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WHAT DOES THE FUTURE LOOK LIKE - HOME HEMODIALYSIS

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ABSTRACT

Home hemodialysis (HHD) is a discovery from 1961 that is now experiencing a revival. It is a convenient and modern method of renal replacement therapy that allows the patient to undergo hemodialysis sessions at home. Due to the growing interest in home hemodialysis, we decided to present the potential of this renal replacement method, show both its benefits and complications resulting from its use.

Undoubtedly, HHD has many benefits resulting mainly from the possibility of regulating the duration of the sessions and increasing their frequency. However, this method is also burdened with numerous complications. There are training courses in the use of HHD for patients who have just been diagnosed with end-stage renal disease as well as for patients undergoing dialysis using other methods. Appropriate patient selection is an important factor for the success of home therapy. There is a fierce battle in the home hemodialysis machine market. Manufacturers are outdoing each other in innovative technologies to ensure ease of use, trouble-free operation and minimize complications. The costs of home hemodialysis include more components than the dialysis treatment itself.

Home hemodialysis gives patients comfort and independence above all. This is part of nephrology that undoubtedly requires a lot of work and development, but is certainly an invention of the 21st century.

Key words: home hemodialysis, dialysis, chronic kidney disease, nephrology

INTRODUCTION: HOW HOME HEMODIALYSIS BEGAN?

Home hemodialysis (HHD) was first discovered in Japan in 1961 by the doctor Yukihiko Nose [1]. In a short time it turned out that this invention was a breakthrough in nephrology at the time and a chance for patients suffering from ESRD to find convenient renal replacement therapy. Home hemodialysis has been gaining more and more followers since then. Patients no longer had to come to centers three times a week for hemodialysis sessions, but instead had them comfortably at home [2,3]. In the 1980s and 1990s, the prevalence of HHD decreased, and after this period it returned again as a method of renal replacement therapy with high patient survival and a chance for a longer life [4,5,6]. Today, more and more countries offer home hemodialysis among the various dialysis options. In Australia and New Zealand, 10-12% of dialysis patients use this promising method [7].

Due to the growing interest in home hemodialysis, we decided to present the potential of this renal replacement method, show both its benefits and complications resulting from its use. For this purpose, we used the latest publications contained in the PubMed and Google Scholar databases using the key words.

MACHINES IN HOME HEMODIALYSIS

Ideal machines for HHD should combine the features of simplicity of use, ease of starting and stopping dialysis. They should allow for a flexible dialysis regimen, do not require the use of systemic anticoagulants, and be adapted to self-cannulation by the patient. They should include safety systems and require as little or no disinfection as possible. A great facilitation is the use of large touch displays and simple set-up instructions explained step by step [8]. In our article we will describe 5 machines, one of which is a conventional in-centre hemodialysis (ICHHD) machine adapted for HHD (Fresenius 2008K @ home), three specially designed for HHD (Quanta TM, Nx Stage TM, and Physidia S3 TM) and the machine currently used in the treatment of patients with acute kidney injury and end stage renal failure, as research into its use in HHD is still ongoing (Tablo™).

The main differences between conventional machines adapted for HHD and the ones designed specifically for HHD are their water purification systems, lower weight (even about 3 times) and shorter time of patient preparation for therapy in favor of the ones designed exclusively for HHD. Additionally, Quanta, Nx Stage and Physidia S3 can be used portably with the bagged dialysis fluid. Conventional machines benefit from a lower minimum blood flow and a higher maximum blood and dialysate flow rate. [9]

In order to adapt the conventional Fresenius machine for use at home, the design has been changed to a more intuitive one, stickers have been added with instructions on how to use the equipment step by step, an automatic rinse-back has appeared, an integrated blood pressure monitor and an integrated anticoagulant pump have been added. Security is ensured by alarm systems and a real-time monitoring system that can communicate with the iCare system [10,11,12].

The Nx Stage machine uses a treatment cartridge designed for single use, so there is no need for disinfection and only minimal maintenance. Dialysis fluid can be obtained using the PureFlow SL system, which allows you to prepare 60 liters within 7 hours from drinking water and can be used up to 96 hours from preparation. The second option is to use prepared sterile dialysis fluid bags. The first solution does not require any special changes in the plumbing system in the patient's home and does not take up much living space, while the sterile bags allow flexibility in the dialysis regimen and allow for treatment away from home, even if there is no water supply [13,14,15,16].

