
A Brief History of Daily Hemodialysis

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Daily hemodialysis has been in uninterrupted practice since its introduction in California in 1967. Early trials were stopped for technical, logistical, and economical problems, but a rapidly increasing number of centers now perform it on close to 200 patients, either as long nightly or short daytime hemodialysis.

Increasing the frequency of dialysis appears much more important in improving patient well-being than increasing the Kt/V dose, and patients quickly experience much more vigor, energy, and improved quality of life when starting daily hemodialysis. Blood pressure improves, and medications can often be discontinued. Similarly, the need for erythropoietin decreases, and nutrition and dry body mass increase.

While the cost of dialysis increases, the total cost for a patient decreases as medications and hospitalizations decrease. Technical innovation will solve the logistical problems by letting a machine do the labor necessary to begin and end a dialysis session. Access problems have decreased for native fistula, and the other access types have not been studied enough.

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Key words

History of hemodialysis, daily hemodialysis, home hemodialysis

Introduction

When hemodialysis for chronic renal failure was made possible through the invention of the Quinton–Scribner shunt in 1960, an exciting new era for dialysis began. The early pioneers of chronic hemodialysis went into completely uncharted territory. The initial use of chronic dialysis was to apply it to patients only when problems such as severe fluid overload, hyperkalemia, or severe acidosis occurred. Other indications were nausea and vomiting or lethargy from uremia. It became clear that this was unsatisfactory, and regular “prophylactic” dialysis was instituted. It was soon realized that dialyzing once a week was insufficient; therefore, dialysis twice a week was instituted. The majority of patients also did badly on this frequency, and for that reason three times per week hemodialysis was introduced and has remained the standard frequency of dialysis. At each of these incremental

steps of dialysis frequency, marked clinical improvement was observed. It is puzzling that a large-scale systematic continuation to more treatments per week has not been universally pursued since three times per week hemodialysis was introduced. Perhaps the reason is that the increase in the number of patients in need of chronic dialysis has kept most dialysis units working at capacity and focusing attention on quantitative rather than qualitative aspects of chronic hemodialysis.

However, within a decade of the birth of chronic hemodialysis, an attempt at daily dialysis was made in Los Angeles (1). In this discussion, daily dialysis is defined as five or more dialysis treatments per week, and regular dialysis is two or three dialysis treatments per week.

The history of daily hemodialysis is depicted in Figure 1. In 1967, the first systematic effort at daily dialysis was initiated in Los Angeles (1). Seven patients doing very badly on three times per week dialysis were started on a program of five dialysis treatments per week. The indications were shunt malfunction and clotting, thought to be due to hypotensive episodes during and between regular dialysis, many symptoms on dialysis, and severe anemia and hypertension. Marked improvements were noted. The clinical problems that led to the start of daily dialysis disappeared. Hematocrit, albumin, and dry body weight increased, and hypertension became manageable. After three years, however, the program was abandoned for several reasons. The increased cost was one factor, but more importantly, the technology for daily dialysis was not developed. There were frequent machine breakdowns and malfunctions that ultimately exhausted the patience of both the staff and the patients (J. DePalma, personal communication, 1998).

The second trailblazing program was in Bologna, Italy (2). In 1972, a two-year research program was initiated in which 6 patients were started on daily dialysis for severe medical problems. The patients experienced great clinical improvement. The hematocrit increased by 43% from 16% to 23%, and transfusion requirements decreased by 90%, from 1.6 to 0.13 transfusions per month per patient. Hypertension became much easier to control, and nutrition and clinical symptoms were much improved. The program was concluded as preplanned after two years (V. Bonomini, personal communication, 1998).

The third daily dialysis effort was at Maimonides Hospital in Brooklyn, New York (3). In 1975, 6 patients, ultimately 11, were started on daily hemodialysis. Many beneficial changes were noted in the patients: the quality of life, measured by different scales, showed increase, and patients previously

