

Improving Albumin Levels Among Hemodialysis Patients: A Community-Based Randomized Controlled Trial

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● **Background:** Low albumin level is a strong predictor of mortality and morbidity among hemodialysis patients, yet few interventions are available to improve albumin levels. Moreover, the relative importance of nutritional barriers versus inflammation in contributing to hypoalbuminemia is unclear. We sought to determine whether targeting specific nutritional barriers will improve albumin levels. **Methods:** We conducted a randomized controlled trial involving 180 patients with baseline albumin levels less than 3.7 g/dL (<37 g/L) at 44 long-term hemodialysis facilities. Study coordinators identified and intervened on specific barriers present among intervention patients, whereas control patients continued to receive the usual care. Barriers targeted included poor nutritional knowledge, poor appetite, help needed with shopping or cooking, low fluid intake, inadequate dialysis dose, depression, difficulty chewing, difficulty swallowing, gastrointestinal symptoms, and acidosis. **Results:** At baseline, intervention and control patients had similar albumin levels, dietary intakes, levels of inflammatory markers, and numbers of nutritional barriers. After 12 months, intervention patients had greater increases in albumin levels compared with control patients (+0.21 versus +0.06 g/dL [+2.1 versus +0.6 g/L]; $P < 0.01$), as well as greater increases in energy intake (+4.1 versus -0.6 Kcal/d/kg; $P < 0.001$) and protein intake (+0.13 versus -0.06 g/d/kg; $P < 0.001$). The intervention appeared most effective for barriers related to poor nutritional knowledge, help needed with shopping or cooking, and difficulty swallowing. About half the subjects had elevated levels of inflammatory markers, but there was no relationship between change in levels of albumin and inflammatory markers. **Conclusion:** A nutrition intervention tailored to patient-specific barriers resulted in modest improvements in albumin levels regardless of levels of inflammatory markers. *Am J Kidney Dis* 48:28-36.

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INDEX WORDS: Hypoalbuminemia; hemodialysis (HD); dietary intake; inflammation.

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HYPOALBUMINEMIA frequently is present in hemodialysis patients and correlates strongly with mortality and morbidity.^{1,2} Estab-

lishing the causality of this relationship would require showing that interventions that correct hypoalbuminemia also improve mortality and morbidity.³ However, few good strategies exist to improve albumin levels in hemodialysis patients. Moreover, many hemodialysis patients have high levels of C-reactive protein, an acute-phase reactant that is elevated in patients with inflammatory states.⁴⁻⁶ Because albumin levels decrease in patients with inflammatory states, it is unclear to what extent hypoalbuminemia is a result of malnutrition or simply a reflection of inflammatory states.

We reasoned that efforts to improve albumin levels should be based on an understanding of patient-specific barriers. In previous work, we identified a number of potentially modifiable nutritional barriers, including poor nutritional knowledge, poor appetite, help needed with shopping or cooking, low fluid intake, and inadequate dialysis dose.⁷ We also pilot tested an intervention tailored to the presence or absence of these barriers in individual hemodialysis patients.⁸ Other investigators have identified depression, difficulty chewing, difficulty swallowing, gastrointestinal symptoms, and acidosis as other poten-

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Received December 30, 2005; accepted in revised form March 22, 2006.

Originally published online as doi:10.1053/j.ajkd.2006.03.046 on May 15, 2006.

Support: Supported by grants DK51472 and GCRC M01 RR00080 from the National Institutes of Health, Bethesda, MD, and by the Leonard C. Rosenberg Renal Research Foundation, Cleveland, OH. Potential conflicts of interest: None.

