
Experience With Nocturnal Hemodialysis

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In order to provide a highly efficient, long-duration form of hemodialysis, we developed nocturnal hemodialysis. Patients were dialyzed nightly at home for 8 – 10 hours, 6 – 7 nights/week. We kept the dialysate flow at 100 mL/min and the blood flow at 250 – 300 mL/min. Patients were monitored remotely from the hospital through a computer connection. An internal jugular line was used as an access. We have trained 12 patients over 30 months and have accumulated 160 patient-months worth of data. The patients tolerated the dialysis very well and slept through the night. There was a significant improvement in their sense of well-being. Nightly Kt/V was 0.99. Weekly removal of phosphate was two times as high and β_2 -microglobulin four times as high as conventional hemodialysis. All patients have discontinued their phosphate binders and have increased their dietary phosphate and protein intake. Hypertension was controlled with fewer medications, and erythropoietin dosages decreased. Complications were infrequent and included catheter occlusion and infections. Reusing the dialyzers decreased the cost of the treatment to levels similar to continuous ambulatory peritoneal dialysis.

Nocturnal hemodialysis represents a viable dialysis modality that combines high quality, low cost, and excellent tolerance.

(Home Hemodial Int., Vol. 1, 32 – 35, 1997)

Key words

Daily hemodialysis, nocturnal hemodialysis

Introduction

Despite the evidence for improved results from home hemodialysis (1), the use of this treatment modality has been declining over the last few years (2). There

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is evidence that increasing the dialysis dose offers improved clinical outcome (3–8). Furthermore, long-duration dialysis offers some advantages (4), although it is not clear if this is achieved by the higher dose of the treatment or the long duration of the dialysis. Elsewhere we reported preliminary results from slow nocturnal hemodialysis, a new form of home hemodialysis that offers a high-dose, long-duration dialysis while maintaining the low cost of home dialysis (9). In this paper we present an update of this new and exciting modality.

Material and methods

The cornerstone of nocturnal hemodialysis has been its long duration, 8 – 10 hours during sleep at night, 6 – 7 nights/week. An internal jugular vein catheter (Cook Critical Care, Bloomington, IN, USA) was used for the dialysis access. Blood flow was maintained between 250 and 300 mL/min, while dialysate flow was kept low, at 100 mL/min. We used the Fresenius 2008H machine and a low surface area (0.7 m²) polysulfone dialyzer (Fresenius F40). All patients were dialyzed using dialysate with a potassium concentration of 2 mEq/L, bicarbonate of 28 – 30 mEq/L, and calcium of 2.5 mg/L. Anticoagulation was achieved with heparin at an average rate of 1000 U/hour. A special box that locked around the catheter–tubing connection was used to prevent accidental disconnection. We used the InterLink connection (Baxter, Becton and Dickinson) to prevent bleeding and air embolism during connection and disconnection of the catheter to the blood lines.

Remote computer monitoring of the dialysis machine was established between the patients' homes and the dialysis unit by using the DAX software (Cybernius Medical Inc., Edmonton, AB). An observer monitored the function of the machines throughout the night. If machine alarms were not handled by the patient, the observer called the patient using a separate telephone line. The nurse, technician, and physician on call were notified, if necessary.

Dialyzers were reprocessed with peracetic acid (Renalin) at the hospital on a weekly basis. During the week, the dialyzers were rinsed by the patient and stored in a small refrigerator.

Results

We have trained 12 patients over 30 months and have accumulated 160 patient-months worth of data. The patients have reported significant improvement in their symptoms. They feel more energetic, and their appetites have improved. They tolerate the dialysis at night very well and even report improved sleep patterns. The hemodynamic stability allows the patients to perform dialysis without the need of a partner. They had no intradialytic or postdialytic symptoms.

The clearances provided by this method have been outstanding, with a Kt/V of 0.99 per dialysis session. This translates to a weekly Kt/V of 6 – 7. The clearances can be further improved by increasing the dialysate flow. Phosphate control is excellent, leading to discontinuation of phosphate binders in all patients. Several patients developed hypophosphatemia post hemodialysis, which in most cases responded to increased phosphate intake, although 2 patients require a small dose of oral phosphate supplement nightly prior to the initiation of dialysis.

Blood pressure control improved, leading to a decrease in the number of medications. There was an increase in hemoglobin, which permitted a decrease in the erythropoietin dosages. Complications of the method were few and were related to the dialysis access. Catheter clotting necessitated the use of urokinase in several patients. With the exception of 3 patients, all were on long-term treatment with low-dose warfarin. Exit-site infections and systemic infections were encountered at a rate of one episode per 25 patient-months and were treated on an outpatient basis, except for one patient who needed a brief hospitalization.

