

# The History of Home Hemodialysis and its Possible Revival

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## Introduction

Home hemodialysis (HHD) is an underused dialysis modality, even though it provides an efficient and probably cost-effective way to provide more frequent or longer dialysis. With the advent of newer HHD systems that are easier for patients to learn, use, and maintain, patient and provider interest in HHD is increasing. There are three types of hemodialysis that can be performed at home [1-6]. They are:

- Conventional home hemodialysis. This is done three times a week for three to four hours or longer each time. Training may take from several weeks to a few months.
- Short daily home hemodialysis. This is usually done five to seven times a week using machines designed for short daily home treatment. Treatments usually last about two hours each. Patients and care partner are trained over 2–3 weeks. Because dialysis is done more often, less fluid generally needs to be removed each time. This reduces symptoms like headaches, nausea, cramping and feeling “washed out” after treatment.
- Nocturnal home hemodialysis. Long, slow treatments done at night while patient sleeps. Patient may do this kind of dialysis six nights a week or every other night. This depends on doctor’s prescription. Treatments usually last about six to eight hours. Patient and care partner are trained over several weeks.

## The Beginning of Home Hemodialysis and Its Development

The history of HHD began in the ‘60s, and the place of origin is still debated. The first mention in literature comes from the heart surgeon Charles Kirby in 1961, as a future perspective to be investigated [1,2]. Other claims came from Professor Y. Nose of Okkaido, in 1963, who experienced the HHD using a filter set in a domestic washing machine, describing the treatment outside the Hospital (Figure 1) [3]. The first projects were documented in 1964 by John Merrill’s group in Boston and Belding Scribner’s in Seattle. They started to think of dialysis programs outside the hospitals for all those high

risk patients not included in hospital programs [4,5]. Scribner’s group, in collaboration with the Group of Professor Babb of nuclear engineering at the University of Washington, developed a HHD machine for a 15-year-old girl, daughter of an assistant of professor Babb, suffering from Systemic Lupus Erythematosus (SLE). The girl was not eligible for the treatment in hospital, and her mother was trained as a care giver in the HHD treatment. Such treatment allowed the girl to attend studies for four years, until her death from complications of SLE (Figure 2) [6]. In the meantime, the development of home hemodialysis in London and Europe is undertaken by Stanley Shaldon, beginning the home night treatment for 6-8 hours, three times a week [7,8].

Figure 1 Professor Y. Nose of Okkaido, in 1963, experienced the HHD using a filter set in a domestic washing machine

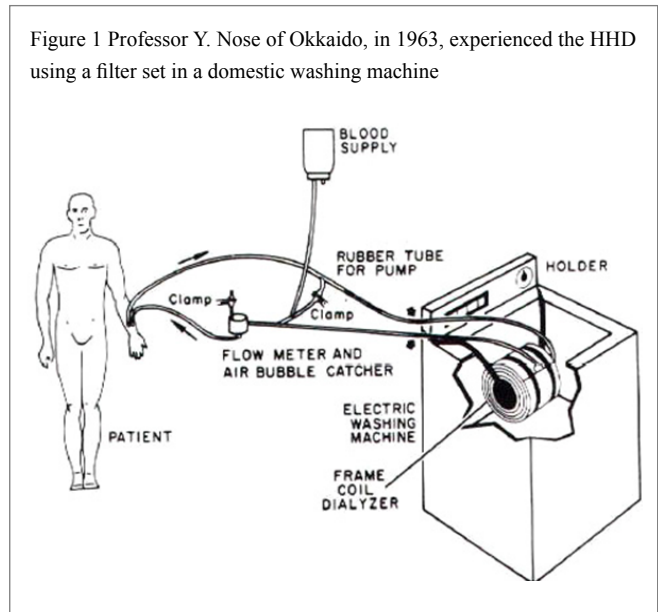
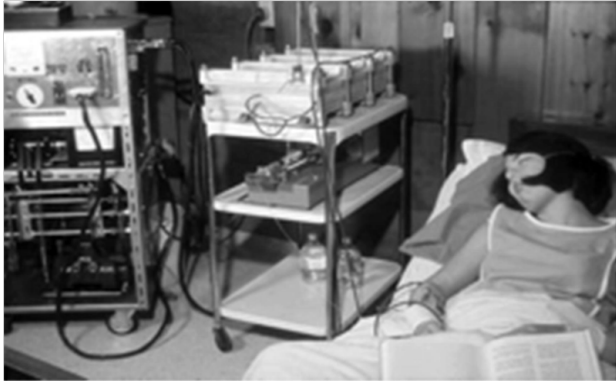


