Nightly Home Hemodialysis: Fifteen Months of Experience in Lynchburg, Virginia

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What constitutes adequate dialysis has been debated in the nephrology literature over the past eight years. The mortality rate of patients on dialysis in the United States is about 20% per year. We believed that short and infrequent dialysis sessions contributed to poor outcomes. To improve the results, Lynchburg Nephrology started the nightly home hemodialysis (NHHD) program in September 1997.

Ten patients were trained in the first 15 months of the program. Patients dialyzed 7 – 9 hours, 6 nights/week, using the Fresenius 2008H machine. A standard dialysis solution with 2.0 mEq/L potassium, calcium concentration of 3.0 – 3.5 mEq/L was used. Dialysis solution flow rates were 200 – 300 mL/min. Serum phosphate levels were maintained above 2.5 mg/dL by adding 0 – 45 mL Fleet's Phosphosoda to the bicarbonate bath.

Patients had marked improvement in quality of life as measured with the SF-36. Blood pressure was better controlled with fewer medications. All phosphate binders were eliminated. Caloric intake and protein intake increased to normal levels as measured by three-day dietary histories pre-NHHD, and at 3, 6, and 12 months on NHHD.

Epoetin alfa dosages were reduced by about 50%.

Nightly home hemodialysis should be considered as a valuable modality option for end-stage renal disease patients; it is potentially superior to conventional thrice-weekly hemodialysis.

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Key words

Nocturnal hemodialysis, anemia, phosphate control, blood pressure control, adequacy of dialysis, nutrition

Introduction

Lynchburg Nephrology started its nightly home hemodialysis (NHHD) program in September 1997, based on reports of Pierratos *et al.* [1,2], which presented excellent results of nocturnal hemodialysis in Toronto, and more than 60 articles supporting daily hemodialysis as a better option for patients with end-stage renal disease (ESRD) [3,4]. The literature reports that daily hemodialysis offers a higher quality of care for patients at an overall lower cost to the Medicare ESRD (end-stage renal disease) program [5]. In the United States, the mortality rate of 20% for ESRD patients exceeds that of patients with breast cancer or prostate cancer [6]. The Lynchburg Nephrology staff visited Pierratos in Toronto, Canada, to witness his program, and we interviewed 6 of their 13 NHHD patients. An interdisciplinary NHHD team was created, comprised of patients and their families, nurses, social workers, a dietitian, a machine maintenance technician, an information systems coordinator, the facility administrator, and physicians. After a 5-month setup time, the program was implemented.

Methods

Hospital data were collected from September 4, 1997 to December 5, 1998, and clinical data were collected from September 4, 1997 to December 31, 1998.

Ten patients have been trained. Data from the sixth patient are not included in this report, because he was only on NHHD for one day before receiving a pancreas/kidney transplant. The average age of our 9 patients was 45.4 years (range 36 – 69 years), average weight was 78 kg (range 50.5 – 147 kg), and average height was 168 cm (range 152 – 185 cm). Six patients were black, 3 were white; 4 were male and 5 female. Their educational levels included 2 with grade 11 education, 2 high school graduates, 3 with one to two years of post-high school training, and 2 with college degrees. Eight of the 9 patients had partners at home, but all 9 patients set up their machines, initiated dialysis, and were responsible for problems occurring during dialysis. The partners were supportive but not responsible for dialysis. The patients' demographics, medical histories, and previous dialysis therapies are outlined in Table I.

Patients dialyzed using the Fresenius 2008H machine (Fresenius Medical Care, Bad Homburg, Germany) 7 – 9 hours, 6 nights/week. Treatment parameters included a blood flow rate of 200 – 250 mL/min, a dialysis flow rate of 200 – 300 mL/min, a standard dialysis solution with 2.0 mEq/L potassium, 3.0 – 3.5 mEq/L calcium concentration, 35 mEq/L HCO_3, and 140 mEq/L sodium. The initial heparin bolus was 0 – 3000 U, with an infusion rate of 500 – 1000 U/hour. Patients added 0 –45 mL of Fleet's Phosphosoda (C.B. Fleet Co. Inc., Lynchburg, VA, U.S.A.) to 5.9 L of sodium bicarbonate concentrate, depending on their serum phosphate levels. The final phosphorus concentration in the dialysis bath was 0 – 3.0 mg/dL, depending on the amount of Fleet's Phosphosoda

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TABLE I Demographics, medical history, and previous therapy

