ORIGINAL RESEARCH

Improved Nutrition After Conversion to Nocturnal Home Hemodialysis

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Background: Protein-energy malnutrition is a frequently observed problem in hemodialysis patients. Nocturnal home hemodialysis (NHHD; 6 × 8 hours during the night) seems to improve patient outcomes, including nutritional state.

Methods: In a single-center, prospective, nonrandomized study, the effects of NHHD on various aspects of nutrition in 14 hemodialysis patients during 1 to 2 years were investigated, using dietary records, appetite questionnaires, laboratory tests, and patient data.

Results: Appetite, body weight, and energy and protein intakes improved. Patients could drink more. Serum phosphate, calcium, and potassium intake increased. Laboratory results remained excellent, without phosphate-binding agents or potassium-binding resins. However, fat intake also increased, with a risk for overweight status.

Conclusions: Nocturnal home hemodialysis has a positive effect on nutritional state.

PROTEIN-ENERGY malnutrition is an important problem in hemodialysis (HD) patients and a risk factor for morbidity and mortality.[1] Several studies suggest that more frequent HD improves nutritional status.[2–4] Daily short home hemodialysis (DHHD, e.g., 6 × 2 to 3 hours a week) and nocturnal long home hemodialysis (NHHD, e.g., 6 × 8 hours a week) are promising alternatives to conventional HD (CHD, 3 × 4 to 5 hours a week).[5–10] Although no large randomized studies have been published, evidence suggests that these intensive treatments improve metabolic and hemodynamic control, as well as quality of life. Patients on NHHD can follow a free diet,[5] resulting in increased serum albumin concentrations and dry weight.[11]

To the best of our knowledge, no detailed information on dietary changes in patients who convert from CHD to NHHD has been published. The present study describes the effects of NHHD on appetite and on protein, mineral, and fluid intake, as measured using dietary records, changes in body weight, and biochemical data.

Methods

Patients

We conducted a single-center, prospective, nonrandomized study. Stable patients on CHD were followed for 1 year after conversion to NHHD. We included 20 adult HD patients in stable condition (preceding 3 months without acute or complicated medical problems) who were able to perform NHHD and agreed to do so, and who lived with a spouse or other partner who could assist them. Table 1 lists patients' characteristics. After a training period, patients were treated with NHHD for 6 days a week, 8 hours per night at home. More details of NHHD treatments are available elsewhere.[5,6] Approval was obtained from the Ethics Committee at University Hospital Utrecht (Utrecht, The Netherlands), and all patients gave informed consent.

Diet Records

Food-intake data and information about phosphate-binder use were obtained with

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Table 1. Patient Characteristics

Patient	M/F	Age (years)	BW (kg)	BMI (kg/m^2)	RRT (years)	Renal Disease
1	M	34	58	18.3	8.5	FSGS
2	M	42	75	22.2	2.3	HUS
3	M	53	42	14.9	27.7	Agenesis/dysplasia
4	M	52	86	24.9	1.8	APKD
5	M	59	67	23.2	4.7	IgA
6	M	41	69	21.5	4.7	MPGN
7	M	55	62	21.5	20.8	MPGN
8	M	39	67	20.8	18.8	SLE
9	M	54	97	26.5	4.9	Ciclosporin
10	M	56	88	26.3	17.8	APKD
11	F	45	65	22.8	24.1	FSGS
12	M	47	86	25.4	2.5	IgA
13	M	42	53	20.2	29.0	Reflux
14	M	39	80	19.5	14.4	MPGN
Mean		47.0	71.1	22.1	13.0	
SD		7.8	15.2	3.4	9.9	

BW, body weight ("dry weight"); BMI, body mass index; RRT, renal replacement therapy; FSGS, focal and segmental glomerulosclerosis; HUS, hemolytic uremic syndrome; APKD, adult polycystic kidney disease; IgA, immunoglobulin A nephropathy; MPGN, membrane-proliferative glomerulonephritis; SLE, systemic lupus erythromatodes; Ciclosporin, Ciclosporin toxicity after cardiac transplant.

a detailed diet record that patients completed during several days at home. The first diet record (5 days, including a weekend) was completed 1 month before commencement of NHHD training. During the first year of NHHD, three diet records (3 days, including 1 weekend day) were completed (at 3, 6, and 12 months after initiation of NHHD). Patients were asked to record their food intake for 1 more day when the actual intake pattern deviated from their normal habits (e.g., in the event of illness or a party). They also recorded their appetites in general, and more specifically for meat, bread, and warm meals, on a questionnaire with a 5-point scale.