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0272-6386/06/4801-0004\$32.00/0

doi:10.1053/j.ajkd.2006.03.046

tially modifiable nutritional barriers.⁹⁻¹¹ We now report results of a full-scale community-based randomized controlled trial targeting patient-specific nutritional barriers. To better understand the role of inflammatory states in modifying the outcome of this intervention, we also measured levels of 2 inflammatory markers (C-reactive protein and serum amyloid A).⁶

METHODS

Subjects and Facilities

All 47 long-term hemodialysis facilities in northeast Ohio agreed to participate. We pilot tested our methods at 1 conveniently located facility, excluded 2 very small facilities, and used a random-number generator to assign the remaining 44 facilities to an intervention or control group. To determine eligibility, study coordinators abstracted medical records to identify patients for whom the most recent serum albumin level and mean serum albumin level for the previous 3 months were both less than 3.70 g/dL (<37.0 g/L) by means of the bromocresol green method or less than 3.40 g/dL (<34.0 g/L) by means of the bromocresol purple method.¹² This ensured that only patients with persistently low albumin levels were included. We selected these albumin cutoff values because about one third of dialysis patients nationally have values less than these thresholds.¹ Additional patient eligibility criteria were age of 18 to 85 years and receiving dialysis for at least 9 months. We excluded new patients because the first several months of dialysis treatment often is a time of changes in diet and nutritional parameters.¹³ We also excluded subjects who could not participate (did not speak English, mentally impaired) or were likely to have unique nutritional issues (ie, nursing home residents, patients with cirrhosis, acquired immunodeficiency syndrome, active malignancy, terminal illness, tube feedings, and total parenteral nutrition). We obtained informed consent from eligible patients, and each was given \$25 at the beginning and again at the end of the trial to thank them for their participation. This study was approved by the Institutional Review Board of MetroHealth Medical Center, Cleveland, OH.

Before entering the study, all subjects received nutritional care from their facility's registered dietitian. This included nutritional status assessment, monthly laboratory test result review, and education regarding the renal diet. On average, facility dietitians were responsible for 124 patients per full-time equivalent and had worked for 10 years as renal dietitians.

Nutritional Parameters, Quality of Life, and Inflammatory Markers

Study coordinators abstracted medical records of intervention and control subjects to obtain demographic characteristics (age, sex, race, ethnicity), medical characteristics (cause of renal failure, time receiving dialysis, number of comorbid conditions), and nutritional parameters (albumin level, postdialysis weight, dietary intake). Number of comorbid condi-

tions was calculated based on the presence or absence of the following 10 disease categories: coronary artery disease, congestive heart failure, peripheral vascular disease, cerebrovascular disease, depression or psychosis, previous solid tumor or hematologic malignancy, connective tissue disease, asthma or chronic obstructive pulmonary disease, diabetes mellitus, and drug or alcohol abuse. Albumin levels generally were available on a monthly basis, whereas postdialysis weight was available after every dialysis treatment (typically 13 treatments/mo). Dietary intake was assessed at the beginning and again at the end of the trial by using two 24-hour dietary recalls. This involved 1 dialysis day and 1 nondialysis day, generally within a 2-week period.¹⁴ Study coordinators performed a brief nutrition-focused history and physical examination (referred to as a subjective global assessment) at the beginning and end of the trial. Patients with inadequate protein stores will be noted to have low muscle mass and/or edema on this focused examination.^{15,16} Study coordinators also assessed patient quality of life at the beginning and end of the trial by using several subscales (related to general health, physical functioning, emotional well-being, social function, pain, and dialysis-related symptoms) of the Kidney Disease Quality of Life questionnaire.¹⁷ A predialysis blood sample was obtained from each patient at the beginning and end of the study and sent to a single central laboratory for measurement of 2 inflammatory markers (C-reactive protein and serum amyloid A).

Identification of Barriers

Study coordinators abstracted medical records and interviewed intervention and control subjects to determine the presence of 10 specific nutritional barriers. Categorization of barriers was based on our pilot study, as well as previous work by other investigators.^{7,8,18,19}

Poor nutritional knowledge. Patients identified high-protein foods from a list of 10 high-protein foods (eg, eggs, beef, fish) and 10 minimal-protein or nonprotein foods (eg, chips, carrots, bread). Patients with 5 or more incorrect responses were categorized as having this barrier.

Poor appetite. Patients rated their overall appetite, as well as their appetite for 12 common high-protein foods, such as eggs, beef, cheese, and peanut butter, by using a 5-point Likert scale ranging from very good to very poor. Patients with fair/poor overall appetite or fair/poor appetite for 4 or more specific foods were categorized as having this barrier.

Help needed with shopping or cooking. Patients were asked whether they needed additional help with shopping or cooking. Patients who said yes were categorized as having this barrier.