Pt No.	*Date of birth*	*Race*	*Gender*	*Renal disease*	*Complications*	*Prior treatment modalities*	*NHHD training*	*First NHHD treatment*
1	03/04/43	White	Female	CGN	Hypertension Recurrent GI bleeding secondary to gastritis S/P parathyroidectomy	PD 10/89–11/93 Transplant 11/93–3/94 PD 4/94–8/96 Center HD 8/96–9/97	9/05/97–10/4/97	10/05/97
2	08/09/57	Black	Female	FSGN	Hypertension S/P parathyroidectomy	PD 12/88–10/89 Center HD 10/89–9/90 Transplant 9/90–9/92 Center HD 9/92–10/97	10/16/97–11/22/97	11/23/97
3	10/10/56	Black	Male	MGN	Hypertension Polyclonal lymphoma assoc with transplant Supraventricular tachycardia requiring ablation of aberrant pathway	Center HD 9/91–10/91 PD 10/91–12/92 Transplant 12/92–3/93 PD 3/93–1/98	1/5/98–2/6/98	02/08/98
4	09/18/65	White	Female	FSGN	Hypertension Tophaceous gout	HD 9/83–10/85 Transplant 10/85–11/97 Center HD 11/97–2/98	2/9/98–3/13/98	03/16/98
5	02/26/29	Black	Male	Nephrosclerosis	Hypertension Coronary artery disease; S/P CABG CHF secondary to fluid overload	Center HD 6/97–3/98	3/16/98–4/24/98	04/26/98
6	11/02/56	White	Male	Type I DM	Hypertension	No previous dialysis or transplant	5/4/98–6/25/98	06/27/98
7	10/17/51	Black	Female	CGN	Hypertension	PD 1/97–6/98	6/29/98–8/8/98	08/09/98
8	05/03/52	Black	Male	Type II DM	Ischemic cardiomyopathy; S/P MI Sleep apneic syndrome Morbid obesity Diabetic retinopathy Severe degenerative arthritis	Center HD 8/94–8/98	8/19/98–9/28/98	09/29/98[a]
9	11/14/98	White	Male	Type II DM	Coronary artery disease; S/P CABG Peripheral vascular disease Bilateral BKA Severe peripheral neuropathy Diabetic retinopathy	HD 10/96–10/98	10/5/98–11/16/98	11/17/98
10	05/06/72	Black	Female	SLE	Hypertension Right AKA secondary to vasculitis Bilateral avascular necrosis of hip	HD 4/96–11/98	11/16/98–12/18/98	12/21/98

NHHD = nightly home hemodialysis; CGN = chronic glomerulonephritis; S/P = status post; PD = peritoneal dialysis; HD = hemodialysis; FSGN = focal segmental glomerulonephritis; MGN = membranous glomerulonephritis; CABG = coronary artery bypass graft CHF = congestive heart failure; DM = diabetes mellitus; MI = myocardial infarction; BKA = below knee amputation; SLE = systemic lupus erythematosus; AKA = above knee amputation.

[a] Last NHHD treatment 11/20/98 2º poor vision.

added. All patients used Fresenius F60 reusable dialyzers. Blood access was obtained using the Bard dual lumen dialysis catheter (Bard Access Systems, Salt Lake City, UT, U.S.A.) or an Ash split dialysis catheter (MEDCOMP, Harleysville, PA, U.S.A.) in the right internal jugular vein, tunneled over the right clavicle. The InterLink device (Becton Dickinson, Franklin Lakes, NJ, U.S.A.) was used to prevent infection and air emboli [7]. Accidental disconnections were prevented by a locking box device as described by Pierratos [7].

All patients reused dialyzers. At the end of treatment, once the patient was disconnected, the patient infused the remaining heparin into the dialyzer, recirculated the saline and heparin at a blood flow rate of 500 mL/min for 10 min, then capped the dialyzer off and placed the dialyzer in a refrigerator designated for reuse. At the end of the week, the patient brought six dialyzers to the center where they were processed using the standard Renalin I (Minntech Corp., Minneapolis, MN, U.S.A.) machine. The patient picked up six additional dialyzers for use the following week, transporting them in a cooler. The average reuse was 11.2 times (range 7 – 14). The water source was city water (4 patients), county water (2 patients), and well water (3 patients). Patients used either a single reverse osmosis system (5 patients) or a deionizer system (4 patients). Reverse osmosis systems required approximately 200 – 240 gallons of water/night, and the deionizer system required approximately 34 gallons/night.