Patients were instructed orally and in writing by the dietitian how to complete their diet records. To enable comparisons of data between patients, they were asked to measure and note the volume of the "cup," "mug," and "bowl" they used, because these volumes vary between patients and between measurements in patients. An envelope was provided along with the printed diet record, so that the record could be returned as soon as possible. One dietitian (M.E.S.) analyzed the records as soon as possible after receiving them. When the information in a record was unclear, the dietitian contacted the patient immediately so that the patient could try to recall actual food intake. Portion sizes not specified by a respondent were obtained from the Dutch portion sizes table.[12] If patients used special or ready-made products, they were asked to collect the food labels and recipes and send them to the dietitian. Diet records were coded by a dietician according to the Dutch Food Composition Table (NEVO Foundation[13]). Food-consumption data were entered into Microsoft Excel, and energy and nutrient intakes, as well as food-group use, were calculated using Microsoft Access and the Dutch Food Composition Table for 2001. Data from breakfast, lunch, and dinner, as well as snacks, were analyzed. Food groups were analyzed and compared with outcomes of the Dutch Nutrition Surveillance System of 1998.[14]

Patients were not informed of the results from their records during the study, because this could influence their behavior. Patients were instructed to follow a healthy diet without specific restrictions, and to pay attention to the laboratory results that were provided to them. The dietitian did not give further specific dietary advice, to prevent an unwanted influence on study outcomes. All patients received a multivitamin preparation, containing 6 mg thiamin, 5 mg riboflavin, 40 mg nicotinic acid, 5 mg pyridoxine, 5 mg folic acid, and 100 mg vitamin C. The contents of the multivitamin capsules were not used for vitamin-intake calculations, and the calcium-containing medication was not included in dietary calcium-intake values.

Laboratory Results

Levels of serum urea, calcium, phosphorus, albumin, potassium, C-reactive protein, and parathyroid hormone were determined using standard laboratory techniques. Single-pool Kt/V (spKt/V) and normalized Protein Catabolic Rate (nPCR) were calculated according to DOQI guidelines.

Statistical Analysis

For statistical analysis, SPSS 12.0 (SPSS Inc., Chicago, IL, USA) was used. Significant differences between treatment time points were evaluated by paired *t*-test, with a significance level of $P < .05$. Mean and standard errors (with ranges in parentheses) are presented.

Results

Patients

Twenty patients were included in the study. Six were lost to follow-up: 3 received a kidney transplant within 1 year, and 3 failed to complete their diet records. Therefore, the data of 14 patients were used for our 1-year analysis. For the characteristics of these patients, see Table 1.

Body Weight, Laboratory Results, and Medications

Table 2 provides an overview of body weight and laboratory results. Body weight and body mass index (BMI) increased significantly during the first year of NHHD. Single-pool Kt/V improved markedly ($P < .001$), whereas nPCR increased, but not to the point of reaching statistical significance ($P = .058$). However, in patients with nPCR <1 g/kg/day at baseline (8 of 14 patients), nPCR significantly increased after 1 year, from 0.8 to 1.6 g/kg/day ($P = .012$). Serum albumin significantly increased after 1 year ($P = .001$). C-reactive protein was unchanged after 1 year ($P = .239$), despite frequent dialysis treatments. Predialysis serum urea decreased dramatically ($P < .001$). Serum potassium, calcium, and phosphate concentrations remained unchanged despite a free diet, the complete cessation of phosphate binders and potassium-binding resins, and the addition of phosphate to the dialysate in many patients.