Low fluid intake. Study coordinators examined flow sheets for the first 6 treatments of the enrollment month. Patients with a mean interdialytic weight gain less than 2.5% of their dry weight were categorized as having this barrier.

Inadequate dialysis dose. Patients with a mean Kt/V less than 1.2 during the previous 3 months were categorized as having this barrier. Because missed treatments do not affect Kt/V, patients with more than 2 missed treatments during the previous 3 months also were categorized as having this barrier.

Depression. Patients completed the Beck Depression Inventory, a standard screening questionnaire for depression. Patients with scores of 15 or higher were categorized as having this barrier.¹⁹

Difficulty chewing. Patients were asked if they had difficulty chewing and answered by using a 4-point Likert scale ranging from never to always. Patients who always or sometimes had difficulty chewing were categorized as having this barrier.

Difficulty swallowing. Patients were asked if they had difficulty swallowing and answered by using a 4-point Likert scale ranging from never to always. Patients who always or sometimes had difficulty swallowing were categorized as having this barrier.

Gastrointestinal symptoms. Patients were asked if they had heartburn or nausea. Patients who answered yes were categorized as having this barrier.

Acidosis. Patients whose predialysis bicarbonate level was less than 22 mEq/L (<22 mmol/L) were categorized as having this barrier.¹⁸ Blood samples were collected in serum separator tubes, allowed to clot for 30 minutes, and then were centrifuged and refrigerated. Study staff transported the separated samples on ice to a central laboratory within 24 hours for analysis.

Intervention Group

Study coordinators educated all intervention patients about the meaning and importance of good nutritional status. They then provided feedback and recommendations to intervention patients. The information was provided during a dialysis treatment and tailored to the specific barriers present. Study coordinators also communicated information about barriers to facility dietitians and modified recommendations based on feedback from these dietitians. Facility dietitians were asked to reinforce study coordinator recommendations when they met with their study patients.

Poor nutritional knowledge. Study coordinators educated patients about high-protein foods by using a variety of interactive activities (eg, puzzles, nutrition label reading), self-teaching activities (eg, word searches, crossword puzzles), and educational handouts.

Poor appetite. Study coordinators recommended increasing the intake of specific foods for which patients had preserved appetite. Study coordinators also provided patients with limited amounts of supplements, such as commercially available enteral nutrition drinks and cookies.

Help needed with shopping or cooking. Study coordinators, in collaboration with facility dietitians and social workers, explored the possibility of obtaining help from family, friends, and social support agencies. Subjects most often mentioned a need for a shopper's aide to assist with carrying bags or providing transportation to stores and a need for cooking assistance because of fatigue and functional status limitations.

Low fluid intake. Study coordinators, in collaboration with facility dietitians, recommended that patients add a protein-containing beverage to their diet (eg, a commercially available enteral nutrition supplement). Study coordinators provided patients with limited amounts of supplements.

Inadequate dialysis dose. Study coordinators determined potential reasons for inadequate dialysis dose (under-

prescription, noncompliance with prescribed treatment time, catheter use) and shared this information with patients' nephrologists.²⁰

Depression. Study coordinators shared elevated Beck Depression Inventory scores with patients' social workers and nephrologists and recommended that patients be evaluated and, if appropriate, treated for depression.

Difficulty chewing. Study coordinators recommended that patients see their nephrologist, primary care physician, and/or dentist for evaluation.

Difficulty swallowing. Study coordinators recommended that patients see their nephrologist and/or primary care physician for evaluation (eg, barium swallow). In some cases, difficulty swallowing was linked to difficulty chewing.

Gastrointestinal symptoms. Study coordinators recommended that patients see their nephrologist and/or primary care physician for evaluation.

Acidosis. Study coordinators shared bicarbonate levels with patients' nephrologists and recommended that nephrologists address reversible causes of acidosis, increase dialysate bicarbonate concentrations, and/or prescribe oral bicarbonate supplements.

During the next 12 months, study coordinators met monthly with patients to reinforce these recommendations, monitor progress, and answer questions. Study coordinators also updated patients' dietitians monthly. Because the study coordinators carried out the intervention, it was not possible for them to be blinded to patients' assignments to intervention versus control groups. There were no adverse events or side effects associated with the intervention.