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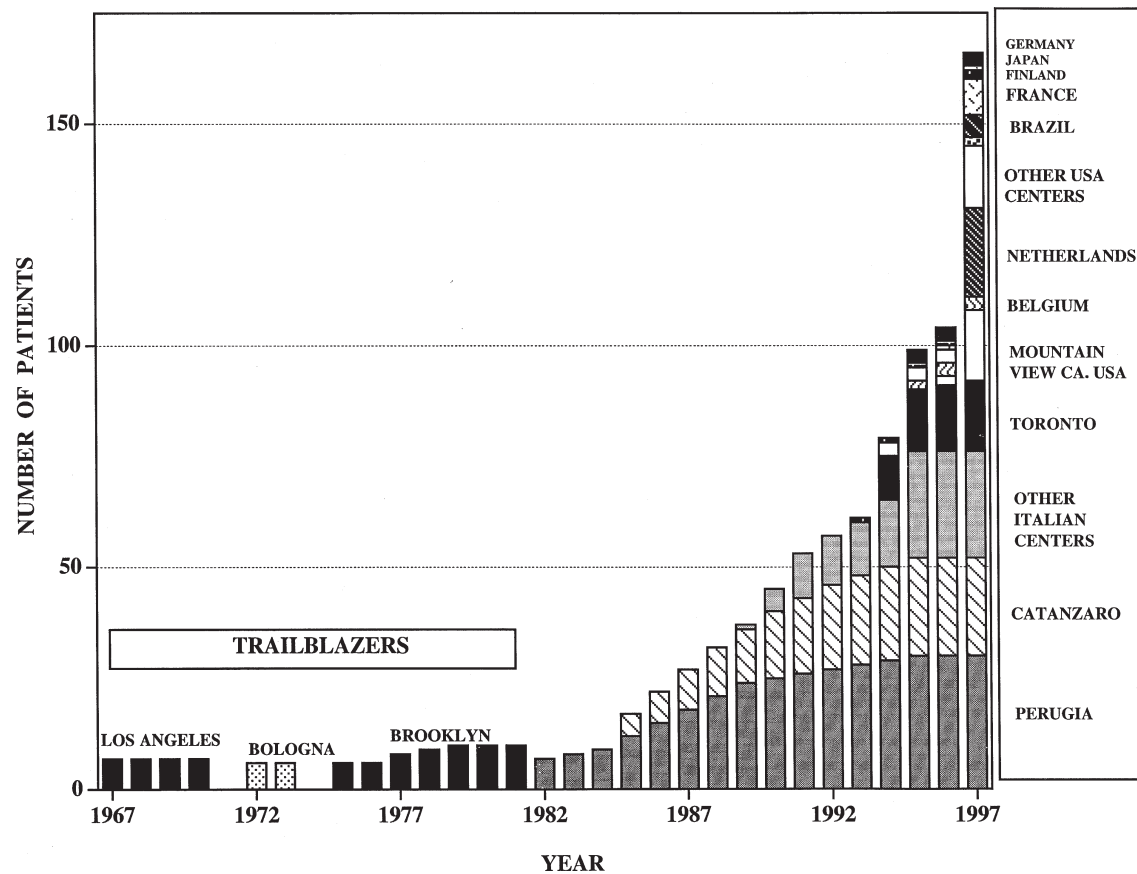


FIGURE 1 Centers and numbers of patients on daily hemodialysis since its first use in 1967. The three pioneer centers in Los Angeles, Brooklyn, and Bologna discontinued their programs after several years for a mix of technical, logistical, and economic problems. The largest programs still functioning are in Perugia and Catanzaro, Italy. The present, fastest-growing programs are in the Netherlands and California. Programs in North and South America and Europe now treat over 150 patients with daily hemodialysis. The figures from 1982 are cumulative.

on welfare and unable to work returned to work. This was the first time the observation was made that daily hemodialysis was, paradoxically, socially less intrusive than regular three times per week hemodialysis. In daily dialysis, patients can spend a very brief time, either before or after work, in the dialysis clinic, which leaves the day free for work or normal social activities. Almost uniformly, the dialysis hangover and fatigue that make patients exhausted and unable to function also disappear with daily hemodialysis; the patient can leave dialysis immediately and go to work. Other observations by the Brooklyn group were that the clinical symptoms such as nausea, vomiting, and pericarditis disappeared. Another observation, curious at first, was that fistula function was better maintained in these patients. Speculation why this occurred includes the absence of hypotensive episodes and perhaps improvement in immune defence. After approximately 10 years the Brooklyn program was abandoned. The research team that originally started the program scattered, and the U.S. reimbursement system made it economically difficult, since this reimbursement is based on treatment three times per week (B. Louis, personal communication, 1998).

