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Self-motivation is associated with phosphorus control in End-Stage Renal Disease

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Summary

Objective—Hyperphosphatemia is common in end-stage renal disease (ESRD), and associates with mortality. Phosphate binders reduce serum phosphorus; however, adherence is often poor. This pilot study aims to assess patients' self-motivation to adhere to phosphate binders, its association with phosphorus control, and potential differences by race.

Design—Cross-sectional

Participants and measurements—Subjects were enrolled from one academic medical center dialysis practice from July–November 2012. Self-motivation to adhere to phosphate binders was assessed with the Autonomous Regulation (AR) scale (range: 1–7), and self-reported medication adherence with the Morisky Medication Adherence Scale (MMAS). Linear regression models adjusting for age, gender, health literacy and medication adherence were applied to determine associations with serum phosphorus level, including any evidence of interaction by race.

Results—Among 100 participants, mean age was 51 years (± 15), 53% were male, 72% were non-white, 89% received hemodialysis, and mean serum phosphorus level was 5.7 [± 1.6] mg/dL.

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DISCLOSURES

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More than half (57%) reported the maximum AR score (7). Higher AR scores were noted in those reporting better health overall ($p=0.001$) and those with higher health literacy ($p=0.01$). AR score correlated with better medication adherence ($r=0.22$; $p=0.02$), and medication adherence was negatively associated with serum phosphorus ($r=-0.40$; $p<0.001$). In sub-group analysis among non-whites, higher AR scores correlated with lower serum phosphorus (High vs. Lower AR Score: 5.55 (1.5) vs. 6.96 (2.2); $p=0.01$). Associations between AR score (β 95% CI: -0.37 (-0.73 – -0.01); $p=0.04$), medication adherence (β 95% CI: -0.25 (-0.42 – -0.07); $p=0.01$) and serum phosphorus, persisted in adjusted analyses.

Conclusions—Self-motivation was associated with phosphate binder adherence and phosphorus control, and this differed by race. Additional research is needed to determine if personalized, culturally sensitive strategies to understand and overcome motivational barriers may optimize mineral bone health in ESRD.

Index words

autonomous regulation; phosphate binder adherence; phosphate control; race

INTRODUCTION

Hyperphosphatemia is a component of chronic kidney disease that is associated with mineral and bone disorders,¹ and has been linked to poor outcomes among patients receiving dialysis.² Racial and ethnic disparities exist in the treatment of end-stage renal disease (ESRD)³, and hyperphosphatemia is more common and more severe in non-whites compared to whites.⁴ Hyperphosphatemia can be effectively managed through diet and medication treatments², but are often limited by poor adherence.⁵

Non-adherence in ESRD is associated with increased morbidity and mortality^{6–8}; however, its importance is often underestimated. Non-adherence in the ESRD population range from 22% to 74%, and affect all areas of phosphorus management self-care.⁹ Modifiable psychosocial factors have been identified as predictors of non-adherence to phosphate binders,⁵ and include depressive symptoms,^{10–11} medication beliefs,¹² and knowledge.^{13–14}

Another potential key factor is a person's sense of autonomous regulation.¹⁵ Patients who view medication adherence as positive are more likely to participate in the behavior.¹⁶ A positive attitude has been shown to be one of the key factors that lessens the burden of treatment and improves adherence in complex patients with chronic conditions.¹⁷ When patients are empowered to make their own health behavior choices, and these positive health behaviors are aligned with the patient's attitude about the behavior, these changes are more likely to persist.¹⁵ In addition to attitudes self-determination theory includes a person's self-efficacy to perform the behavior as well as their perception of their provider's support (Figure 1). Patient characteristics including age, gender, and race may influence attitudes. Examining these factors may assist in our understanding of adherence to phosphate binder therapy.

The objective of this pilot study was to examine dialysis subjects' self-motivation to adhere to phosphate binder medication therapy, and its association with medication adherence and

also phosphorus control. We hypothesized that dialysis subjects with higher autonomous regulation (AR) scores would report higher adherence to their phosphate binders and also have lower serum phosphorus levels. Racial influences on these measures were also examined. We hypothesized that self-motivation to adhere to phosphate binders would differ between white and non-white subjects.