Control Group

Control patients continued to receive usual care from their nephrologists, dietitians, and social workers. Study coordinators met monthly with control patients and administered questionnaires related to dietary intake, nutritional barriers, and/or quality of life. However, neither control patients nor their providers received feedback from study coordinators.

Follow-Up Procedures

All patients were recruited between February 2002 and September 2003 and followed up for 12 months or until they died, moved, received a transplant, or were hospitalized (and did not return to outpatient dialysis by the end of the study). During this interval, medical records of intervention and control patients were abstracted on a monthly basis to obtain data for nutritional parameters and barriers.

Outcomes

A primary outcome is change in serum albumin level. To obtain more precise estimates, the final albumin level of each patient is defined as the mean of albumin measurements in the final 3 months of study participation, whereas baseline albumin level is the mean of albumin measurements in the 3 months before subject enrollment. Change in albumin level was calculated as final minus baseline albumin value. Because we expected it would take about 3 months for our intervention to have an effect, patients who died, moved, withdrew, or became mentally incompetent in the

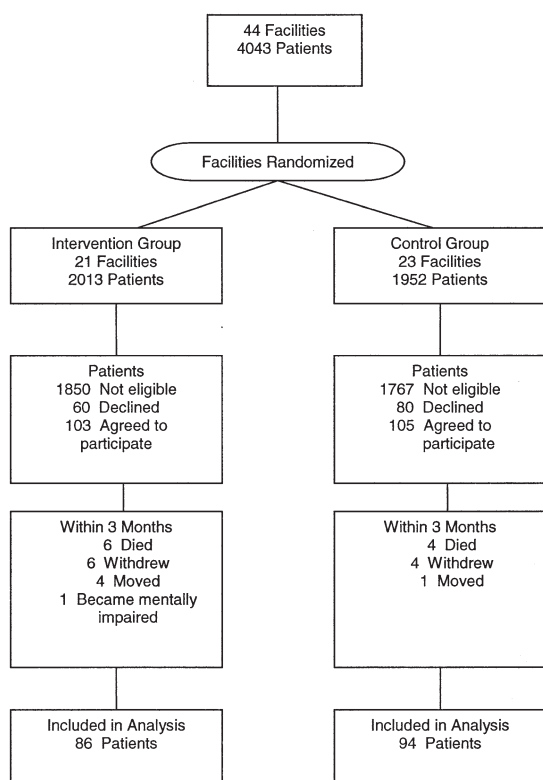


Fig 1. Flow of participants through the trial.

first 3 months were not included in the main analysis (Fig 1).⁸

Because improved albumin levels may decrease mortality, we defined another primary composite outcome that combined change in albumin level and survival. Specifically, we examined the proportion of patients who had an increase in albumin level of 0.20 g/dL or greater (≥ 2.0 g/L) and survived to the end of the study. We selected 0.20 g/dL (2.0 g/L) because it corresponds to a 25% decrease in the odds of death in observational studies.²

Secondary outcomes were changes in values for other nutritional parameters (weight, dietary intake, subjective global assessment), whether patients overcame specific nutritional barriers, and changes in quality of life. Patients with a specific barrier at baseline were considered to have overcome the barrier if they no longer met the definition of the barrier at the end of the trial. For example, subjects with baseline Beck Depression Inventory scores of 15 or higher were categorized as overcoming the depression barrier if their final scores were less than 15.

Statistical Analysis

Because facilities comprised the unit of randomization, our main analyses account for clustering of patients by facility. Specifically, we compared change in albumin level for intervention versus control patients by using an adjusted *t*-test that reflects this clustering. Similarly, we used an

adjusted chi-square test that reflects clustering to compare the proportion of patients in each group who achieved the composite outcome of increase in albumin level of 0.20 g/dL or greater (≥ 2.0 g/L) and survival. Baseline characteristics of intervention versus control patients and changes in nutritional parameters, specific barriers, and quality of life were compared by using chi-square test for categorical variables or Mann-Whitney rank-sum test for continuous variables. We used Spearman correlation coefficient to determine the relationship between change in levels of albumin and inflammatory markers. JMP and SAS statistical software were used for all analyses (both from SAS Institute Inc, Cary, NC). We performed a post hoc power calculation and estimated that our trial of 180 patients had greater than 90% power to detect a difference in albumin levels between intervention and control patients of 0.065 g/dL (0.65 g/L) with a 2-tailed α of 0.05. We also estimated that we had greater than 80% power to detect a difference of 15% in the composite outcome between intervention and control patients.²¹