A single hospital system performs more than 95% of outpatient x rays, emergency room visits, other diagnostic work-ups, and in-patient care for the NHHD patients. The patients' hospital days were tracked from December 5, 1998, in a retrospective analysis comparing each patient's time on NHHD to the same time pre-NHHD. Pre-NHHD data were collected for each patient at 6 and 3 months prior to starting training. Data were also collected at 3, 6, 9, and 12 months after the initiation of NHHD.

Results

Adequacy

All 9 patients have had a two- to threefold increase of weekly Kt/V as measured by the formula of Basile and Francesco [8] (2.3 × urea reduction ratio – 0.284) (Fig. 1). Pre-blood urea nitrogen samples were obtained by the patient at the initiation of dialysis, and post-blood urea nitrogen samples were obtained after completion of dialysis.

Nutrition parameters

Patients' albumin levels have been maintained within normal limits, and weights have remained steady in 8 of 9 patients. Three-day food records pre-NHHD and after 3, 6, and 12 months on NHHD indicate improved caloric and protein intakes. Additional vitamin needs have been met by increasing vitamin supplementation to two tablets per day as needed. Vitamin B_{12} and folate levels are measured every 3 months.

Phosphate control

Patients did not require phosphate binders (Fig. 2). Seven of 9 patients required Phosphosoda supplementation to their bicarbonate baths each night to maintain normal phosphate levels. Increased dietary phosphorus was encouraged.

Anemia

Hematocrits were maintained in the 30% – 36% range while on NHHD. Epoetin alfa (EPO) dosages decreased markedly in most of the 9 patients on NHHD (Table II). The total dose of EPO given for a month was measured at pre-6 month, pre-3 month, and at 3, 6, 9, and 12 months on NHHD.

Blood pressure control

Blood pressure improved in 8 of 9 patients without changes in dry weight. The number of medications needed to control blood pressure was reduced in 4 patients. Only one patient required an increase in blood pressure medication (Table III).

Blood access

As of December 31, 1998, there had been 1929 patient days on NHHD. Patients had performed 1650 dialysis treatments at home. These 9 patients required 17 catheters (14 Bard and 3 Ash split), all placed by the same radiologist. Some of the patients had catheters for hemodialysis access prior to starting NHHD. There was a total of 2792 catheter days for the 9 patients. There were two episodes of septicemia (defined as positive blood

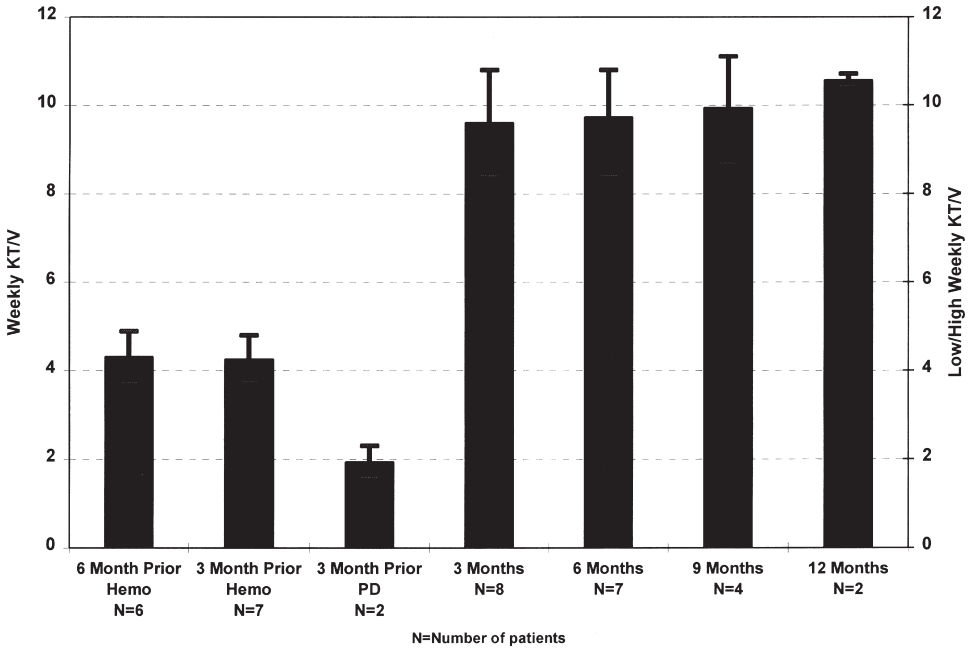

FIGURE 1 Average Kt/V per week.