STUDY POPULATION AND METHODS

Design, Participants and Setting

In this cross-sectional study, adult subjects receiving dialysis treatment for ESRD were recruited from three dialysis units affiliated with a large, urban, tertiary care academic medical center from July to November 2012. Subjects were eligible for participation if they were 18 years or older, English speaking, and currently prescribed phosphate binder medication therapy. Exclusion criteria included uncorrectable poor vision, and an existing diagnosis of psychosis or dementia. This study was approved by the Institutional Review Board at our institution. All participants provided written informed consent and were offered \$5 for their time.

Variables and data sources/measurement

Surveys were administered to each subject during a face-to-face interview, most commonly during their dialysis treatment. The time needed to complete the survey ranged from 20 to 45 minutes. Evaluation of dialysis subjects' self-motivation to adhere to phosphate binders was determined using a version of the Autonomous Regulation (AR) scale adapted specifically to assess self-motivation to adhere to these medications (Table S1).¹⁸ The AR scale has six items and responses range from 1 (not at all true) to 7 (very true). The overall AR score is the calculated mean of the six items. As is common with other scales that assess patient perceptions of care, high attitudes are attributed to an overall score of 7 and lower attitudes with any overall score less than 7.¹⁹

The Morisky Medication Adherence Scale (MMAS),²⁰ adapted to reference phosphate binders, was used to determine self-reported medication adherence. This 8-item scale has been shown to have good internal consistency ($\alpha=0.83$) and good concurrent and predictive validity in predicting medication adherence assessed using objective methods in a low-income patient population with hypertension.²⁰ The scale ranges from 0–8, and previous studies suggest that high, medium, and low adherence are defined as scores of 8, 6–7, and <6, respectively.²⁰

Additional measures included patient demographics and health literacy. Demographics were self-reported including age, gender and race. Race was dichotomized into two groups: whites and non-whites. Health literacy was assessed using the short form of the test of functional health literacy in adults (S-TOFHLA).²¹ It is a timed, 7-minute test comprised of 36 questions, with a total score range from 0 to 36. Limited health literacy (e.g. < 9th grade reading level) is reflected by a score of 22 or lower, and adequate health literacy by a score of 23 to 36.²¹ Serum phosphorus level was abstracted from the subjects' medical record using the clinical monthly assessment closest to the time of the survey administration.

Statistical analyses

Descriptive statistics of subject characteristics and AR scores were performed. AR scores were dichotomized into high AR (≥ 7) and low AR (< 7) to analyze differences in subjects. This categorization cut-off was determined by median score of 7 in this sample, and also previous research applying this type of classification when data are skewed.^{19,22} The findings are presented as either means and standard deviations for continuous variables or proportions of the total subject population for categorical variables. Differences by race in individual attitude items were analyzed using the Wilcoxon-rank sum test and plotted graphically. Linear regression models were constructed to determine factors associated with serum phosphorus level where the serum phosphorus variable was assessed as a continuous measure. Unadjusted analyses were performed as well as adjusted analyses controlling for potential confounding variables including age, gender and health literacy. We further examined for evidence of interaction by race. All analyses were performed using Stata 13.0 (Stata Corp, College Station, Texas).

RESULTS

Subject Characteristics

Of 152 prevalent dialysis subjects that were screened for participation, 34 declined participation, 18 did not meet eligibility criteria, and 100 subjects were enrolled. Subject characteristics are presented in Table 1. The mean (standard deviation, SD) age was 51 (15.2) years, 53% were male, and 72% were non-white. Almost half of the subjects had limited health literacy. The most commonly used phosphate binders were Sevelamer carbonate (40%) and Calcium acetate (33%), although use of all types of phosphate binders was reported. The mean serum albumin level was 3.94 mg/dL and this did not differ between non-whites and whites (mean (SD): 3.94 (0.66) vs. 3.93 (0.36); $p = 0.95$).