Appetite

Table 3 shows that up to 50% of patients had an increased appetite after 1 year of NHHD, whereas the scores of other patients remained unchanged. There was no difference in appetite for meat and other food products. Appetite tended to improve more in patients with a lower baseline nPCR.

Dietary Intake

Table 4 shows that energy intake tended to increase after 1 year of NHHD, but this increase did not reach statistical significance. Energy intake relative to body weight did not change. However, protein intake in grams per day, as well as in gram per kilogram of body weight per day, increased significantly. This increase was already obvious after 3 months of NHHD treatment. As percentages of energy intake, the protein and alcohol intakes increased, but carbohydrate intake decreased, and fat intake did not change. However, in absolute amounts, fat intake increased by

Table 2. Mean (± SE) Body Weight and Predialysis Laboratory Results at Baseline on CHD, and at 3, 6, and 12 Months of NHHD Treatment

	Baseline	3 Months	6 Months	12 Months	*P*-Value*
Body weight (kg)	71 ± 4	74 ± 4	74 ± 4	76 ± 5	.001
BMI	22 ± 1	23 ± 1	23 ± 1	24 ± 1	.001
spKt/V	3.2 ± 0.2	9.7 ± 0.7	9.6 ± 0.6	8.6 ± 0.7	.001
nPCR (g/kg)	1.1 ± 0.1	1.6 ± 0.1	1.6 ± 0.1	1.5 ± 0.1	.058
Urea (mmol/L)	29 ± 2	13 ± 1	13 ± 1	16 ± 1	.001
Creatinine (μmol/L)	1038 ± 55	541 ± 34	586 ± 51	633 ± 44	.001
Calcium (mmol/L)	2.5 ± 0.0	2.5 ± 0.1	2.5 ± 0.1	2.4 ± 0.1	.600
Phosphate (mmol/L)	1.6 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	1.5 ± 0.1	.505
Potassium (mmol/L)	5.5 ± 0.2	5.2 ± 0.2	4.9 ± 0.2	5.2 ± 0.2	.263
Albumin (g/L)	40 ± 1	43 ± 0	43 ± 1	42 ± 1	.001
CRP (mg/L)	12 ± 2	11 ± 2	12 ± 3	10 ± 1	.239
PTH (pmol/L)	36 ± 10	20 ± 7	22 ± 8	18 ± 5	.080

**P*-values: baseline versus 12 months of NHHD.

Table 3. Median Appetite Score (on a Scale From 1 to 5) at Baseline on CHD, and at 3, 6, and 12 Months of NHHD Treatment

	Base line	3 Months	6 Months	12 Months	Patients Improving (n)
Generally good appetite for warm meal	4	5	5	5	7/14
Generally good appetite for bread meal	4	5	5	5	6/14
Generally good appetite for meat in warm meal	4	5	5	5	6/14
Generally good appetite for meat on bread	4	5	5	5	5/14
I eat less than I should	2	1	1	1	4/14
I eat less meat than I should	1	1	1	1	1/14

roughly 13%. Water and other beverage intakes increased. Intakes of potassium, calcium, and phosphorus increased by 25% or more (not including medications). Intakes of milk and dairy products increased by 100%, from about 1 to 2 glasses per day, and intakes of red meat and fish increased by 47%. Combined intakes of potatoes, vegetables, and fruit increased by about 25%. During the same period, intakes of sweets and bakery products decreased by 35%.

Follow-Up After 1 year

In 9 patients, data were available after a full second year; 5-day diet records were kept at 18 and 24 months. During the second year, the adequate laboratory results remained constant. The main change was a significant increase in fat intake, from 35.5% ± 1.7% to 39.6% ± 1.7% of energy intake ($P = .027$). This change could be attributed to an 11% increase in fat intake (about 4 g), and a decrease in carbohydrate and protein intakes. The percent energy from saturated fat did not significantly increase. From baseline to 24 months, gram fat intake had increased by 21%. Compared with baseline, BMIs had increased further, to 17%. The intakes of potatoes, vegetables, and fruit decreased by 28% ($P = .017$), from about 350 g to about 250 g, half of this decrease was due to a decrease in fruit intake ($P = .016$). Therefore, patients tended to eat fewer healthy products.

