in nonfrail individuals extends to shorter recovery time after dialysis is unknown. Additionally, identifying this association could help in planning interventions to improve the experience of patients on dialysis.

The objectives of this study were to identify the distribution of postdialysis recovery times among patients new to hemodialysis and quantify the association between frailty and hemodialysis recovery time among both older and younger patients on hemodialysis.

Materials and Methods

Study Design and Population

Frailty was measured in 378 patients who had received dialysis for <6 months and were enrolled in the Predictors of Arrhythmic and Cardiovascular Risk in End Stage Renal Disease (PACE) study (14). Briefly, participants were recruited from 27 dialysis units in Baltimore, Maryland from November 2008 to August 2012. Inclusion criteria were (*1*) ≥18 years of age and (*2*) ability to speak English. Exclusion criteria were (*1*) institutionalized persons, (*2*) persons with a cancer diagnosis other than nonmelanoma skin cancer, (*3*) persons with a pacemaker or an automatic implantable cardioverter defibrillator, and (*4*) pregnant or nursing women. All participants received thrice weekly hemodialysis. This study additionally excluded participants if they could not be contacted for the telephone interview ($N=74$) or did not report postdialysis recovery time ($N=19$) for the final study population of $N=285$. The study protocol was approved by the Johns Hopkins University Institutional Review Board, MedStar Health Systems, and the medical director of each dialysis unit. Participants provided written informed consent.

Frailty

Frailty, measured at study enrollment on a nondialysis day, was operationalized using the Fried phenotype, which has been previously validated in both ESKD populations (9,10,13) and older adults (7,15,16), and it has previously been described in PACE (12). The Fried phenotype is the most commonly used measure of frailty in geriatric and renal research (17). The frailty phenotype is characterized by five components: shrinkage (unintentional weight loss >10 pounds dry weight in the previous year), low physical activity (kilocalories per week below an established cutoff), exhaustion (self-report), weakness (grip strength below an established cutoff), and slowed gait speed (time to walk 15 feet below an established cutoff) (7). An overall frailty score was calculated by summing the component scores (range from zero to five). The nonfrail participants were those with a score of zero or one, the intermediately frail participants were those with a score of two, and the frail participants were those with a score of three or higher. In secondary analyses, frailty was defined as a score of greater than or equal to two as previously done (9) because the vulnerability to patient-centered outcomes manifests with both intermediately frail and frail status.

Other Participant Characteristics

At study enrollment, sociodemographic characteristics (age, sex, and race), smoking status, alcohol use, and medical history were collected through standardized questionnaires. Older age was defined as age >65 years. Body mass index was calculated as the ratio of self-reported dry weight (kilograms) to height (meters) squared. Comorbidities were assessed by medical chart review, adjudicated by the PACE Study Endpoint Committee, and classified using the Charlson Comorbidity Index adapted for patients with ESKD (18). Systolic and diastolic BPs were obtained by averaging three consecutive measurements with participants in a seated position on a nondialysis day. Ultrafiltration rate (milliliters per hour per kilogram) was calculated as interdialytic weight gain/length of dialysis treatment/postdialysis weight and was analyzed as a 90-day average from dialysis initiation. Relative fluid removal was calculated as (predialysis weight – postdialysis weight)/postdialysis weight, and it was examined as a 90-day average from dialysis initiation. Intradialytic systolic and diastolic BP difference was examined as a 90-day average of predialysis to postdialysis BP difference. Measures of dialysate composition, serum albumin, serum creatinine, serum calcium corrected for albumin, serum phosphate, single-pool Kt/V, and hemoglobin were examined as 90-day averages from dialysis initiation. Medication use was assessed at baseline by medical record review from electronic records of patients on dialysis and by participant self-report.

Posthemodialysis Recovery Time

Postdialysis recovery time was assessed by telephoned interview. Participants were asked the following question: "How long does it take you to recover from a dialysis session?" Responses were converted to minutes as follows. Answers given in minutes were recorded directly, answers given in hours were multiplied by 60, answers such as "half a day" or the "next day" were given a value of 720

min, and answers of "1 day" were given a value of 1440 min (4). Frailty was measured prior to this patient-centered outcome, and participants had time to stabilize following hemodialysis initiation.