Unanimously, the trailblazers noted marked improvements in their patients. Still programs could not be maintained for a mixture of economic and logistical problems, because the technology to successfully perform daily dialysis was not there. Travel time, buildup, preparation, and cleanup time, which necessarily double with daily dialysis, proved the ultimate obstacles. By the 1980s, several of these problems had at least been improved with easily disposable dialysis filters, and reasonably quick setup and teardown procedures. Hemodialysis machinery had also become more reliable, but perhaps technically more difficult to run. With these changes, a second era in daily hemodialysis was ready to begin.

A comparison of daily hemodialysis to more dialysis time, Kt/V

One question that needed an answer was whether daily hemodialysis was better because it is more dialysis. The early three pioneer groups had addressed that question, although not in a planned or controlled fashion. In all three programs the patients received less dialysis on daily hemodialysis than

patients on regular dialysis. In the Los Angeles program, dialysis time per week was decreased from 24–30 hours to 20–25 hours, with a resulting increase in predialysis creatinine levels. In the Brooklyn program, the dialysis time per week was decreased from 15 to 7.5–10 hours, and in the Bologna program, from 30 to 15–20 hours. Thus, in spite of a decrease in overall dialysis time and thereby Kt/V (since a compensating increase in clearance was not done), patients improved considerably. These findings strongly indicated that doubling of hemodialysis frequency more than compensated for a marked decrease in weekly Kt/V.

The only systematic study of the relative influence of dialysis frequency and dialysis time on patient welfare was done by Twardowski in 1974 (4). Fourteen patients participated in a clinical experiment. In 6 patients the dialysis time and thus Kt/V increased 17.5%. In the other group of 8 patients the patients' weekly frequency of dialysis was increased from 2–3 or 3–4, but weekly dialysis time was held constant. The mean follow-up time was approximately 6 months. Both groups showed improvement in many parameters, but the improvement was almost always greater in the patients who were treated with an increased frequency of dialysis. Thus in the increased frequency group the hematocrit increased 4% compared to 1% in the increased duration group. Corresponding values for the albumin were 0.45 g/dL versus 0.3 g/dL. The improvement in systolic (a decrease of 14 mm Hg) and diastolic (a decrease of 7 mm Hg) blood pressure was similar in the two groups of patients. This experiment proves that frequency is more important than Kt/V for dialysis patients' welfare. This observation is further supported by the fact that continuous ambulatory peritoneal dialysis patients do very well, in spite of low Kt/V values.

The establishment of daily hemodialysis

The first continuous and longest operating daily hemodialysis was in Perugia, Italy. Since 1982, over 30 patients have been started there on chronic daily hemodialysis, and the patients who have been treated the longest have been on daily hemodialysis for over 15 years. Several observations reported in several publications have emanated from this program (5–8). These observations include improvements in hematological parameters, blood pressure control, body fluids, nutrition, quality of life, and myocardial function and morphology. In the beginning, very low Kt/Vs, less than 2 per week, were used. In spite of this, clinical improvement occurred in the patients. Lately, higher Kt/Vs have been used on the patients. The second longest operating program was started in 1985 in Catanzaro. Over 20 patients have begun daily hemodialysis there, with observations of improvements similar to those by others. This group has also studied several hormones, almost all of which show more normal values during daily than regular hemodialysis. One young woman has been pregnant three times on daily dialysis (9). Other Italian centers have participated but settled on 3.5–4 dialyses per week, and report improved survival rates, albeit in younger and selected patients (10).

A novel approach: long nightly dialysis

Almost all the early efforts for daily hemodialysis used a reduced time for each dialysis resulting in essentially constant or even lower total weekly dialysis time than when the patients were treated with regular hemodialysis. In 1994, a novel approach was taken in Toronto, Canada. Patients were put on long, nightly dialysis (11). Thus dialysis was made even less socially intrusive, since sleep time was utilized. This allowed much higher Kt/Vs than had been previously used, but also introduced special problems with blood access. Clearly, to be asleep with two needles in an arm is difficult; therefore, a special central venous catheter, developed in Toronto, was utilized.