RESULTS

Subject and Facility Characteristics

Of 44 long-term hemodialysis facilities, 41 (93%) were free standing (versus hospital based) and 35 (80%) were for profit. Figure 1 shows the flow of participants through the trial. Of all ineligible patients, about 80% in both groups were excluded because their albumin levels were too high. One hundred eighty patients completed the trial, including 86 intervention subjects and 94 control subjects. One hundred forty eligible subjects declined to participate, and another 27 subjects died, withdrew, moved, or became mentally impaired before reaching the evaluation phase. These 167 nonparticipants did not differ from the 180 participants in demographic characteristics, time receiving dialysis, or baseline albumin level.

Intervention and control patients had similar baseline demographic characteristics, medical characteristics, nutritional parameters, and inflammatory marker levels (Table 1). The 2 groups also had a similar total number of nutritional barriers, although they differed somewhat on specific nutritional barriers. Intervention patients were more likely to have low fluid intake and difficulty swallowing, whereas control patients were more likely to have poor appetite. The most common barriers in both groups were poor nutritional knowledge and poor appetite.

Changes in Nutritional Parameters

As listed in Table 2, intervention patients had 3.5-fold greater increases in albumin levels compared with control patients (mean, 0.21 ± 0.04

Table 1. Baseline Characteristics of Intervention and Control Subjects

	Intervention (n = 86)	Control (n = 94)	P
Mean age (y)	62	60	0.35
Female (%)	58	53	0.50
Race (%)			
Black	45	59	
White	51	38	0.20
Other	3	3	
Hispanic (%)	1	1	0.95
Cause of renal failure (%)			
Diabetes	45	49	
Hypertension	24	24	0.73
Glomerulonephritis	20	14	
Other	10	13	
Mean no. of comorbid conditions	1.9	2.1	0.38
Mean years receiving dialysis	2.8	3.1	0.47
Mean duration of treatment (min)	227	228	0.93
Using high-flux dialyzer (%)	70	76	0.39
Type of vascular access (%)			
Fistula	35	26	
Graft	37	49	0.24
Catheter	28	26	
Mean Kt/V	1.46	1.40	0.17
Albumin (g/dL)	3.40	3.40	0.90
Mean postdialysis weight (kg)	81.3	78.0	0.30
Mean body mass index (kg/m ²)	29.0	27.9	0.40
Mean energy intake (Kcal/d/kg)	20.3	19.9	0.73
Mean protein intake (g/d/kg)	0.83	0.83	0.90
Subjective global assessment (%)			
Well nourished	48	40	
Mildly to moderately malnourished	49	55	0.60
Severely malnourished	3	4	
C-Reactive protein (mg/L)	18	19	0.81
C-Reactive protein > 10 mg/L (%)	57	46	0.15
Serum amyloid A (mg/L)	46	32	0.35
Serum amyloid A > 10 mg/L (%)	60	54	0.45
Total no. of barriers	3.2	3.1	0.74
Specific barriers (%)			
Poor nutritional knowledge	41	44	0.69
Poor appetite	60	74	0.04
Help needed with shopping or cooking	34	23	0.12
Low fluid intake	26	12	0.02
Inadequate dialysis dose	9	19	0.06
Depression	31	31	0.94
Difficulty chewing	36	33	0.67
Difficulty swallowing	31	13	<0.01
Gastrointestinal symptoms	24	33	0.20
Acidosis	24	27	0.74

NOTE. To convert albumin in g/dL to g/L, multiply by 10.