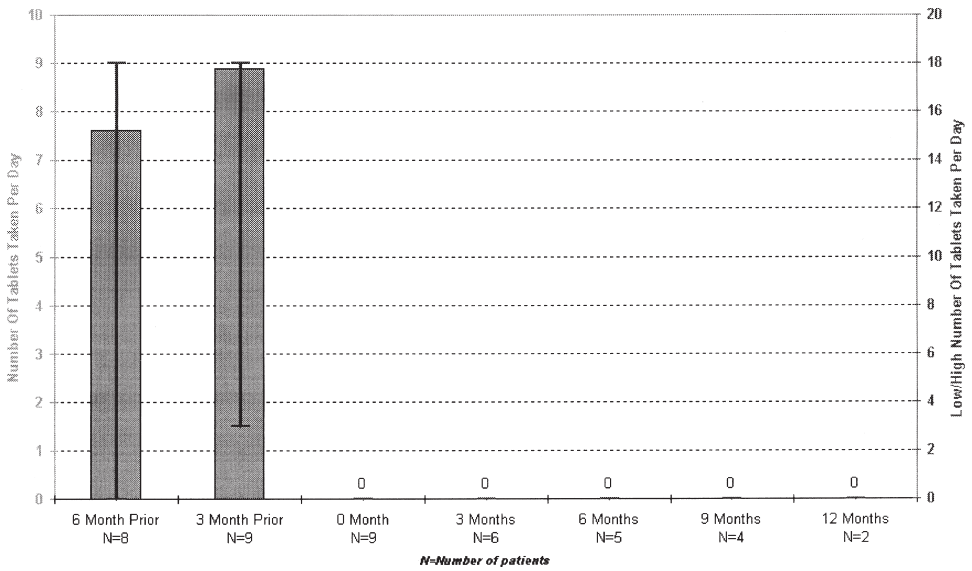

FIGURE 2 Phosphate binder usage.

TABLE II Erythropoietin dose per patient per month

Patient	*Pre 6 mo.*	*Pre 3 mo.*	*3 mo.*	*6 mo.*	*9 mo.*	*12 mo.*
1	30 000	36 000	12 000	9 000	10 000	8 000
2	42 000	24 000	24 000	36 000	20 000	48 000
3	32 000	24 000	24 000	20 000	16 000	
4	—	36 000	17 000	12 000	10 000	
5	39 000	24 000	9 000	12 000	4 000	
7	32 000	16 000	24 000			
8	24 000	26 000				
9	16 000	12 000				
10	64 000	75 000				

TABLE III Number of blood pressure medications per patient per month

Patient	*Pre 6 mo.*	*Pre 3 mo.*	*3 mo.*	*6 mo.*	*9 mo.*	*12 mo.*
1	4	4	0	0	0	0
2	0	0	0	0	0	0
3	3	4	2	2	1	
4	—	2	1	1	0	
5	3	3	2	3	4	
7	3	2	0			
8	0	0				
9	0	0				
10	2	2				

cultures) associated with catheters, thus a catheter infection rate of 0.72/1000 total catheter days and a catheter infection rate of 1.03/1000 NHHD catheter days. There were two episodes of exit-site infections (defined as positive culture with evidence of inflammation); thus the exit-site infection rate was 0.72/1000 total catheter days and 1.03/1000 NHHD catheter days.

Hospital days

There were 53.4 patient-months prior to training for NHHD, 11.3 patient-months during training for NHHD, and 59.1 patient-months on NHHD. The data show a dramatic reduction of hospital days while on NHHD. Pre-NHHD hospital rates were 0.65 hospital days/patient-month as compared to 0.08 hospital days/patient-month while on NHHD.

Quality of life

All 9 patients have reported marked improvement in overall feeling of well-being. Seven of eight parameters of the SF-36 [9] have been scored on 8 of the patients prior to NHHD and 5 patients at 3 and 6 months on NHHD (Fig. 3). For these 5 patients there is improvement in their SF-36 scores, supporting the patients' and their families' reports of their sense of hope and improved well-being.

Discussion

Kjellstrand has reviewed the literature on daily hemodialysis for the past 30 years [10,11]. This review supports the position that more frequent dialysis is a better modality in providing ESRD care. Buoncristiani *et al.* and Ting *et al.* have documented how short daily hemodialysis improves patient care [3,4,12–18]. Pierratos *et al.* and Uldall *et al.* have documented the improvement in patient care using slow overnight dialysis [1,2,7,19,20].