Discussion

Appetite, nutrient and food-group intake, body weight, and biochemical values, despite less medication, improved in our patients after conversion from standard HD to NHHD. Both protein and mineral intakes (potassium, calcium, and phosphate) improved significantly within 3 months of treatment, due to a free diet without restrictions on fluids, fruit, vegetables, milk, and meat. Despite the free diet and cessation of phosphate-binder and resin use, metabolic control was excellent. In particular, patients with a pretreatment nPCR below 1.0 g/kg/body weight showed improvements in protein intake. In anabolic situations, nPCR underestimates the catabolic rate, and therefore protein intake may have been even higher than suggested by the change in nPCR. The free diet, and perhaps the more physiologic metabolic control, resulted in a better nutritional state.

One limitation of this study is its small number of patients, resulting in low power. However, despite the low power, many changes were statistically significant. Another limitation involves the selection of patients, because they had to be clinically stable and able to perform NHHD. On the other hand, the average patient has a long history of renal replacement and usually several comorbid conditions (mostly cardiovascular). In less healthy patients, however, the improvements may be even more pronounced, as indicated by the dramatic improvements in patients with a pretreatment nPCR of less than 1.0 g/kg/body weight.

Regarding a strength of this study, dietary data were obtained prospectively over a long period (at least 1 year), and all records included data from several days (3 to 5 days, including weekend days). These kinds of data were not previously reported for NHHD patients. For individual protein-intake data, the period of observation should be 7 days, and for individual energy data, the period of observation should be 5 days.[15] Based on previous experience, however, we decided that 3-to-5-day records would be a heavy burden on participants. This was illustrated by the fact that 3 patients failed to complete their records and had to be excluded from follow-up.

Improvements in appetite could have been influenced by less medication use, especially of phosphate-binders, potassium-binding resins, and sodium bicarbonate. In the average patient, this

Table 4. Mean (± SE) Intake of Energy, Nutrient, and Several Food Products at Baseline on CHD, and at 3, 6, and 12 Months of NHHD Treatment

	Baseline	3 Months	6 Months	12 Months	*P*-Value
Energy and Nutrient Intake					
Energy (kcal/day)	2083 ± 119	2305 ± 132	2282 ± 131	2213 ± 159	.220
Energy (kcal/kg)	31 ± 3	34 ± 3	33 ± 3	31 ± 3	.998
Protein (g/day) (energy percent)	74 ± 4 (14)	90 ± 6 (16)	93 ± 6 (17)	92 ± 6 (17)	.003 .001
Protein (g/kg)	1.1 ± 0.1	1.3 ± 0.1	1.3 ± 0.1	1.3 ± 0.1	.024
Protein, non animal (g/day)	31 ± 3	32 ± 3	31 ± 3	31 ± 3	.865
Fat (g/day) (energy percent)	79 ± 6 (34)	85 ± 6 (33)	90 ± 7 (35)	89 ± 9 (35)	.123 .413
Saturated fat (g/day) (energy percent)	32 ± 3 (14)	35 ± 2 (14)	35 ± 2 (14)	35 ± 3 (14)	.114 .224
Cholesterol (mg/day)	179 ± 20	223 ± 26	243 ± 24	231 ± 28	.092
Carbohydrate (g/day) (energy percent)	263 ± 17 (51)	287 ± 20 (50)	262 ± 18 (46)	249 ± 18 (45)	.318 .015
Dietary fiber (g/day) (g/MJ)	21 ± 2 (2.5)	22 ± 2 (2.3)	20 ± 2 (2.2)	22 ± 2 (2.5)	.500 .957
Alcohol (g/day) (energy percent)	3 ± 2 (1)	4 ± 2 (1)	8 ± 4 (2)	7 ± 4 (2)	.158 .195
Water (g/day)	1523 ± 111	1990 ± 160	2112 ± 199	2037 ± 142	.001
Potassium (mg/day)	2577 ± 159	3261 ± 217	3190 ± 293	3198 ± 176	.005
Calcium (mg/day)	848 ± 122	1220 ± 163	1093 ± 106	1082 ± 114	.010
Phosphor (mg/day)	1347 ± 82	1657 ± 113	1660 ± 109	1644 ± 120	.011
Food Product Intake*					
Beverages† (g/day)	900 ± 84	1147 ± 121	1310 ± 137	1204 ± 132	.017
Potatoes, fruit, and vegetables (g/day)	247 ± 28	312 ± 43	287 ± 41	314 ± 33	.080
Milk and dairy products (g/day)	159 ± 33	335 ± 51	305 ± 54	290 ± 59	.019
Cheese (g/day)	40 ± 9	46 ± 8	50 ± 8	41 ± 7	.923
Meat and meat products (g/day)	93 ± 14	110 ± 10	129 ± 17	124 ± 16	.065
Fish (g/day)	4 ± 3	10 ± 7	14 ± 7	19 ± 7	.031