Quanta SelfCare+ stands out from other typical HHD machines with high-flow dialysate rate. Simple configuration shortens the time to set up the machine. The equipment includes a touch-screen and a telemonitoring system [17,18,19]. Like the Nx Stage machine, it can use dialysis fluid obtained from a domestic water supply or from sterile fluid bags [15].

Physidia S3 is the only one that allows hemodiafiltration in addition to hemodialysis. Unfortunately, due to the dialysis fluid used, it only allows relatively low levels of hemodiafiltration exchange [20]. It is distinguished by the lowest weight among the machines mentioned - it weighs only 23 kg [21].

Tablo uses a compact water purification system that can produce ultrapure dialysis fluid from drinking water. Ease of use is ensured by a touch screen, 10-step configuration setup and automatic transfer of treatment data. The machine is not yet approved for use in HHD, but the research on it looks promising [22].

COMPLICATIONS OF HOME HEMODIALYSIS

Complications of HHD cover all ICHHD situations, but there are also additional aspects resulting from the lack of professionals in operating the equipment, most of the activities the patient has to perform on his own. In addition, HHD requires more frequent and longer dialysis sessions which increases the risk of complications. Complications can be divided into medical, psychosocial and technical [23].

MEDICAL COMPLICATIONS

It is worth mentioning that the "buttonhole cannulation" technique is eagerly chosen by patients due to its ease of use, less pain and reduced hematoma formation, but it carries a three times greater risk of infection compared to the rope-ladder method [23,24]. It is recommended not to use the buttonhole method until more data is collected [25-27]. However, if its use is necessary, special care should be taken to disinfect the skin [28].

Other medical complications are generally rare. There have been only isolated cases of severe hypotensive episodes. In addition, the use of more frequent and longer HD sessions leads to an improvement in the condition of the cardiovascular system [23] and allows for precise control of serum phosphate levels and an improvement in the mineral metabolism of the skeletal system [29]. There was no evidence of increased loss of nutrients [30].

PSYCHOSOCIAL COMPLICATIONS

Mental stress often coexists in dialysis patients [31]. Transitioning to HHD may exacerbate anxiety and depression as patients have concerns about their safety, new responsibilities and financial burden already during training [32]. Some patients experience fear of a new type of therapy due to social isolation and lack of medical staff. Greater fear of HHD was reported in countries where it was less used [33]. Worse mental results were noticed in younger patients, with other mental illnesses, and in marital conflicts.

Other factors negatively influencing the course of the disease were external motivation for treatment, patient burnout, and poor ways of coping with the disease. The patient's attitude plays a key role in the course of the

treatment process. The diagnosis and treatment of mental disorders must not be overlooked in the HHD treatment [23].

In 2012-2015, a pilot project was carried out in Ontario, Canada, the aim of which was to provide HHD with the assistance of 'Personal Support Workers' (PSWs), i.e. people paid with public funds working under the supervision of a health care professional. PSWs were trained to perform daily HD in specific patient(s), nocturnal dialysis was not offered. The role of PSW was to conduct dialysis, prepare the dialysis machine, test the patient's blood, and administer drugs intravenously. The conclusions of the project were as follows: PSWs assistance helps overcome patients' fears related to HHD and increases the comfort and quality of life of patients, the costs associated with assisted HHD are lower than the traditional in-center hemodialysis [34].

TECHNICAL COMPLICATIONS

Especially in patients using HD overnight, large blood losses due to needle dislocation or dialyser leakage may go unnoticed. Effective methods of fighting hemorrhages include the use of a central catheter with additional protection instead of an arteriovenous fistula, precise protection of the needle and the use of blood detectors. In order to ensure the highest effectiveness of the monitors, their operation and battery status should be regularly checked [23].

An important problem remains the discontinuation of HHD, which is more common in obese people, addicted to substances, not eligible for a kidney transplant, and in city dwellers. The highest failure rate is recorded in the first year of therapy, and it decreases in the following years [35]. According to a Canadian study, 50% of technical failures are due to social or resource scarcity [36].