Figure 2 The Group of Professor Babb of nuclear engineering at the University of Washington, developed a HHD machine for a 15-year-old girl, daughter of an assistant of professor Babb, suffering from Systemic Lupus Erythematosus (SLE)



Clinical, psychological, economic and logistical advantages of home treatment were achieved during these years. In fact, the HHD encourages independence of the patient, strengthens social relationships, promotes more freedom, reduces the transport time to the hospital three times a week, reduces the risk of infection, and is cheaper than the traditional dialysis [9]. The disadvantages include the huge volume of the HHD equipment and materials, a caregiver, specific hydraulic and electrical settings with a high water and electricity consumption, and a great family effort [10,11].

These difficulties faced by the family, especially the psychological pressure on the partners and the necessity of structural changes of the location are the main causes of HHD decline [12].

In the '70s, the demographic ageing of the population, suffering from comorbidities like diabetes, and the beginning of peritoneal dialysis and renal transplant programs reduce dramatically the number of patients eligible for HHD treatment [13]. In addition, a wide dissemination of new dialysis Centers draws increasingly hospital hemodialysis, eliminating the HHD necessity [14].

In the mid '90s, the interest in the HHD increases thanks to studies showing the best survival, better quality of life and rehabilitation of patients. The necessity of a easier HHD machine for home treatment, shortens training times for both the patient and the partner, and reduced preparation and machine disinfecting times are the new goals to be achieved [15,16].

Already in 1988 Umberto Buoncristiani started using a short daily and frequent HD, bringing better acid-base balance control, with reduction of uremia symptoms, such as thirst, anorexia, insomnia, itching, fatigue, better intra-and interdialytic pressure control, an improvement of peripheral neuropathy, an increase in muscle strength, increased hemoglobin values, in addition to a subjective improvement and overall welfare [17,18].

Between the '90s and the new millennium, the history of HHD is, therefore, linked to the development of more frequent dialysis with higher survival than the three times a week dialysis, thanks to a better blood pressure control, a reduction of left ventricular hypertrophy, a better control of fluid overload, a reduction of vascular calcification and a small use of erythropoietin [19-21].

Frequent dialysis treatments show a greater removal of inorganic phosphate, because intracellular ion purification is more sensitive to frequency rather than to dialysis length. In addition, such removal is associated with a reduced demand for phosphate binders [22-26].

Such a treatment shows a reduction of inflammatory markers in the patients, with less resistance to the action of erythropoietin and an increase of hemoglobin values [27,28].

## Epidemiology

In the last decade, Australia and New Zealand have highly developed HDD, especially for a 10% of patients affected with chronic hemodialysis; the main reason lies in the territorial vastness, with hospitals located mostly along the coast, with severe discomfort for patients of central regions. Globally only 0.4% of patients in HD is treated with HHD and 57% are located in the US, Australia and France.

Mark S. MacGregor shows how starting a home dialysis program can quickly lead to the expansion of treatment; an example in this regard is represented by Finland, a country which until 1997 had no patients using the HHD, and just few years later has become the fourth Nation worldwide [29-31].