Statistical Analyses

Participant characteristics were summarized using means and SDs for normally distributed data, medians and interquartile ranges (IQRs) for skewed data, and frequencies and proportions for categorical data. Characteristics were compared between those above and below median postdialysis recovery time (20 minutes) using the *t* test, the Mann–Whitney *U* test, or the chi-squared test.

Association of frailty with postdialysis recovery time was estimated using negative binomial regression. Negative binomial regression allows for modeling of outcomes that are counts (*e.g.*, number of minutes required to recover from a dialysis session) and accounts for overdispersion of the outcome data. A forward model-building approach was used in which initial variable selection was conducted on the basis of known risk factors for frailty and hemodialysis recovery time, *P* values from univariate analyses, and changes in effect size. We also examined the associations of the individual frailty components (shrinkage, low physical activity, exhaustion, weakness, and slowed gait speed) with postdialysis recovery time.

Heterogeneity of effect was assessed by including separate multiplicative interaction terms between frailty and age, sex, and race in adjusted models. Stratified analyses were performed to estimate the association of age with postdialysis recovery time by frailty category (frail [score of greater than or equal to two] versus nonfrail [score of one or zero]). All statistical analyses were performed in Stata version 14.0.

Results

Study Population

Two hundred eighty-five adults receiving hemodialysis were included in this study (Table 1, Supplemental Table 1). At study enrollment, the mean age was 55 years, 24% were >65 years, 43% were women, and 73% were Black participants; 51% of participants were frail, 29% were intermediately frail, and 20% were nonfrail at the time of study enrollment. Median time between dialysis initiation and study enrollment was 3.4 months (IQR, 2.7–4.9), median time between study enrollment and assessment of postdialysis recovery time was 6.8 months (IQR, 5.8–9.5), and median time between dialysis initiation and recovery time assessment was 11 months (IQR, 9.3–15). Among participants (N=198) for whom frailty was assessed at study initiation and after 1 year, frailty status was stable (P=0.20). In aggregate, 57% of these participants were frail at baseline, and 62% were frail after 1 year.

Hemodialysis Recovery Time

Median hemodialysis recovery time reported in our study population with a median dialysis duration of 11 months was 20 minutes (IQR, 10–120). Seven percent of individuals reported requiring no time to recover from hemodialysis, 65% reported recovering in 0–1 hours, 20% reported recovering in 1–6 hours, 5% required 6–12 hours to recover, and <5% required >12 hours to recover (Figure 1). Among younger adults, 6% reported needing no time to recover, 63% required 0–1 hours, 21% required 1–6 hours, 5% required 6–12 hours, and 5% required >12 hours. In older adults, the distribution was weighed more heavily toward shorter recovery times: 11% reported needing no time to recover, 71% required 0–1 hours, 14% required 1–6 hours, 4% required 6–12 hours, and none required >12 hours. The distribution of reported recovery times was similar between younger and older adults. Individuals who reported a hemodialysis recovery time ≥20 minutes had similar demographic, clinical, and dialysis-related characteristics to those who reported <20-minute recovery times (Table 1).

Risk Factors for Longer Hemodialysis Recovery Time

Within the first year of hemodialysis, the median recovery time reported by younger individuals was 20 minutes (IQR, 10–120), and that reported by older individuals was 15 minutes (IQR, 10–60). Younger age was associated with 2.36-fold longer postdialysis recovery time (95% confidence interval [95% CI], 1.44 to 3.85) (Table 2), independent of demographic, clinical, and dialysis factors. Individuals with obesity reported a median recovery time of 30 minutes (IQR, 10–120) as compared with 20 minutes (IQR, 10–67.5) for the nonobese and had a recovery time that was 1.76-times longer (95% CI, 1.16 to 2.63). Those with prevalent cerebrovascular disease at study enrollment reported a median recovery time of 30 minutes (IQR, 13.8–210) as compared with 20 minutes (IQR, 10–90) for those without and had a recovery time that was 2.03-times longer (95% CI, 1.21 to 3.43).