[SE] versus 0.06 ± 0.03 g/dL [2.1 ± 0.4 versus 0.6 ± 0.3 g/L]; $P < 0.01$). Forty-two percent of intervention patients and 29% of control patients achieved the composite albumin/survival outcome, but this difference was of marginal statistical significance ($P = 0.06$). Intervention patients

also had increased energy and protein intake compared with control patients. On average, intervention patients increased their energy intake by 333 ± 70 Kcal/d, whereas control patients decreased their energy intake by 47 ± 66 Kcal/d ($P < 0.001$). Most of this increase ($\sim 70\%$)

Table 2. Changes in Nutritional Parameters and Nutritional Barriers

	Intervention	Control	<i>P</i>
Albumin (g/dL)	+0.21	+0.06	<0.01
Change in albumin \geq 0.20 g/dL and survived (%)	42	29	0.06
Postdialysis weight (kg)	-0.06	-0.50	0.52
Body mass index (kg/m ²)	-0.06	-0.18	0.62
Energy intake (Kcal/d/kg)	+4.1	-0.6	<0.001
Protein intake (g/d/kg)	+0.13	-0.06	<0.001
Subjective global assessment (%)			
Improved	16	16	
No change	77	76	0.93
Worsened	7	9	
Poor nutritional knowledge			
Subjects with barrier	35	41	
Overcame barrier (%)	89	22	<0.001
Poor appetite			
Subjects with barrier	52	70	
Overcame barrier (%)	33	20	0.11
Help needed with shopping or cooking			
Subjects with barrier	29	22	
Overcame barrier (%)	86	55	0.01
Low fluid intake			
Subjects with barrier	22	11	
Overcame barrier (%)	55	64	0.62
Inadequate dialysis dose			
Subjects with barrier	8	18	
Overcame barrier (%)	88	67	0.25
Depression			
Subjects with barrier	27	29	
Overcame barrier (%)	41	34	0.63
Difficulty chewing			
Subjects with barrier	31	31	
Overcame barrier (%)	58	55	0.80
Difficulty swallowing			
Subjects with barrier	27	12	
Overcame barrier (%)	74	42	0.05
Gastrointestinal symptoms			
Subjects with barrier	21	31	
Overcame barrier (%)	62	45	0.23
Acidosis			
Subjects with barrier	21	25	
Overcame barrier (%)	76	72	0.75

NOTE. To convert albumin in g/dL to g/L, multiply by 10.

occurred on nondialysis days. Similarly, intervention patients increased their protein intake by 10.7 ± 3.3 g/d, whereas control patients decreased their protein intake by 4.7 ± 3.2 g/d ($P < 0.001$). There were no differences in postdialysis weight or subjective global assessment.

Changes in Nutritional Barriers

Of the 76 patients with poor nutritional knowledge at baseline, intervention patients were 4 times more likely to overcome this

barrier by the end of the study (89% versus 22%; $P < 0.001$; [Table 2](#)). Intervention patients also were more likely to overcome barriers related to help needed with shopping or cooking (86% versus 55%; $P = 0.01$) and difficulty swallowing (74% versus 42%; $P = 0.05$). A greater percentage of intervention compared with control patients also overcame barriers related to poor appetite (33% versus 20%), inadequate dialysis dose (88% versus 67%), and gastrointestinal symptoms (62% ver-

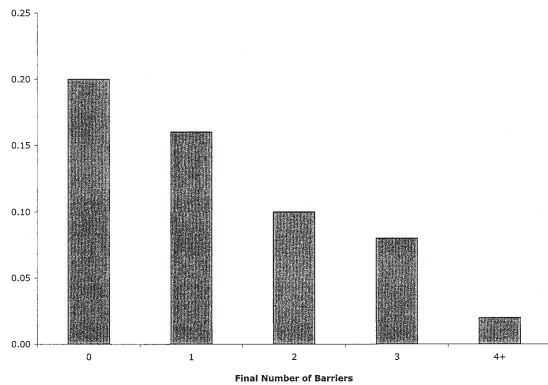


Fig 2. Final number of barriers remaining versus change in albumin levels among all patients. To convert albumin in g/dL to g/L, multiply by 10.

sus 45%), but these differences were not statistically significant (all $P \geq 0.11$).

The number of barriers remaining at the end of the trial correlated strongly with change in albumin level for all patients. Mean increase in albumin level was 0.20 g/dL (2.0 g/L) in patients with no barriers remaining, whereas mean increase was only 0.02 g/dL (0.2 g/L) in patients with 4 or more barriers remaining (Fig 2).