## Advantages and Drawbacks

In literature, the landmark study that confirmed both the clinical benefits and the improvement of the "short home daily hemodialysis" life quality is the "FREEDOM Study" [32,33]. This study, along with other clinical trials, shows the benefits of this treatment in terms of small and medium-sized molecules depuration, life quality and survival time [34-36]; frequent and short dialysis show a reduction of cardiovascular risks, a blood pressure improvement, a reduction of left ventricular hypertrophy due to reduced interdialytic and intradialytic weight gain, an improved sodium and potassium purification [37]. The effects caused by frequent HHD on cardiovascular parameters have been ground for studies and research just because of the connection among instability and cardiovascular issues and body stress during conventional HD three times a week. In a meta-analysis on the daily HD effects on cardiovascular parameters a significant reduction of left ventricular mass index was highlighted, with an increase in left ventricular ejection fraction, a significant reduction in systolic, diastolic and mean blood pressure, and a consequent decrease in the average number of antihypertensive drugs taken, with a suspension of therapy in 53.5% of patients [38,39].

Other issues to be considered in patients on dialysis are the high prevalence of depressive symptoms, which are a strong predictor of adverse events and an increased risk of hospitalization or death, and the postdialytic fatigue, an indefinite bad feeling that limits the patient's usual activities [40,41]. HHD causes a significant reduction of the depressive symptoms from 41% to 27%, and a substantial decrease in recovery time needed after treatment, considered as recovery forces and subjective well-being, which decreases from 8.9 hours for the three times a week treatment to 1.2 now in HHD [42,43].

The "short daily HHD" is also associated with an improvement of restless legs and sleep disorders, which are common in HD by affecting the 60% of patients [44].

The improvement of these parameters can significantly and positively influence patients life and family relationships, with better psychophysical wellbeing, increased energy and vitality, and a marked quality of life improvement.

The “short daily HHD” patient can regain one quality of life day by day compared to the HD patient in hospital, as shown. The renewed interest in the HHD has led to the designed for home use [45]. Many dialysis machine manufacturers have created equipments which facilitate home treatments, focusing on safety, reliability, compactness, flexibility and simplicity of the different devices, including the NxStage System One.

The risks associated with the HHD can be:

- Technical type, related mainly to equipment malfunction or bad preparation of the circuits, and in particular to the possibility of air presence that can cause air embolism, or human error in dosing heparin, which can be overcome with proper maintenance of the equipment and an adequate training program of the patient and partner;
- Psycho-social type, related mainly to patients, partner and family poor compliance, which can be prevented through appropriate selections of patients and partners;
- Clinical type, i.e. the complications of underlying disease and replacement treatment (cardiovascular, infectious, etc.), whose frequency appears lower than the traditional HD [46].

Adverse events were significantly lower in the HHD (six sessions per week) with the NxStage System One than the hospital HD, as demonstrated by a study of 32 patients who performed a period of 8 weeks in daily hospital HD, followed by 2 weeks of transition and 8 weeks home HD. The frequency of adverse events, referred to 100 treatments, was of 5.3 in hospital and 2.1 at home. The study showed also a significant improvement in blood pressure levels and in interdialytic increase, compared to retrospective data of the same patients on conventional HD [47].

The only risks which appear increased with daily hemodialysis are those related to the greater frequency in use of vascular access. In a Canadian trial involving 245 patients, randomized to daily hospital HD or conventional HD, the overall risk of vascular access repair or hospitalization due to the malfunctioning of venous access in the daily HD was 76% greater than in conventional HD and even 90% greater than in patients with arteriovenous fistula (AVF), with a statistically significant difference between the two groups ( $p = 0.02$ ) [48]. A recent survey shows the importance of adequate patient’s training for vascular access management, both FAV and central venous catheter (CVC), especially for hygiene requirements to reduce the risk of infection [49]. The hospital admissions for infectious problems were in fact greater in the HHD than in the three times per week HD hospital, while the admissions for cardiovascular issues were reduced [50].