Frailty and Hemodialysis Recovery Time

The median recovery times among nonfrail, intermediately frail, and frail individuals were 25 minutes (IQR, 10–60), 20 minutes (IQR, 10–150), and 20 minutes (IQR, 10–105), respectively. As compared with nonfrail individuals, those who were intermediately frail had a longer postdialysis recovery time (Incidence rate ratio [IRR], 2.56; 95% CI, 1.45 to 4.52), as did those who were frail (IRR, 1.72; 95% CI, 1.03 to 2.89; P_{trend}=0.20), independent of demographic, clinical, and dialysis factors. The association of intermediate frailty and frailty with recovery time did not differ by sex or race (all $P_{interaction}$=0.05). None of the individual frailty components were associated with dialysis recovery time (Supplemental Table 2).

Frailty, Age, and Hemodialysis Recovery Time

Among participants in this study, 15% were frail (score greater than or equal to two) and >65 years. The distribution of dialysis recovery time across frailty and age categories is shown in Figure 2. Among frail individuals, younger (≤65 years) age remained associated with a longer postdialysis recovery time (IRR, 2.55; 95% CI, 1.46 to 4.43) (Table 2). There was no evidence of association between age and recovery time among the nonfrail (IRR, 1.18; 95% CI, 0.41 to 3.39). The association of age and length of postdialysis recovery time, however, was not statistically different between frail and nonfrail individuals ($P_{interaction}$=0.83).

Table 1. Predictors of Arrhythmic and Cardiovascular Risk in End Stage Renal Disease study participant characteristics

Variables	*N*	Mean (± SD), Median (Interquartile Range), or Frequency (%)		
		Overall	Postdialysis Recovery Time <20 min (*N*=147)	Postdialysis Recovery Time ≥20 min (*N*=138)
Demographic and clinical factors				
Age, yr	285	55±13	56±12	54±14
Women	285	123 (43)	63 (43)	60 (43)
Black	285	207 (73)	109 (74)	98 (71)
Body mass index, kg/m^2	283	29.5±7.9	28.9±7.4	30.1±8.3
Ever smoker	285	164 (58)	89 (61)	75 (54)
Diabetes	285	161 (56)	85 (58)	76 (55)
History of coronary artery disease	285	98 (34)	47 (32)	51 (37)
History of congestive heart failure	285	114 (40)	61 (41)	53 (38)
History of cerebrovascular disease	285	60 (21)	25 (17)	35 (25)
Systolic BP, mm Hg[a]	284	136.9±25.6	136.1±25.0	137.5±26.3
Diastolic BP, mm Hg[a]	284	74.3±14.4	73.4±13.8	75.3±15.0
Dialysis factors				
Vascular access type	285			
Arteriovenous fistula		92 (32)	41 (28)	51 (37)
Arteriovenous graft		7 (2)	2 (1)	5 (4)
Venous catheter		186 (65)	104 (71)	82 (59)
Relative fluid removal, %	246	3.1±1.3	3.0±1.0	3.1±1.4
Interdialytic weight gain, kg	271	2.16±0.84	2.20±0.81	2.13±0.88
Length of dialysis treatment, min	261	215±20	215±20	216±19
Intradialytic systolic BP change, mm Hg	284	−9.6±11.6	−9.8±11.1	−9.4±12.2
Intradialytic diastolic BP change, mm Hg	284	−4.9±6.2	−4.8±5.8	−5.1±6.6
Calcium dialysate concentration, mEq/L	269	2.29±0.24	2.29±0.23	2.29±0.24
Potassium dialysate concentration, mEq/L	269	2.15±0.34	2.14±0.33	2.17±0.34
Bicarbonate dialysate concentration, mEq/L	245	37±2	37±2	37±2
Ultrafiltration rate, mg/kg per h	261	7.4±2.9	7.6±3.0	7.1±2.7
Medication use				
Total number of antihypertensive medications	273	3 (2–4)	3 (2–3)	3 (2–4)
α-blockers	261	26 (9)	12 (9)	14 (10)
β-blockers	261	180 (69)	90 (67)	90 (71)
Angiotensin-converting enzyme inhibitors	261	85 (33)	37 (27)	48 (38)
Angiotensin II receptor blockers	261	34 (13)	21 (16)	13 (10)
Centrally acting agents	261	39 (14)	21 (16)	18 (14)
Diuretics	261	62 (24)	29 (21)	33 (26)
Vasodilators	261	87 (33)	43 (32)	44 (35)
Calcium channel blockers	261	167 (64)	89 (66)	78 (62)
Erythropoetin stimulating agents	277	270 (97)	138 (98)	132 (97)

[a]BPs were obtained by averaging three consecutive measurements with participants in a seated position on a nondialysis day.