Marked clinical improvements are observed in the patients, but also some new metabolic problems. Rather than extradialysis phosphate removal, as is common with most patients on hemodialysis, phosphate actually has to be added to most patients' dialysate (12). Obviously, the central venous catheter, used for a long time, creates concerns with infection. Anecdotal evidence suggests that there is no increase in such problems, although other centers have noticed such problems. The relative merits of daily brief or nightly long dialysis, or which patient group benefits most from which approach, are unknown; this area requires clinical research and comparisons.

The present era

Several groups in Canada, Italy, Belgium, the Netherlands, France, Finland, Germany, Brazil, and at least five centers in the United States now practice daily hemodialysis, most of them utilizing the short daily approach (13). There is uniform agreement about the improvement on hematological parameters, blood pressure, and nutrition. The many dangerous and annoying symptoms during and between dialyses show a marked decline, while quality of life, physical strength, and social life improve. The influence of daily dialysis on amyloid, bone disease, and neuropathy has not been elucidated. While many observations are anecdotal, uncontrolled, and cover different time periods, the strength of the clinical research must be appreciated. Almost all studies are performed as cross-over studies, where patients are their own control, and the uniformity in many observations gives credence to the statement that daily hemodialysis is, without a shadow of a doubt, the best hemodialysis.

Much research remains to be done with this fascinating hemodialysis method. Which patient group benefits from which approach? Which access can be used and which cannot? How much dialysis is the best for individual patients? Daily dialysis, by allowing a doubling of Kt/V, may, for the first time, create severe dialysis depletion syndromes.

References

- 1 DePalma JR, Pecker EA, Maxwell MH. A new automatic coil dialyzer system for daily dialysis. *Proc Eur Dial Transplant Assoc* 1969; 6:26–34.
- 2 Bonomini V, Mioli V, Albertazzi A, Scolari P. Daily-dialysis

- programme: Indications and results. Proc Eur Dial Transplant Assoc 1972; 9:44–52.
- 3 Manhor NL, Louis BM, Gorfien P, Lipner HI. Success of frequent short hemodialysis. Trans Am Soc Artif Intern Organs 1981; 27:604–9.
 - 4 Twardowski Z. Effect of long-term increases in the frequency and/or prolongation of dialysis duration on certain clinical manifestations and results of laboratory investigations in patients with chronic renal failure. Acta Med Pol 1975; 16:236–49.
 - 5 Buoncrisiani U, Quintaliani G, Cozzari M, Giombini L, Ragaiolo M. Daily dialysis: Long-term clinical metabolic results. Kidney Int 1988; 33(Suppl):S137–40.
 - 6 Buoncrisiani U, Fagugli RM, Pinciaroli MR, Kulurianu H, Ceravolo G, Bova C. Reversal of left ventricular hypertrophy in uremic patients in treatment with daily hemodialysis. Contrib Nephrol 1996; 119:152–6.
 - 7 Buoncrisiani U, Fagugli R, Kulurianu H. Daily hemodialysis: An optimal treatment for uremic cardiovascularopathy. Sixth European Meeting on Cardioneurology. Editorial Bios 1997; 193–8.
 - 8 Buoncrisiani U, Cairo G, Giombini L, Quintaliani G, Bonforte G. Dramatic improvement of clinical-metabolic parameters and quality of life with daily dialysis. Int J Artif Organs 1989; 12:133–6.
 - 9 Pinciaroli AR. Results of daily home hemodialysis in Catanzaro: 12-year experience with 22 patients treated for more than one year. Home Hemodial Int 1998; 2:12–17.
 - 10 Mastrangelo F, Alfonso, L, Napoli M, Massari F, Russo F, DeBlasi V. Increased frequency of HD sessions reduces the mortality in HD. Perit Dial Int 1998; 18(Suppl 1):S78.
 - 11 Uldall R, Francoeur R, Ouwendyk M, *et al.* Simplified nocturnal hemodialysis: A new approach to renal replacement therapy. J Am Soc Nephrol 1994; 5:80P.
 - 12 Pierratos A, Ouwendyk M, Francoeur R, *et al.* Nocturnal hemodialysis: Three-year experience. J Am Soc Nephrol 1998; 9:859–68.
 - 13 Kjellstrand C, Ing T. Daily hemodialysis—History and revival of a superior dialysis method and literature review. ASAIO J 1998; 44:117–22.