### The Economic Aspect

The economical aspect of dialysis, one of the most expensive life-saving treatments, has to be considered separately. The economic crisis, associated with money restrictions, has led to a different vision regarding the care centralization, suggesting that dialysis should return in homes, better integrated with everyday life. Already in the ‘70s in a study of Rae the positive aspects of home dialysis from a social and economic point of view were underlined, regarding hospital beds availability and the return to work and family care [51].

The treatment costs do not involve only technical equipment, but the staff, infrastructure, professional training and social costs, medications, and transportation to and from the hospital.

All these factors are cleared with home dialysis, despite the consumables costs are greater than in HD because of the number of the weekly sessions (five/six per week versus three).

In addition, it is worth to highlight that patients can better manage their work, making it more compatible with the dialysis.

Finally, the improvement of the clinical parameters with HDD reduces the costs related to hospital admissions and days of hospitalization, without considering the benefits achieved for a better quality of life [52].

### Other Pros and Cons in the History of Home Dialysis

The home hemodialysis was introduced in Seattle in the 60s, as life-saving treatment to sick patients, not suitable for HD treatment. In Europe, after the experience of nocturnal dialysis at home, home hemodialysis programs have been started three times a week.

Later on the HHD was gradually given up due to the families heavy involvement, the patients and care-giver long training periods and the dialysis complexity. Further impediments were the installation at home of suitable water and electric systems, in addition to the need of having ample spaces both for the care area and the stock of materials.

Finally, the introduction of Dialysis Centres with limited assistance has increased the availability of beds for hemodialysis, reducing the need of home hemodialysis [53].

Today the HHD is going to be rehabilitated twenty years after a waning phase that in the ‘80s had transformed home hemodialysis in a preserve of few passionate centers for very few patients motivated. Differently from the years between 1980-1990, the present economical resources are deeply limited and that’s why the HHD treatment has encouraged patients to be cared at home.

At the same time, the recent demonstration that high frequency treatments and efficiency have better outcomes in terms of mortality and morbidity has encouraged frequent dialysis.

### The NxStage System experience

Today many difficulties of HHD seem to be overcome thanks to new technologies, such the NxStage System (Figures 3,4). This equipment allows frequent dialysis sessions, avoiding long periods between sessions and allowing the organism a nearly continuous purification.

It was conducted a multicenter observational study to assess the efficacy and tolerance of this new method. This study involved 500 patients enrolled during three years and followed for at least one year and it was compared the number of days of hospitalization per patient per year among the group of HHD patients with the one in hospital, assessing changes in quality of life from time zero to 12 months. Also the kinetics of urea, phosphocalcic metabolism, nutrition, anemia, the surgery of the vascular access, and the use of medications were improved.

Figures 3,4 Today many difficulties of HHD seem to be overcome thanks to new technologies, such the NxStage System



Many positive aspects of the HHD are also confirmed in our experience, although limited to 9 patients. The quality of life is quite important, like appetite improvement with lower water restrictions, fewer depressive symptoms, better physical and mental wellbeing, increased energy and vitality, better physical recovery post-dialysis, increased self-esteem (diminution of the feeling of illness), better organisation of leisure, travel, better management of disease. The HHD metabolic control is similar to the hospital one, moreover it is obtained with less use of medications. The HHD most frequent treatment allows less use of phosphorus binders, interdialytic weight gain reduction with better control of hypertension and less use of hypotensive drugs.

The HHD with NxStage solved technical difficulties, it is easy to learn and it does not require patient's house structural changes, like osmosis system, appropriate electrical line and generator set.

### Conclusions

In conclusion, the HHD definitely improves the patient's psycho-physical rehabilitation, with social benefit reducing the impact of the disease. This treatment allows less absences from the workplace, increases productivity and reduces social impact related to pathology.

The HHD also represents a cost saving due to the absence of medical and nursing staff and does not require transportation from home to the dialysis Center.

A more frequent dialysis can improve efficiency and prevent damages caused by uremia.

An enhancement of the HHD is desirable to free the congested hospitals and represents a further possibility of replacing renal function [54].

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