Sensitivity Analyses

The association of frailty and dialysis recovery time was similar when separately adjusted for baseline serum albumin, ultrafiltration rate, length of hemodialysis treatment, dialysate composition, relative fluid removal, hemoglobin, antihypertensive medication use, and intradialytic systolic and diastolic BP difference. Additionally, there was no evidence of postdialysis recovery time differences between centers (P=0.12).

Discussion

In this prospective cohort of adults of all ages within the first year of dialysis, nearly three-quarters of participants recovered within an hour, one-fifth required between 1 and 6 hours, and 5% reported recovery times >12 hours. Longer recovery times were associated with frailty and younger age. Individuals who were either intermediately frail or frail had postdialysis recovery times that were about two times longer than those of nonfrail individuals. No single frailty component was associated with postdialysis recovery time. Individuals ≤65 years of age had recovery times 2.36-fold longer than older individuals. Among frail individuals, younger age was associated with 2.55-fold longer recovery time. However, among the nonfrail, age was not associated with recovery time.

The pathophysiology of dialysis recovery is complex and likely changes over years while on dialysis. We hypothesized that the capacity of an individual to withstand the stress of hemodialysis may be reflected in their recovery time (5). Self-reported postdialysis recovery time is a validated measure with high test-retest correlation, and it is sensitive to change over time (4). Moreover, this metric is simple to obtain and easy for patients to understand. This

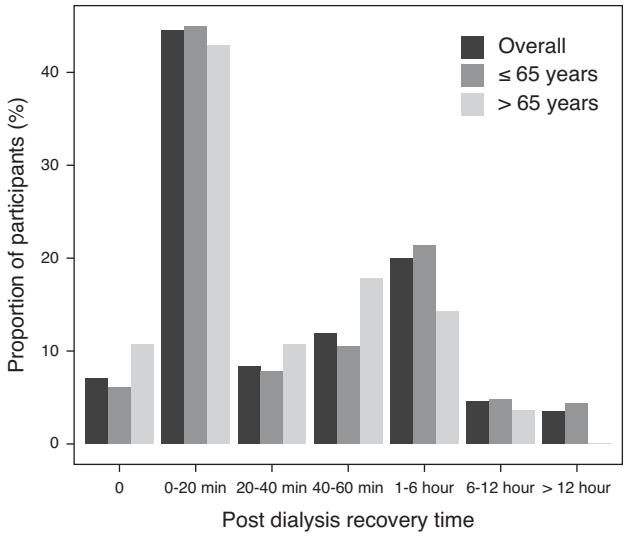

Figure 1. | **Postdialysis recovery time and age.**

patient-centered outcome is associated with HRQoL and increased risk of hospitalization and mortality (4,5). Our understanding of the physiologic mechanisms underlying the postdialysis fatigue that manifests as perceived recovery time remains incomplete. Hemodialysis instigates osmotic imbalances, and these shifts from homeostasis may be greater following more stressful dialysis sessions. Although exhaustion was not associated with recovery time, the stress imposed on the patient may result in longer recovery times in individuals less equipped to withstand stressors.