Quality of Life

There were no differences between intervention and control patients in quality-of-life subscales, including general health, physical functioning, emotional well-being, social function, pain, and dialysis-related symptoms.

Inflammatory Markers

There were no significant changes in mean levels of C-reactive protein (mean change, +0.3 mg/L; $P = 0.21$) or serum amyloid A (mean change, +5 mg/L; $P = 0.15$) during the trial. There was no relationship between change in albumin level and baseline C-reactive protein level (correlation coefficient, 0.03; $P = 0.69$). There also was no relationship between change in albumin level and baseline serum amyloid A level (correlation coefficient, -0.003 ; $P = 0.97$).

DISCUSSION

We found that a nutrition intervention tailored to patient-specific barriers resulted in modest improvements in albumin levels in hemodialysis patients. Although many patients had elevated

levels of C-reactive protein and serum amyloid A, these inflammatory markers did not predict changes in albumin levels. This suggests that even patients with high levels of inflammatory markers can respond to nutritional interventions. The graded relationship between number of barriers and change in albumin level (Fig 2) further supports the role of these nutritional barriers in hemodialysis patients. Our approach has the advantages of being simple, low cost, and easy to implement.

By engaging the participation of virtually all dialysis facilities and renal dietitians in a large geographic area, we enhanced the generalizability of our findings. With the exception of race and ethnicity, patient and facility characteristics are approximately similar to national data.²² The large number of black subjects reflects the inner-city location of many of the participating facilities, whereas the small number of Hispanic subjects reflects the population of northeast Ohio. Another strength of this study is its randomized design, which resulted in similar intervention and control groups in terms of patient demographic and medical characteristics, nutritional parameters, inflammatory markers, and number of nutritional barriers (Table 1).

The magnitude of improvements in albumin levels is consistent with what we found in an earlier pilot study.⁸ Three recent clinical trials also found improvements of approximately 0.2 to 0.3 g/dL (2 to 3 g/L) in serum albumin levels after administration of oral nutritional supplements or appetite stimulants.²³⁻²⁵ Although these trials had small sample sizes and were not randomized, they further support the conclusion that modest improvements in albumin levels in hemodialysis patients are possible.

Our results have important implications for patients, providers, and policy makers. Patients should be actively involved in improving their nutritional knowledge, reporting nutritional barriers to providers, and trying to overcome barriers and increase dietary intake. The level of patient involvement required to improve albumin levels is much greater than that needed to address other dialysis-related quality parameters, such as hemoglobin levels, which are largely under the control of providers. Providers should routinely monitor not only albumin levels, but also the 10 specific nutritional barriers addressed

in this clinical trial. In particular, we found that providers were unaware of the high prevalence of depression, difficulty chewing, and difficulty swallowing among their patients. Policy makers should ensure that sufficient personnel and resources are available to address nutritional barriers. Addressing the nutritional barriers we identified requires a moderate amount of time, as well as collaboration among various providers (eg, dietitians, social workers, nephrologists). However, dietitians and social workers typically are responsible for more than 100 patients apiece, and patient to provider ratios are likely to increase further if reimbursement is reduced.²⁶ Other key resources needed to address such specific barriers as nutritional supplements and dental care currently are not covered by Medicare.

Our results also are relevant to the continued utility of albumin level as a clinical performance measure by the Medicare program.¹ Clinical performance measures are indicators that deal with important conditions for which quality of care is either variable or substandard and can be improved by providers.²⁷ Because our trial, as well as 3 recent trials, showed improvements in albumin levels, it may be argued that providers should be able to improve albumin levels in usual care settings, as well.²³⁻²⁵ However, improvements in albumin levels in these trials were modest and required additional personnel and resources not available under current Medicare coverage. If albumin level continues to be used as a clinical performance measure, it should be with an understanding that improvements in albumin levels are likely to be modest, that multiple providers have a role in improving albumin levels (not just dietitians), and that additional resources may be necessary (such as supplements and dental care).