Outcome data and main results

Autonomous Regulation Scores—The AR scale had very high internal consistency in our study (Cronbach's $\alpha = 0.92$). The mean (SD) autonomous regulation score was 6.43 (1.0), with a range of 1.17–7.0. The highest AR score (≥ 7) was reported by 57% of the subjects. Compared to subjects with lower AR scores (< 7), those with the highest AR score were older (53 years (15.5) vs. 48 years (14.6)), less likely to be male (50% vs. 56%), and more likely to be non-white race (78% vs. 63%), although no statistically significant differences were observed (Table 1). Despite the relatively high prevalence of limited literacy in this sample of dialysis patients, there were no observed differences by AR score. We further analyzed the individual items on the AR scale.²³ The individual questions describing the rating of each reason for taking phosphate binders ranged from a mean (SD) score of 6.33 (1.3) (the belief that “taking phosphate binders are best for health”) to 6.53 (1.1) (“taking phosphate binders are important for being as healthy as possible”). There were racial differences noted in the mean AR scores of non-whites and whites but this did not reach statistical significance ($p = 0.08$). There were also no statistically significant differences by race on any individual item, although the means for non-white subjects were higher than white subjects for all six items.

The percentage of patients reporting high AR score (=7) was examined for each question by race (Figure 2). There was a significantly higher proportion of non-white compared to white subjects reporting the highest AR score for three questions identifying reasons for taking phosphate binders: (1) important for being as healthy as possible (84% vs. 64%; $p=0.03$), (2) they personally believe it is the best thing for their health (74% vs. 50%; $p=0.02$), and (3) they have carefully thought about it and believe it is important for many aspects of their life (80% vs. 61%; $p=0.04$).

Autonomous Regulation Scores and Medication Adherence—The mean (SD) phosphate binder medication adherence score was 5.18 (2.1) and those with high AR scores were associated with higher medication adherence scores compared to those with low AR scores (5.5 (1.8) vs. 4.7 (2.3); $p=0.05$) (Table 1). In unadjusted linear regression analyses, higher AR score was significantly associated with medication adherence (β (95% Confidence Interval): 0.81 (0.01 – 1.62); $p=0.05$). This relationship became non-significant after adjusting for age, gender and health literacy (β (95% Confidence Interval): 0.72 (–0.09 – 1.53); $p=0.08$).

Autonomous Regulation Scores and Phosphorus Control—The mean (SD) serum phosphorus level for all subjects was 5.8 (1.6) mg/dL and subjects with the highest AR scores had lower serum phosphorus levels compared to those who had lower AR scores (5.6 (1.5) vs. 6.0 (1.7) mg/dL; $p=0.27$) (Table 1).

In a linear regression analysis, medication adherence was strongly associated with serum phosphorus level (β (95% CI): –0.25 (–0.40 – –0.11); $p=0.001$) even after adjusting for AR score, age, gender and health literacy (Table 2). In the overall sample AR scores were not significantly associated with serum phosphorus level.

An *a priori* exploratory analysis of differences in association of attitudes and phosphorus control by race revealed that AR score was significantly associated with serum phosphorus level in both non-whites (β 95% CI: –0.37 (–0.73 – –0.01); $p=0.04$) and whites (β 95% CI: 0.53 (0.04 – 1.02); $p=0.04$) (Table 2), but in opposite directions. Non-whites with higher AR scores were more likely to have lower serum phosphorus, however, white participants with higher AR scores were more likely to have higher serum phosphorus levels (p -interaction=0.01). Medication adherence scores remained significantly negatively associated with serum phosphorus level in both non-white and white participants.

DISCUSSION

In dialysis patients, self-motivation to adhere to phosphate binders was correlated with better self-reported medication adherence. Our study also demonstrates a strong positive relationship between self-reported phosphate binder adherence and serum phosphorus control. Furthermore, we report important differences in self-motivation for phosphate binder adherence and their association with serum phosphorus levels in white and non-white dialysis subjects.

According to self-determination theory, autonomous motivation facilitates self-regulation and promotes positive health-related behavior.¹⁸ It has been found to be predictive of success in weight-loss programs²⁴ as well as in tobacco cessation.²⁵ It has also been shown to correlate with medication adherence in adult outpatients with chronic diseases.¹⁵ However, to our knowledge, no other study to date has reported the influence of autonomous regulation on phosphate binder adherence and serum phosphorus control in dialysis subjects.