The distribution of recovery times in our study of adults having received dialysis for a median of 11 months was weighted more heavily toward shorter times than those from studies involving participants with longer dialysis vintage. Notably, patients on prevalent hemodialysis and patients on incident hemodialysis comprise very distinct populations that differ significantly due to the high mortality rate in the first year of dialysis, the physical and cognitive decline associated with chronic dialysis, and transplantation following dialysis initiation (6). For example, whereas 72% of the participants in our study recovered within 1 hour, only 24% of 701 individuals having received dialysis for a median of >2 years recovered within this time period (19). Twenty-three percent of these recipients of prevalent hemodialysis required over 12 hours to recover, compared with 5% in our study. Nonetheless, 28% of participants in our study reported recovery times >1 hour. The disposition of prevalent hemodialysis recovery times to longer periods is found in three other studies as well. In two large cohorts of participants on hemodialysis for a median of 3.3 years, 32%–55% reported recovery time of <2 hours, and 10%–20% reported recovery times of >12 hours (5,20). In a study with median dialysis vintage of 2.4 years, 52% of the 364 participants reported recovery times <2 hours, and 27% reported recovery times >7 hours (21).

A risk factor for prolonged recovery time investigated in a small number of studies of patients on prevalent dialysis includes age. As older age is associated with decreased HRQoL (22), an association with postdialysis recovery time is likely but remains ambiguous. Among 6040 participants on prevalent hemodialysis, older adults were more likely to report longer recovery times (adjusted odds ratio, 1.03 per 5 years; 95% CI, 1.01 to 1.06); nonetheless, the effect was modest (5). Age was not associated with postdialysis recovery time, however, in two smaller studies (19,23). Our study extends these findings by demonstrating that, in a cohort of adults new to hemodialysis, age ≤65 years was associated with longer recovery time. This association runs contrary to the expectation that older individuals might be

Table 2. Associations of baseline age and frailty with postdialysis recovery time among adults new to hemodialysis

	Unadjusted Associations		Adjusted Associations	
Model	IRR (95% Confidence Interval)	*P* Value	IRR (95% Confidence Interval)	*P* Value
Demographic factors and frailty[a]				
Age ≤65 versus >65 yr	2.18 (1.36 to 3.47)	0.001	2.36 (1.44 to 3.85)	0.001
Obese versus nonobese	1.35 (0.79 to 2.29)	0.30	1.76 (1.16 to 2.68)	0.008
Prevalent cerebrovascular disease	1.79 (0.99 to 3.23)	0.05	2.03 (1.21 to 3.43)	0.007
Frailty status				
Nonfrail	Reference		Reference	
Intermediately frail	1.46 (0.85 to 2.51)	0.20	2.56 (1.45 to 4.52)	0.001
Frail	1.06 (0.65 to 1.72)	0.80	1.72 (1.03 to 2.89)	0.04
Age stratified by frailty (score ≥2)[b]				
Among nonfrail (*N*=58)				
Age ≤65 versus >65 yr	2.74 (0.96 to 7.89)	0.06	1.18 (0.41 to 3.39)	0.81
Among frail (*N*=227)				
Age ≤65 versus >65 yr	2.07 (1.23 to 3.49)	0.006	2.55 (1.46 to 4.43)	0.001

[a]The model was also adjusted for sex, race, smoking status, diabetes mellitus, coronary artery disease, congestive heart failure, and mean interdialytic weight gain. Nonfrail was defined as a score of zero or one, intermediately frail was defined as a score of two, and frailty was defined as a score of three or higher.
[b]Frailty was defined as a score of greater than or equal to two, which includes intermediately frail and frail. Models were adjusted for sex, race, obesity, and cerebrovascular disease.
IRR, incidence rate ratio.

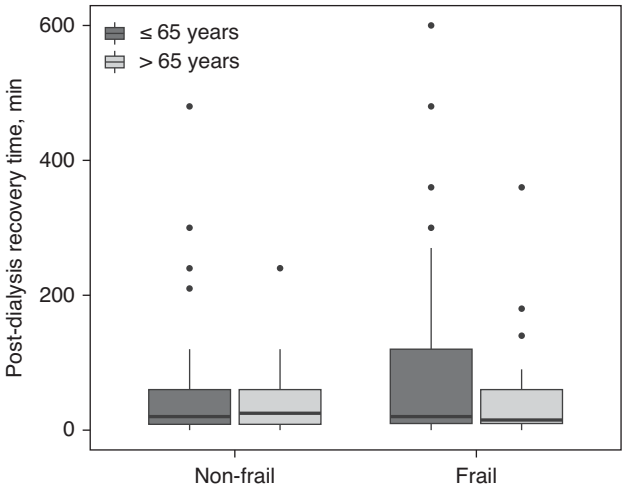

Figure 2. | **Frailty status and age.** Frailty was defined as a score of greater than or equal to two, which includes intermediately frail and frail.

less equipped to recover from the stress of a dialysis session, but as discussed below, it may reflect lower expectations and greater satisfaction despite poorer clinical profiles in older patients.