Compared with control patients, a greater proportion of intervention patients overcame 9 of the 10 nutritional barriers (Table 2). However, this difference was statistically significant only for barriers related to poor nutritional knowledge, help needed with shopping or cooking, and difficulty swallowing. The inability to find statistically significant differences for other barriers likely is caused by a combination of the small numbers of patients who had specific barriers and a limited impact of our intervention compared with usual care. In particular, both our

intervention and usual care had little effect on poor appetite and depression. Further refinements of our approach may be needed to increase its potency for specific barriers. Moreover, the somewhat larger number of subjects with poor appetite in the control group may have disadvantaged the control group because this barrier was particularly difficult to overcome.

Several limitations must be considered in interpreting our results. First, improvements in albumin levels were modest. Second, we focused on a single geographic area. Third, it is possible that control patients improved in part because they were being observed (the Hawthorne effect) or because control dietitians were influenced by intervention dietitians (contamination). However, both these effects would tend to decrease the difference between control and intervention patients; therefore, the measured effect size (albumin change, $0.21 - 0.06 = 0.15$ g/dL [$2.1 - 0.6 = 1.5$ g/L]) may underestimate the value of our intervention. Fourth, we did not have sufficient power to rigorously evaluate the impact of our intervention on specific subgroups. Fifth, although we did not specifically try to exclude patients with chronic inflammatory diseases or high C-reactive protein levels, it is possible that some of our exclusion criteria (eg, being a nursing home resident) may have had this effect in some cases. Thus, our intervention may not generalize to all patients with elevated levels of inflammatory markers.

In conclusion, we recommend that providers monitor and address specific nutritional barriers. Although our sample size and follow-up period are insufficient to show an impact on patient mortality and morbidity, larger observational studies showed a link between albumin levels and these outcomes.^{2,28,29} Thus, overcoming patient-specific nutritional barriers has the potential to enhance survival and decrease both hospitalizations and inpatient expenditures.

ACKNOWLEDGMENT

The authors thank Arianna M. Aoun, MS, RD, CSR; Anika Avery-Grant, MS, RD, LD; Earlyn Bentfeld, RD, LD; Carmen Blakely-Adams, MEd, RD, LD; Donna M. Bodnar, RD, CSR, LD; Renée W. Boehnlein, RD, LD; Angela Oriti Brainard, DTR; Christina Buccino, MHHS, RD, LD; Cindy M. Carrell, RD, LD; Lisa Cary, RD, LD; Julie A. Charif, BS, DTR; Iris Cheers, DTR; Sherilyn Churchia, RD, LD; Rose Deis, RD, LD; Charlene DePalma, RD, LD; Carolyn Dep-

pisch, RD, LD; Susan Dombrowski, MEd, RD, LD; Eva Petkac Donnelly, RD, LD; Patricia W. Ellis, MS, RD, CSR, LD; Laura Eusano, RD, LD; Mary Gamberale, RD, LD, CDE; Suzanne Gregory, RD, LD; L. Gail Groves, RD, LD; Deborah A. Hutsler, MS, RD, LD; Linda Janson, RD, LD; Pamela S. Kent, MS, RD, CSR, LD; Jennifer Kernc, RD, LD; Linda Lackney, MS, RD, LD; Margaret L. Lander, MS, RD; Marla Lipman, MS, RD, LD; Gina M. Mendiola, RD, LD; Lisa A. Miller, MS, RD, LD; Lois A Morris, RD, CSR, LD; Eileen Moore, CNSD, RD, LD; Christine M. Muñoz, RD, LD; Donna K. Neroni, RD, LD; Heather Ohlrich, RD, LD; Sally Oneacre, RD, LD; Kristin E. Paccione, MS; Pamela Pochatila, MS, RD, LD; Chatura Ravishankar, MS, RD, LD; Kristin Roach, RD, LD; JoAnn Ruggeri, RD, LD; Diane Rupp, RD, LD; Laura Schoeffler, RD, LD; Janet B. Schueller, MS, RD, LD; Kathy Seese, MS, RD, LD; Maxine Smith, RD, LD; Jeanette Soinski, RD, LD; Hollie Sunderland, RD, LD; Camille Switzer, RD, LD; Virginia M. Viselli, MEd, RD, LD; Alice Watkins, RD, LD; Melissa A. Wilson, RD, LD; and Wendy Youmans, MS, RD, LD, for their help.

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