Our study suggests that predictors of the highest AR scores include being female, older, and non-white. The type of phosphate binders did not have any relationship with AR score. Even though there are limited data on gender and age differences in attitudes, there is evidence of higher self-reported adherence in female ESRD patients on PD,²⁶ and older dialysis patients are more adherent to phosphate binders compared to younger patients.^{5,26,27} Based on our study findings, it is plausible that the correlation between older age, female gender and improved phosphate binder adherence may be mediated through autonomous regulation.

The findings in this study also suggest a potential racial disparity in which non-white dialysis subjects reported higher AR scores overall compared to white subjects. It is unclear if autonomous regulation is influenced by factors such as knowledge, length of time on phosphate binders, or particular cultural beliefs about the role of medications in disease management. Differences by race were statistically significant in three of the six AR scale items that evaluated perceptions of phosphate binders as being (1) important for health, (2) the best option for health, and (3) important for life. Non-white dialysis subjects have an increased prevalence and severity of bone mineral disorder^{4,28} and perhaps, over time, this experience with more severe disease may result in higher autonomous regulation towards phosphate binders as an adaptive mechanism compared to their white peers.

In our study, we found a positive correlation between self-motivation and adherence to phosphate binder medications. This relationship is important because it suggests that an intervention aimed to improve patients' self-motivation to adhere to phosphate binders may lead to improved phosphate binder adherence. We did not find a significant association between higher AR scores and better serum phosphorus control overall in this study, but we did identify a potentially important difference by race. Non-white dialysis subjects who reported higher AR scores had lower serum phosphorus levels. This finding suggests that autonomous regulation of phosphate binder therapy may be a more salient factor in non-whites compared to whites. A similar finding has been demonstrated in African American asthmatic adults, whereby willingness to use inhaled steroids was the only factor that correlated with adherence to these medications while, in whites, adherence to inhaled steroids was affected by multiple factors including perceived necessity, knowledge of these medications, perception of providers' autonomy support and willingness to use these medications.²⁹ The fact that African Americans are reportedly less adherent to medications than whites,³⁰ even after adjusting for important confounders like demographics, depression, social support and health literacy,^{31–33} suggests that, perhaps, autonomous regulation may be a key factor in improving medication adherence in this at-risk patient population.

Paradoxically, we found that white dialysis subjects who reported higher AR scores had higher serum phosphorus levels. The reason for this unexpected relationship is unclear. Even

though the white subjects in this study had a higher health literacy level, it has been suggested that patients who are more knowledgeable about phosphate binders can, ironically, result in greater non-adherence to these medications.³⁴ However, this finding remains controversial because health literacy has been found to correlate with adherence and partially account for observed racial disparities with medication adherence in diabetics³⁵ and HIV.³⁶

It is also unclear if the complex and controversial relationship between race, adherence to low phosphorus diet, underlying nutritional status, and serum phosphorus levels in dialysis patients, contributed to our observed paradox. In one study of 95 dialysis patients, White participants were found to self-report greater adherence to a low phosphorus diet, yet were much less likely to have a controlled serum phosphorus level³⁷. A post hoc analysis of the Hemodialysis Study found that non-whites were more likely to be prescribed a low phosphorus diet and these patients were also more likely to have lower serum albumin and mildly lower serum phosphorus levels³⁸. There is limited research available specifically by race describing the effect of varying phosphorus dietary prescription and intake patterns to inform their impact on bone health in dialysis. We acknowledge that this is likely as important as medication therapy, and the lack of detailed dietary characterization in this study is a limitation.

Limitations

There are several additional limitations to acknowledge in this study. First, our sample size was small and was derived from one practice; therefore, potentially limiting the generalizability of our findings to all dialysis patients. This especially may apply to the findings related to our study's sample of white participants. Second, there is the possibility of residual confounding, i.e. the interpretation of our results may be modified by possible confounding factors including diet, non-adherence to dialysis prescription, knowledge and depression. Third, we used a self-reported measure for phosphate binder adherence, which is subject to recall and information bias; however, previous research supports that this particular scale is reliable and valid.²⁰ Finally, the possibility of reverse causality in cross-sectional study designs makes it difficult to determine temporal sequencing. Therefore, it is plausible that better phosphate binder adherence may actually be the cause of better phosphate binder attitudes rather than being a consequence of it.