*Food groups of the Dutch Food Composition Table are used. Potatoes, fruit, and vegetables are combined into one group.

†Alcoholic and nonalcoholic beverages.

resulted in 8 to 15 less pills per day, most of them taken with meals. Appetite appeared to improve more in patients with a lower nPCR at baseline.

The increase in protein intake resulted from increased intakes of milk, meat, and fish. Food groups with high protein content also provided an important source of phosphate, but serum phosphate concentrations remained acceptable. A restriction of milk was not needed. Milk intake was observed to change from 1 to 2 glasses, as is usual for this age group in The Netherlands.[14] Increased milk intake also results in increased calcium intake, but this was compensated for by the cessation of calcium-containing phosphate-binders. No change in serum calcium concentration over a 1-year period was evident.

Increased intakes of potatoes, vegetables, and fruit contributed to an increased potassium intake. However, higher potassium intake did not result in hyperkalemia. Intake data of fluids, dietary fiber, and vitamins also reflected higher intakes of these products. Most patients did not follow recommendations for a healthy diet with 200 g of vegetables and two portions of fruit per day. This is, unfortunately, in line with the general Dutch population.[14]

Sodium intake was not measured, because it is difficult to determine how much sodium is added and how much is lost during the preparation of meals. Many patients on CHD will feel that fluid restriction is the most difficult part of their diet (and perhaps of their lives as dialysis patients). Patients on NHHD could drink more (roughly 300 to 500 mL/day), and reported the disappearance of thirst. Patients were not hypertensive and could discontinue most antihypertensive medications, as described previously.[5]

The contribution of fat to energy did not change during the first year, whereas for animal-based protein, it increased. This finding is attributable to an increased consumption of milk, dairy products, meat, and fish. Intake from seeds and snacks also seemed to increase. We did not measure physical activity, but patients felt better and had more time to be physically active during the day, compared with patients receiving CHD. After 2 years, arm muscle areas (as determined by triceps skinfold and arm circumference) had improved significantly ($P = .05$; 9 patients, data not shown).

The intake of potatoes, fruit, and vegetables decreased in the second year, whereas the trend during the first year indicated an increase. Perhaps the novelty of being able to eat previously restricted foods wears off. Fat intake changed from below the national average (37 energy percent) to almost 40 energy percent by the end of the second year. Factors other than changes in dialysis modality are likely to play a role in food choices.

Can we prescribe NHHD patients the same normal, healthy diet that is recommended for the healthy population, as opposed to a restricted diet? Yes, dietary restrictions are not necessary, but the same advice regarding limited fat intake and a higher fruit and vegetable intake applies equally to NHHD patients and the general population.

Nocturnal home hemodialysis results in improved appetite and better nutritional status, with a potentially positive effect on morbidity and mortality, although this has not been proven in a randomized study. At the same time, dietitians must be aware of unhealthy "Western" eating habits, especially after the first year of NHHD.

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