Frequent prolonged home haemodialysis: three old concepts, one modern solution

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Keywords: adequacy; daily haemodialysis; haemodialysis; nocturnal haemodialysis; prolonged haemodialysis

Adequacy redefined

Most haemodialysis patients are, even when treated ‘adequately’ according to current standards, exposed to the so-called unphysiology of dialysis, which was described more than 25 years ago [1]. They are still at high risk of being overhydrated and dehydrated, hypertensive and hypotensive, acidotic and alkaliotic, or hyperkalaemic and hypokalaemic thrice weekly. Furthermore, most patients are treated in an unfamiliar hospital setting where they are confronted with illness and death of fellow patients and chronic lack of time of overworked professionals, resulting in neglect of attempts of patients to self-determination. Despite many good evidence-based protocols and standards, current chronic intermittent haemodialysis is associated with high mortality and morbidity and low quality of life, and hardly deserves the adjective ‘adequate’. Dialysis should be referred to as ‘adequate’ when it results in normal life expectancy, normal morbidity, normal quality of life and the absence of dialysis-associated symptoms. We are challenged to turn such visions of adequate treatment into reality. The old concepts of frequent ‘daily’ haemodialysis [2,3], prolonged haemodialysis [4], and the combination of both, ‘nocturnal’ haemodialysis [5], can guide us in our attempts to improve dialysis outcome. For logistical and practical reasons, frequent and nocturnal haemodialysis are preferably performed at home, and another old concept, home haemodialysis, deserves serious attention and revival.

Old concept no. 1: frequent haemodialysis

In comparison to conventional (three times a week for 4 h) haemodialysis, a ‘daily’ (six times a week for 2 h) schedule results in lower urea peaks, lower mean urea concentrations and less fluctuation of urea concentrations around the mean [6]. The efficiency of urea removal is enhanced [7,8]. Far less urea is removed...
at the end of a haemodialysis session than at the beginning. This is the result of an exponential decrease in urea transmembrane concentration gradients over time and a solute desequilibrium between blood and other compartments. Therefore, a lower single pool Kt/V per week is required for a similar dialysis efficiency in frequent dialysis [7,8]. The concepts of equivalent renal clearance [8,9] and standard Kt/V (std-Kt/V) [8,10] have been developed to make comparisons of urea kinetics between treatment schedules with different frequencies possible. Clinically, frequent dialysis results in an improved nutritional state, illustrated by increased body weight, nPCR, caloric intake and serum albumin concentrations [11–15]. Erythropoiesis is enhanced [11,14–16] and perhaps endogenous erythropoietin production improves [17]. There are minor effects on the removal of phosphate [12,14,15,17] and beta-2 microglobulins [17], both substances that require prolonged dialysis duration [18, 19]. More importantly, increasing frequency results in less overhydration, lower volume fluctuations, better tolerance of ultrafiltration and subsequently better blood pressure control despite fewer prescribed antihypertensive drugs [2,3,12–16]. Left ventricular mass reduces [16,18,20]. The mechanism for a better haemodynamic control is not known yet. Frequent ultrafiltration results in more stable haemodialysis sessions, and a lower dry weight can be reached. Additionally, less activation of the sympathetic system resulting in lower peripheral vascular resistance has been reported [21]. Quality of life improves markedly and many common symptoms improve or disappear [12,22]. Patients on frequent short haemodialysis report (i) less fatigue, anorexia, prurigo, insomnia, thirst, (ii) a better physical and mental condition, and (iii) fewer dialysis-related symptoms, such as cramps and headache. They can resume normal daily activities directly after a dialysis session without signs of ‘hangover’. The effects on long-term mortality are not yet known, since the reported studies included small numbers of patients and lacked the proper design and biostatistical power to justify conclusions on survival. A review showed a high survival rate of 80% over 5 years [15].

Old concept no. 2: prolonged haemodialysis

Thrice weekly long (e.g. 8 h) haemodialysis results in adequate extracellular volume control. The ultrafiltration rate is low and side effects of ultrafiltration occur less frequently or disappear [23–25]. Patients on thrice weekly 8 h haemodialysis in Tassin showed lower mortality than similar groups treated with conventional schedules, which is ascribed to lower cardiovascular mortality due to a normalization of blood pressure [23,24]. The excellent blood pressure control may be caused by an adjustment of the extracellular volume. However, some normotensive patients on thrice weekly prolonged haemodialysis showed a higher extracellular volume than normotensive and hypertensive haemodialysis patients on conventional haemodialysis [25], suggesting that factors other than strict volume control are also important. Antihypertensive drugs are prescribed in less than 5% of cases [23–25]. Dry weight increases [23], suggesting a better nutritional status. Haematocrit increases, while the erythropoietin dose can be reduced [23].