Lynchburg Nephrology has 15 months of experience with NHHD. The data support a two to three times higher weekly Kt/V and increased caloric and protein intake with normal serum albumin levels. The patients have normal phosphorous levels with elimination of phosphate binders. Blood pressure

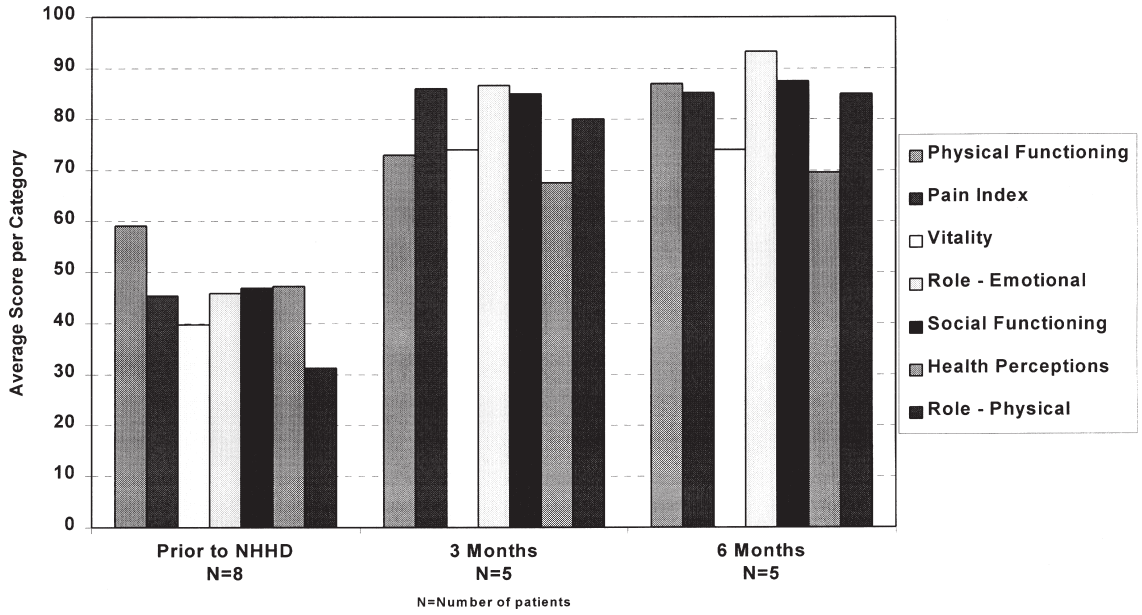

FIGURE 3 SF-36 scores.

control is improved with reduction in the number of medications required. Hematocrits are maintained with a reduction of EPO requirements if iron stores are maintained. Hospital days per patient-month are reduced from 0.65 hospital days/patient-month pre-NHHD to 0.08 hospital days/patient-month while on NHHD.

The most important observations and data obtained from the patients are the improvements in their quality of life. Patients' setup time on NHHD is 30 – 45 min/night, and their time coming off dialysis in the morning is 15 – 20 min. The remainder of the time spent on dialysis is "downtime" (sleeping at night). This means they are receiving a higher quality of dialysis at a "cost" in time of only 7 – 8 hours/week. All the patients report feeling significantly better since starting NHHD, compared with how they felt on peritoneal or in-center hemodialysis. They report having more energy, being more involved with their families and with activities. They are excited about their newly liberated diet and fluid intake. Their families share their increased excitement with all aspects of life due to the patient's enhanced sense of well-being.

Conclusions

Nearly 230 000 Americans suffer from ESRD, and each year that number grows by approximately 8%. The mortality rate of ESRD patients is very high, approximately 20% per year. Nightly home hemodialysis results in a higher quality of life. Patients like this new modality: it does not interfere with sleep, and it provides two to three times the amount of dialysis recommended in the DOQI (Dialysis Outcomes Quality Initiative) guidelines. Nightly home hemodialysis provides a smoother, slower ultrafiltration, improves blood pressure control with fewer medications, maintains hematocrits with less EPO, and controls phosphate without phosphate binders; NHHD also reduces the number of days of hospitalization for ESRD patients. This treatment should be considered as a new, valuable modality option to improve outcomes for ESRD patients.

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