Modern machines used for HHD are of a high technical level. Complications such as air embolism have not been described for years. A technical error would indicate incorrect maintenance of the machine by the patient [23].

BENEFITS FOR PATIENTS AND ADVANTAGES

Home hemodialysis is gaining popularity. The number of patients receiving hemodialysis at home is increasing all the time. And all because this method has many advantages over traditional methods of treatment. These advantages relate to health, psychological and economic aspects.

The main advantage of home hemodialysis is the possibility of extending its duration and increasing its frequency. This is what allows for better control of dialysis parameters, fluid loss or the removal of waste products, including urea [37-40]. This allows blood pressure to be monitored more closely [41-43]. Increasing the frequency of dialysis sessions also resulted in more precise phosphate control [44,45]. Dialysis patients often struggle with depression, which has a major impact on treatment. A study was conducted which showed that increasing the frequency of hemodialysis had a positive effect on the course of depression [46]. Home hemodialysis reduced the use of erythropoietin [47] and iron supplements [48] but also reduced renal ischemia [49,50]. Patients undergoing overnight hemodialysis sessions show less fatigue and enjoy better sleep quality. In addition, patients undergoing home hemodialysis are subject to less stringent dietary restrictions [51] and enjoy a better nutritional status of the body [52]. All this undoubtedly also contributes to the overall improvement of the quality of life [53].

Another situation where home hemodialysis is more beneficial than traditional hemodialysis is pregnancy. Dialysis affects the outcomes and course of pregnancy, increases the rate of miscarriage, and may be associated with preterm labor, thus contributing to complications in the course of pregnancy. Increasing the duration or frequency of home hemodialysis gives an opportunity to improve pregnancy outcomes and extend the gestational age [54].

There is also some speculation that intensive hemodialysis may increase testosterone levels and reduce hypoprolactinemia, thus improving male fertility [55].

Even economically, home hemodialysis has great benefits. It generates much lower costs than hemodialysis performed by patients in centers. Moreover, the costs of hospitalization of these patients are also reduced [56].

TRANSITIONAL CARE UNIT AND TRIAL PROGRAM - WHAT IS IT?

Due to the continuous development and dissemination of HHD, there was a need to familiarize patients with ESKD with the possibilities of this method of dialysis. Therefore, the idea was born to create transitional care units (TCUs) for patients starting dialysis and trial programs (TP) for patients already on dialysis who would like to learn more about the home hemodialysis program [57].

The idea of TCU is not new, as it arose about 40 years ago. [58] It is an educational program for patients starting their adventure with hemodialysis. It lasts 3-5 weeks and focuses mainly on educating patients on HHD, but also PD or kidney transplantation. The program involves a whole team of people working together, such as nutritionists, technicians, nurses, nephrologists and social workers. The common task of these people is to care for the patient, but also to encourage them to develop HHD. According to studies, of patients with ESRD who were not educated and who undertook hospital dialysis, 30-75% would choose home dialysis [59]. TCUs should enable patients to familiarize themselves with the equipment necessary for home hemodialysis.

Trial programs are patient learning programs that last approximately 2 weeks. During these sessions, the patient can see for himself the benefits of increased dialysis frequency. This is the time when the patient learns to use HHD home equipment and learns about practical and technical aspects. [57] Most of the trial programs admitted that they felt better. [60]

SELECTING PATIENTS FOR HOME HEMODIALYSIS.

A very important element for the success of home hemodialysis is the appropriate selection of patients and their training. Patient selection in terms of physical and intellectual fitness is essential for qualification. Psychological aspects such as motivation and attitude also play a major role. The patient must first of all want. Candidates for home hemodialysis include patients with persistent hyperphosphataemia, severe sleep apnea, uncontrolled ascites, right ventricular failure, and unmanageable hypertension. In addition, predisposing people are those who cannot achieve complete control of uremic symptoms under conventional hemodialysis, or those who take a long time to recover from regular hemodialysis.

Tests are performed to assess the manual skills of patients, but also their eyesight and hearing. However, a negative test result should not discourage patients from undertaking home hemodialysis. Obviously, a more active and self-coping patient will be more and better in compliance. But it is possible to involve your tutor in the help [61].