Old concept no. 3: home haemodialysis

Home haemodialysis is an outstanding treatment for selected patients, resulting in better quality of life, self-determination and rehabilitation [26–29], decreased morbidity and perhaps even in less mortality [30]. Nevertheless, the popularity of home haemodialysis has declined, obviously due to the availability of peritoneal dialysis, which is indeed a good alternative for patients who are able to perform dialysis at home. An important drawback of home haemodialysis is that it requires specific and complex organization. A home haemodialysis programme should include an excellent training programme, carried out by skilled nurses in adequate facilities, good technical service of the dialysis machine and the water treatment devices at home, simple but adequate home adjustments, easy access to medical and psychological support by nurses and social workers at home, a well functioning logistical organization, state-of-the-art quality of treatment and devices, and a good quality control system. This can only be organized adequately and cost-effectively when large numbers of patients are involved. Most centres take care of only small numbers of home haemodialysis patients, if any. Therefore, a home haemodialysis programme can only succeed when centres collaborate in the organization. For instance, the (non-profit) Dianet home haemodialysis network includes over 20 dialysis centres in The Netherlands, and takes care of 70 patients. Medical care is provided by the individual centres, but training, nurse supervision, technical servicing, logistics and quality control are organized by the network. The network has access to a pool of 90 part-time working nurses who can supervise home haemodialysis treatments when patients do not have spouses who are able or willing to assist. In The Netherlands, nurse aids are paid, but nevertheless home haemodialysis is cheaper than in-hospital haemodialysis, and it is fully reimbursed by all Dutch insurance companies. The Dutch government stimulates home haemodialysis, including frequent home haemodialysis and nocturnal home haemodialysis. Therefore, we have provided daily home haemodialysis since 1995 and we started a pilot study on nocturnal home haemodialysis in 2001.

Three old concepts, one new solution: nocturnal home haemodialysis

Nocturnal home haemodialysis, first described by Uldall et al. [5] and Pierratos [31], combines all three above-mentioned concepts: frequent, prolonged and
home haemodialysis. Patients are dialysed at home 6 or 7 days a week while they are asleep (e.g. 7–8 h). Vascular access is provided by catheters, fistulas or grafts. Blood flow varies between 180 and 400 ml/min, and dialysate flow varies between 200 and 300 ml/min. High flux polysulphone dialysers are used. The dialysis machine is connected by the telephone network or the Internet to a call centre, where all critical functions of the dialysis machine are monitored, and alarms to which patients do not respond can be detected. Weekly single pool Kt/V reaches values between 10 and 15 [17], suggesting an unparalleled small molecule clearance. Weekly phosphate removal is much higher than on conventional haemodialysis [32]; phosphate concentrations normalize [17,31,32] despite discontinuation of phosphate binding agents and addition of phosphate to the dialysate is necessary in many. Decreased serum phosphate concentrations allow an increase in dialysate calcium concentration. Elevated PTH levels decrease [31]. Beta-2 microglobulin removal is four times higher than in conventional haemodialysis and serum beta-2 microglobulin concentrations decrease [33]. Iron deficiency develops in many patients, but when iron is supplemented the efficacy of erythropoietin improves [31]. There are practically no diet restrictions, and nitrogen and caloric intake, body weight and nPCR increase [17]. Amino acid losses through the high flux dialyser are significant [31], but serum amino acid concentrations increase [34]. Homocysteine levels decrease [35]. The effects of nocturnal haemodialysis on blood pressure control are excellent [17,31]. Dry weight can be reduced without adverse symptoms. Antihypertensive drugs are discontinued in most patients. Reductions in blood pressure are accompanied by regression of left ventricular hypertrophy [36]. Quality of life, measured with several questionnaires, improves markedly [31,37]. Many patients assume full-time employment. Dialysis-related symptoms and anorexia disappear. Sleep apnoea improves [38]. The treatment appears to be cost-effective, and is cheaper than conventional in-centre haemodialysis [39].

Using the Dianet home haemodialysis network, we organized a nocturnal home haemodialysis pilot study with special focus on clinical results, quality of life and cost-effectiveness. Within 6 months we included 15 patients. Up to now, we only accepted patients with a spouse. All patients and spouses received regular home haemodialysis training, and 2 weeks of special nocturnal haemodialysis training, including three in-centre nocturnal treatments. The clinical effects we have seen so far are completely comparable to the results described by the Toronto group.

The dialysis machines are Gambro AK 200 with a blood volume monitor that is on-line every night. The water treatment system includes a sediment filter (5 μm, Pure Water Systems), a water softener (Ewatec, Pure Water Systems), a charcoal filter (0.5 μm, Pure Water Systems), an RO system (Aquaboss, Lauer) and an additional polysulphone filter at the inlet (Ultrafilter U 8000 S, Gambro). We use high-flux polysulphone artificial kidneys (F60, Fresenius). The water is checked for bacteria monthly, for endotoxins every 4 months and for inorganic substances twice yearly. In case of water leakage, water detectors stop the water supply. Blood leakage is detected by enuresis alarm sensors, fixed near the vascular access. The types of vascular access used are AV fistulas, grafts and tunnelled catheters. The machine is connected via a bed-side node (Gambro) and routers (Cisco) to a server (Cisco) in a call centre in Amsterdam by the national telephone network. All patients have an ISDN connection for the data produced by the machine, but also an analogous connection for telephone contact, so the call centre can be reached even in cases of power failure. For each possible alarm, we defined the length of the period during which patients should have solved the problem; when the problems are not solved after this period, the ‘nightwatch’ in the call centre will call the patient. When the patient doesn’t respond, the nightwatch will contact a neighbour who has a doorkey of the patient’s house. In the case of severe problems, patients or their spouses can have telephone contact with the call centre by pressing one button. So far, no calamity has occurred.

Conclusion

Current standard haemodialysis treatment (thrice weekly for 4 h) is still a long way from providing adequate renal replacement. Three old concepts, frequent haemodialysis, prolonged haemodialysis and home haemodialysis, may be the solution for many patients in need of better treatment, certainly when combined as nocturnal home haemodialysis.

References