Discussion

Nocturnal hemodialysis provides a radical departure from conventional hemodialysis regimens. The main characteristic is its long duration, which has been associated with improved patient outcome. Indeed, the Tassin group in France reported excellent survival of patients on long-duration hemodialysis three times per week (4). The long duration of dialysis can

contribute to the improved results in several ways: it provides hemodynamic stability, it provides increased clearance of larger molecules, and it provides smoother changes of the uremic products. Furthermore, there is evidence from the same group that long-duration dialysis provides better blood pressure control (10).

High-frequency dialysis has also been associated with improved results. The rationale for the daily dialysis is the hemodynamic stability and the more physiological changes in serum chemistry with smaller fluctuations. Buoncristiani has demonstrated that daily short hemodialysis is associated with improvement of well-being, lower blood pressure, a decrease in cardiac hypertrophy, and an improvement in libido (11,12).

Nocturnal hemodialysis provides the highest clearance of any routine dialysis method. Although studies did not show further improvement in mortality with increasing Kt/V to more than 1.4, the number of patients on this higher dose was not adequate to make this conclusion credible (3,8). Although we have no data at this point, it is expected that improved dialysis will translate to decreased hospitalization rates (5).

Dialyzing patients with large body size is a challenge when using conventional hemodialysis three times a week. In the case of nocturnal hemodialysis, the clearance can be further increased by increasing the dialysate flow to 200 or 300 mL/min so that patients of any size can receive high-dose dialysis.

The hemodynamic stability on nocturnal hemodialysis is excellent even in patients with impaired cardiovascular function. Nightly fluid removal up to 4 L has not presented any difficulty and is not associated with postdialytic symptoms. This has removed the requirement for a home partner. Another implication of the hemodynamic stability on nocturnal hemodialysis is that less stable patients can be considered for home dialysis.

Nocturnal hemodialysis offers significant financial advantages. It is less expensive than the in-center hemodialysis, mainly due to the decreased use of personnel. The increased cost of the high-frequency dialysis and the overnight monitoring is canceled out by the savings of reusing the dialyzer. We have already experienced the financial benefits of using fewer medications, such as antihypertensives, erythropoietin, and calcium supplements. While we have incurred increasing

costs for warfarin, the occasional use of urokinase, and antibiotics for the treatment of dialysis catheter-related infections, detailed financial analysis on the medication costs has not been done. However, it is almost certain that the savings outweigh the new costs, especially considering the decreased erythropoietin and antihypertensive medication use.

The significant subjective improvement of the patients and the freedom from dialysis during the day will likely attract patients not suited to continuous ambulatory peritoneal dialysis and/or patients who fail transplantation. Lastly, the improved well-being as well as the lack of need for dialysis during the day will allow vocational rehabilitation of the patients. Several of our patients have indeed returned to full-time employment.

Another benefit of nocturnal hemodialysis, much appreciated by the patients, is their free diet. The patients are encouraged to increase the consumption of food items previously out of reach, such as foods containing high phosphate. Furthermore, there is no fluid restriction. Very high potassium intake still can cause hyperkalemia, but up to this point, decreasing the dialysate potassium to less than 2 mEq/L has not become necessary. Protein intake has increased significantly.

The overnight remote monitoring of the patients has been useful in several ways: it has provided a sense of security to the patients; on many occasions it has helped to correct alarm states, which if left unattended would otherwise have led to clotting of the extracorporeal circuit. Lastly, it ensured patient compliance. This is particularly important in the case of nocturnal hemodialysis. Lack of compliance with the length and frequency of dialysis may not be safe for some patients. It is the long duration and high frequency of the method that offer the hemodynamic stability that allows patients to be on hemodialysis, while asleep, without monitoring of their vital signs, in the absence of a partner. Conversely, it is likely that the remote monitoring is not critical for all patients, and its need should be examined in the future.

Who can be considered for nocturnal hemodialysis? All patients capable of being trained for traditional home hemodialysis can perform nocturnal hemodialysis. Furthermore, patients who were considered ineligible for home hemodialysis because of the lack of a partner can be trained for nocturnal

hemodialysis. Patients with family members willing to undertake the task of performing the dialysis can be on nocturnal hemodialysis. Family members are more likely to be available at night than during the day to provide their services. Another group of patients suitable for nocturnal hemodialysis who are ineligible for home hemodialysis are patients considered hemodynamically unstable. Conversion to nocturnal hemodialysis could provide the necessary stability and provide the solution to this problem.

In summary, nocturnal hemodialysis has been shown to be feasible, highly efficient, and inexpensive. It could be considered as an alternative to the other dialysis modalities for the patients who can be trained. Simplification of the available hemodialysis machines and availability of *in situ* reuse of dialyzers will increase the number of eligible patients for this dialysis modality.

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