Frailty, a phenotype characterized by increased susceptibility to stressors, was first described in community-dwelling older adults (7). In hemodialysis populations, frailty is prevalent in adults of all ages and has been associated with falls (13), hospitalization (10), and cognitive dysfunction (24). We hypothesized that susceptibility to stressors would result in frail individuals requiring longer to recover from the stress of a dialysis session. Indeed, we find that frail and intermediately frail participants on hemodialysis in our study report longer dialysis recovery times than their nonfrail counterparts. This result was robust to length of hemodialysis treatment and ultrafiltration rate. Importantly, none of the individual frailty components were associated with postdialysis recovery time, supporting the characterization of frailty as a phenotype in which the combination of components is more important than any individual component.

Although the prevalence of frailty increases with age in the general population, it is highly prevalent among patients on hemodialysis of all ages (10,11). Possibly because of the common association of frailty with older age, frailty is often overlooked in younger adults undergoing hemodialysis (25). This oversight may be of clinical significance as our results suggest that younger frail adults may be more susceptible to the stressors of hemodialysis, manifested as longer perceived postdialysis recovery time. Among nonfrail individuals, age was not associated with recovery time, suggesting that there are resilient patients on hemodialysis across the age spectrum. That is, among those with the most physiologic reserve, patients recover at similar rates regardless of age.

The use of self-reported recovery time can be complicated by the complex subjective nature of this metric, which is influenced by not only the patient's physical state of well-being but also, their perception of their well-being. Shorter recovery times reported by older patients may reflect lowered expectations and greater satisfaction despite poorer clinical profiles. Conversely, younger patients with more active lifestyles may perceive the limitations imposed by dialysis recovery as greater. Interestingly, a study of 714 adults undergoing chronic hemodialysis found that individuals under 75 years of age attained lower levels of emotional health, as measured by the Kidney Disease Quality of Life (KDQOL) Short Form, than their older counterparts despite reporting better physical function (26). In a study of patients on incident hemodialysis, those under 65 years had better physical function KDQOL scores than older participants but worse scores on pain, kidney disease symptoms, and quality of social interactions (27). These results were echoed in two further studies conducted in prevalent hemodialysis populations. The first showed that younger patients had better physical well-being but worse effects of kidney disease and poorer sleep quality than patients over 70 years (28). The second reported that, despite better clinical profiles, patients under 65 years demonstrated worse KDQOL effects of kidney disease and patient satisfaction and worse overall quality of life than older patients (29). The extent to which these HRQoL-associated factors may play a role in explaining the prolonged postdialysis recovery time of younger frail patients on hemodialysis remains unclear, but our observations suggest that this subgroup may comprise an overlooked population that may be vulnerable to the stressors of hemodialysis.

Strengths of the study include the prospective nature of this large cohort of patients new to hemodialysis, the inclusion of adults of all ages, and the use of a validated patient-centered outcome. We also measured frailty status prior to the assessment of recovery time to establish temporality. Additional strengths include the use of a validated and objective instrument to measure frailty, a well-characterized cohort, and adjudication of comorbidities. The results of this study may not, however, be generalizable to the entire United States hemodialysis population because of possible selection bias that can occur when generally healthier participants are recruited for a prospective study. There was also risk of survival bias because outcome ascertainment was a median of 11 months after dialysis initiation, and 43% of participants for whom we do not have an outcome died within the first year of dialysis. Although 74 participants could not be contacted for telephone interview, these participants did not differ from those included in the study by frailty status or any other clinical factors (Supplemental Table 3). We are also limited by our lack of information on how frailty status might have changed between frailty assessment and recovery time assessment. We assessed effects of baseline potential confounders and could not account for confounding characteristics that may have changed over the study time period. We also lack information on residual kidney function and urine output at dialysis initiation or dialysate temperature, which may affect postdialysis recovery time. Finally, although this study was sufficiently powered to detect independent associations between frailty and recovery time and between age and recovery time, we may not have had sufficient power to detect interactions in the analyses of effect modification.