HOW MUCH DOES IT COST?

The costs of home hemodialysis treatment were calculated on the basis of data mainly from the USA and other highly developed countries where the rate of use of this method is significant. In the United States, 80% of dialysis patients use Medicare as a healthcare payer. It's worth noting that Medicare has separate rates for the first 120 days of starting chronic dialysis and thereafter [62]. As it takes an average of 45 months from the diagnosis of ESRD to the transition to HHD [63], we will focus on the cost of the treatment longer than 4 months from the onset of chronic hemodialysis. Medicare provides 25 training sessions to prepare patients for home dialysis. Each additional session is an expense of \$ 96. One of the main factors determining the cost of HD is its frequency. Effective home hemodialysis requires 4-6 treatments per week due to the low flow of dialysate [64]. Decades ago, Medicare reimbursed the costs of up to 14 treatments for a 31-day month, and the costs of other treatments only in specific cases where additional dialysis was necessary for medical reasons (e.g. acidosis, hyperkalemia, fluid overload), but these indications differed among multistate jurisdictions [65].

In 2019, the indications were standardized, and their scope remained relatively wide. Reimbursement scheme for home HD and in-facility HD has been the same [66].

The second factor significantly influencing the costs of hemodialysis is hospitalization. In 2018, hospitalization cost one-third of Medicare's expenditure on a dialysis patient [67]. In the conducted analysis, the risk of hospitalization of patients undergoing home hemodialysis and in-facility HD was almost identical, but patients treated at home were more often admitted to hospital due to infections, and in-facility patients due to cardiovascular reasons [68].

Limiting the number of infections can significantly reduce the cost of home hemodialysis, so it is worth emphasizing the correct asepsis technique during HHD training. Another expense is the salary of the nephrologist. The doctor will receive the same fee for a patient undergoing treatment in the facility 2-3 times a week as for a patient using HHD [62].

Analyzing data from Australia and Canada, home hemodialysis, whether conventional or frequent, was cheaper in subsequent years than in-facility HD, while in Great Britain frequent HHD was always the most expensive solution [69]. In Manitoba, Canada, in-facility HD costs were estimated at \$ 64,000 per patient per year, while home hemodialysis using conventional equipment was only \$ 39,000. The shortest time to achieve savings in relation to in-facility HD was obtained using the NxStage machine and was 9.6 months. This was obtained thanks to a lower training cost of \$ 16,000 [70]. In Hong Kong, the use of nocturnal home hemodialysis resulted in savings of 45% in the first year of therapy and 75% in the second [71]. An Ontario analysis showed that the adjusted 5-year cost was more than \$ 100,000 lower for home HD compared to in-facility HD and nearly \$ 50,000 lower than peritoneal dialysis, with the highest survival reported with HHD [72]. The patient's expenses are not without significance, especially when it comes to the home modifications and the additional paid care of medical personnel.

In summary, the frequency of dialysis and number of hospitalizations have the greatest impact on the cost of HHD. Frequent hemodialysis increases the costs of treatment, but has a positive effect on the cardiovascular system, reducing the risk of hospitalization or treatment in specialized outpatient clinics for this reason. The real milestone would be to reduce the number of infections in HHD that often result in hospitalization. Developments in this area can be a breakthrough in the cost-effectiveness of home hemodialysis [62].

SUMMARY

Home hemodialysis has been experiencing a revival since 2005. It is a method of renal replacement therapy that gives dialysis patients the hope of independence and self-reliance. Despite the many complications to be reckoned with, HHD is an invention that can change the lives of many people. Of all the benefits and advantages it brings, the most important is the amazing improvement in the quality of life. Until now, a hemodialysis patient is a patient completely dependent on regular sessions at the center, whose life must be subordinated to hospital visits. Therefore, we can see that home hemodialysis brings not only a better mood or an improvement in the clinical condition. It gives a new life.

Certainly, this method still requires many improvements. Training for both patients and healthcare professionals is being introduced to facilitate the implementation and dissemination of HHD. Undoubtedly, home hemodialysis will become more and more popular with time. In the 21st century, people increasingly strive for convenience, and this is the domain of HHD.

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