Conclusion

This is a novel study because it examines the relationship between autonomous regulation of phosphate binder therapy and serum phosphorus control. The use of the Autonomous Regulation scale specifically for phosphate binder therapy is also a novel application of this measure. This pilot study suggests that there is potential clinical utility in the use of the AR scale to identify attitudes that could be amenable for intervention within a group of subjects who are non-adherent to phosphate binders.

Practical Applications

Patient-centered interventions are needed to improve phosphate binder adherence in the ESRD population. In the small sample of dialysis patients used in this study, we identified

racial differences in the association between patients' self-motivation and their phosphate binder adherence and serum phosphorous control. To understand better a patient's self-motivation for medication adherence in ESRD, providers can administer a brief measure of autonomous regulation and use the outcomes of this assessment to support dialysis patients in their medication self-management. Motivational interviewing, which is a goal-oriented and person-centered counseling approach to effect behavioral change, can be used to complement assessments of self-motivation and improve adherence outcomes. Additional research is needed to examine how perceptions of support from providers and self-efficacy specific to phosphate binder therapy adherence may be associated with autonomous regulation in culturally diverse patient populations, and to evaluate the influence of motivational interviewing on phosphate binder self-management.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Conceptual model of self-motivation and medication adherence

Figure 2.
Percent with Maximum Autonomous Regulation Score by race

Table 1

Patient Characteristics by Autonomous Regulation Score

CHARACTERISTICS	ALL Subjects (n=100)	LOWER AR Score < 7 (n=43)	HIGHER AR Score = 7 (n=57)	p-value
Age (years) mean (SD)	51 (15.2)	48 (14.6)	53 (15.5)	0.13
% Male	53%	56%	50%	0.56
% Non-white 71% African American	72%	63%	78%	0.08
Health literacy score mean (SD)	23.4 (11.5)	22.6 (12.6)	24.0 (11.2)	0.55
Type of phosphate binder				
Sevelamer carbonate (40%)	39%	21%	18%	0.31
Calcium acetate (33%)	33%	17%	16%	0.27
Calcium carbonate (15%)	15%	7%	8%	0.85
Sevelamer hydrochloride (7%)	8%	3%	5%	0.97
Ferric citrate (6%)	6%	0%	6%	1.00
Lanthanum (5%)	5%	1%	4%	0.80
Medication adherence mean (SD)	5.2 (2.0)	4.7(2.3)	5.5 (1.8)	0.05
Serum phosphorus (mg/dL)	5.8 (1.6)	6.0 (1.7)	5.6 (1.5)	0.27

AR=Autonomous regulation; SD=standard deviation;

Table 2

Phosphorus control in all subjects and by race

Variable	All Subjects		Non-white N=72		White N=28	
	β (95% CI)	p-value	β (95% CI)	p-value	β (95% CI)	p-value
AR Score	-0.11 (-0.40 – 0.17)	0.44	-0.37 (-0.73 – -0.01)	0.04	0.53 (0.04 – 1.02)	0.04
Medication Adherence Score	-0.25 (-0.40 – -0.11)	0.001	-0.25 (-0.42 – -0.07)	0.01	-0.34 (-0.62 – -0.07)	0.02
Age	-0.03 (-0.05 – -0.01)	0.001	-0.03 (-0.06 – -0.00)	0.04	-0.03 (-0.07 – 0.01)	0.09
Gender Ref: female	-0.63 (-1.20 – -0.06)	0.03	-0.74 (-1.44 – -0.04)	0.04	-0.43 (-1.33 – 0.47)	0.34
Health Literacy S-TOFHLA score	0.01 (-0.02 – 0.04)	0.44	0.01 (-0.03 – 0.05)	0.55	0.00 (-0.05 – 0.05)	0.89