In summary, we observed that participants within the first year of hemodialysis reported postdialysis recovery

times shorter than those typically reported by patients on prevalent hemodialysis in other studies, with almost two-thirds of participants reporting recovery times of <1 hour and only 5% reporting >12 hours. Frailty and younger age were associated with prolonged recovery time among these patients on hemodialysis independently of demographic, clinical, and dialysis factors, including length of hemodialysis treatment and ultrafiltration rate. In particular, younger frail participants were more likely to report longer recovery times. Among nonfrail patients on hemodialysis, however, age was not associated with recovery time. Our results suggest that frail and particularly, younger frail individuals should be targeted for interventions to improve recovery times. Future studies are needed, however, to confirm these results and to assess the efficacy of such interventions.

Disclosures

M.M. Estrella reports consultancy agreements with Eiland & Bonnin and PC; research funding from Bayer Inc. and Booz Allen Hamilton; honoraria from the American Kidney Fund, AstraZeneca, Boehringer Ingelheim, and the National Kidney Foundation; and scientific advisor or membership as a *CJASN* editorial board member. B. G. Jaar reports honoraria from the American Board of Internal Medicine–Nephrology; scientific advisor or membership with the American Board of Internal Medicine, *BMC Nephrology*, *BMC Medicine*, *CJASN*, and the National Kidney Foundation; and other interests/relationships with UpToDate (royalties as an author). M.A. McAdams-DeMarco reports honoraria from UpToDate. R.S. Parekh reports ownership interest in Coramed (stock) and Synaptive (stock); research funding from the Canadian Institute of Health Research, the Kidney Foundation of Canada, and the National Institutes of Health; scientific advisor or membership with *CJASN* as an associate editor and the International Society of Nephrology council; and other interests/relationships with Bishop Strachan School as a member of the board of directors. D.L. Segev reports consultancy agreements with CSL Behring, Genzyme/Sanofi, and Novartis; honoraria from CSL Behring, Genzyme/Sanofi, and Novartis; scientific advisor or membership as the editor in chief of *Current Transplant Reports*; and speakers bureau for CSL Behring, Genzyme/Sanofi, and Novartis. T. Shafi reports consultancy agreements with Siemens; research funding from Baxter (clinical trial); honoraria from Cara Therapeutics, the National Institutes of Health, and Siemens; and scientific advisor or membership with *American Journal of Kidney Diseases* and *CJASN*. All remaining authors have nothing to disclose.

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Author Contributions

M.M. Estrella, B.G. Jaar, M.A. McAdams-DeMarco, J.M. Monroy-Trujillo, R.S. Parekh, D.L. Segev, T. Shafi, and S.M. Sozio conceptualized the study; M.M. Estrella, B.G. Jaar, R.S. Parekh, and S.M. Sozio were responsible for data curation; J. Fitzpatrick was responsible for formal analysis; M.M. Estrella, B.G. Jaar, M.A. McAdams-DeMarco, J.M. Monroy-Trujillo, R.S. Parekh, D.L. Segev, T. Shafi, and S.M. Sozio were responsible for methodology; M.A. McAdams-DeMarco and R.S. Parekh provided supervision; J. Fitzpatrick wrote the original draft; and M.M. Estrella, J. Fitzpatrick, B.G. Jaar, M.A. McAdams-DeMarco, J.M. Monroy-Trujillo, R.S. Parekh, D.L. Segev, T. Shafi, and S.M. Sozio reviewed and edited the manuscript.

Supplemental Material

This article contains the following supplemental material online at http://kidney360.asnjournals.org/lookup/suppl/doi:10.34067/KID.0001052021/-/DCSupplemental.

Supplemental Table 1. Extended PACE participant characteristics.

Supplemental Table 2. Associations of baseline age and frailty components with postdialysis recovery time among adults new to hemodialysis.

Supplemental Table 3. Baseline PACE participant characteristics among those with and without outcome ascertainment.

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