FOUR AND ONE-HALF YEARS' EXPERIENCE WITH CHRONIC HEMODIALYSIS

At present 19 patients are being treated on the chronic hemodialysis program in Seattle, among whom are 3 of the 4 original patients started 4½ years ago. Five patients are treated at the University Hospital, 2 at home (one of them under the care of Dr. C. R. Blagg) and 12 at the Artificial Kidney Center under the direction of Drs. Pendras and Murray. The majority of patients have renal creatinine clearances below 1 ml./min.; 2 patients have been anuric for 4 years now. All patients have the teflon silastic cannula(1). The modified Kiil kidney is used because no priming or bloodpump is needed. Dialysis fluid is made in individual tanks(2) or delivered by a centralized fluid system consisting of a tank with concentrated mineral solution and a supply of tap water mixed together by proportioning pumps(3). The equipment is assembled by technicians and all dialyses in hospital are carried out by trained nurses. Most patients are dialyzed twice weekly for 10 to 18 hours per dialysis.

Four of the 5 patients at University Hospital are rehabilitated and live a normal life; one has had severe neuropathy since the first dialysis 4½ years ago and is disabled. These patients are 24 to 54 months on chronic dialysis treatment. Of the 2 patients on the home dialysis program, one is well, the other has markedly decreased strength in the legs, but is able to do part time office work (Figure 1). Of the 12 patients at the Artificial Kidney Center, 10 are able to do their normal jobs, 2 have pronounced neuropathy but are ambulatory and able to do part time work(4). Thus more than 80% of the patients are rehabilitated and do their normal work. In the 4½ years of the program one patient has died of coronary infarction after being well for 12 months of treatment.

To date, the most severe complication is neuropathy. Although overt clinical symptoms are present in only 3 patients, nerve conduction times are below normal in all (Figure 2). The lower limbs are mostly affected; the upper limbs are seldom abnormal. The cause is unknown, and the development of neuropathy is unpredictable.

Blood pressure in our patients is related to sodium accumulation between dialyses. Control of hypertension is achieved with low sodium intake and fluid and salt removal during dialysis(5). Studies on total exchangeable sodium and blood pressure in these patients were presented here by Dr. Blumberg (see Index).

Two of the patients have had recurrent attacks of painful joint swellings, followed by calcification of the soft tissue surrounding the joints. This involved fingers, wrists, elbows, shoulders, and hips. The calcified nodules were easily detected, especially in the hands. It has been shown by Caner and Decker that arthritic attacks can be provoked by adding uric

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acid to the bath fluid so as to prevent uric acid removal during dialysis and that Colchicine is the drug of choice to terminate an attack. Others have decreased the incidence of arthritic attacks by giving aluminum hydroxide which lowered the serum phosphate level.

Patient C.S. has now been on the dialysis program for more than 4½ years and has not passed urine for 4 years. He was very handicapped during the first 2 years by atrophy of muscles of the lower legs due to neuropathy and by attacks of joint swelling and extensive calcinosis. On aluminum hydroxide therapy for several months, the nodules became smaller and have since disappeared. The average Ca X PO₄ product in this patient did not change remarkably on this therapy. The calcifications have also resolved as is seen in the x-rays of the hands taken in 1962 and 1964, respectively (Figure 3, 4). His strength in the legs meanwhile has improved and during the last 9 months he has been working full time in a machine shop.

A recent survey of the world experience with chronic hemodialysis using the pumpless system shows a total of 128 patients have been started in the last 4½ years; 24 of them died during the first year of opening of centres when physicians, nurses and technicians were in the phase of learning to overcome the difficulties of the technique. Seven other patients died from causes unrelated to dialysis. The overall survival is thus 75%. We believe a further decrease in mortality will be seen if a center is equipped with a sufficient number of trained nurses and technicians. It is most important to have trained personnel take care of routine assembly of equipment and monitoring routine dialysis, leaving medical problems and new development to the physician. Furthermore, a dedicated surgeon is essential for the dialysis team, because only with good functioning cannulas will it be possible to run a smooth dialysis.

PERIODIC PERITONEAL DIALYSIS

During the last 2½ years periodic peritoneal dialysis has also been tried for treatment of end stage uremia; this method is still in an experimental phase. A total of 42 patients have been reported; 30 died before 6 months were over, 4 were alive after 6 to 9 months, 3 between 9 and 12 months, and 5 for more than one year.

All investigators reported peritonitis and adhesion formation sooner or later. This we believe is related to contamination of fluid during changing bottles and to use of indwelling catheters or indwelling access fittings. These communicate between the outside environment and the peritoneal cavity, providing a portal of entry for bacteria. To eliminate these factors we sterilize our fluid in large containers, use a cycling machine and use the repeated puncture technique which involves insertion of the catheter for each dialysis and removal of the catheter after dialysis.

Figure 5 shows a cycling machine which has been used for 2½ years and more than 200 dialyses. All bottles and tubes are sterile. The inflow and outflow bottles are calibrated which facilitates calculation of fluid balance during dialysis. Figure 6 shows a schematic drawing of the machine. Fluid is pumped from the large bottle into a small bottle where the inflow volume can be preset. The sequence of operation is described in the figure. The timer regulates the valves and pumps.
Figure 7 shows a portable cycling machine designed by one of us (F.K.C.). This machine will be available on the market soon. A signal is generated by a cam cycler and fed through relays to control the valves and pumps. Easy access to the cam cycler permits adjustment of inflow and outflow time to the patient's need. Colored pilot lights on the front panel indicate the period of the cycle. Manual override switches allow greater versatility. This machine has now been used for home peritoneal dialysis for more than 4 months.

The advantages of our peritoneal dialysis system are:

1. A closed sterile system is maintained throughout the entire dialysis.
2. Nursing time is reduced to a minimum.
3. The cost of fluid made in our hospital is low.

The patient we would like to present briefly is Mrs. J.D., a 28-year-old married woman known to have chronic pyelonephritis since the age of 14. Chemical data for the first 65 weeks are shown in Figure 8. Pre- and post-dialysis blood urea nitrogen, creatinine and uric acid levels are seen, also pre-dialysis total protein and hematocrit levels, urine volume and creatinine clearance. On May 5, 1963, a silastic access fitting was implanted and once weekly dialysis was started on May 8. After 3 dialyses the BUN level stabilized below 100 mg%. Despite meticulous care and sterile technique, pneumococcal peritonitis developed after 10 weeks. Both the BUN and serum creatinine rose sharply during this period and body weight dropped. The peritonitis was cleared by antibiotics, the access tube removed, and since then the repeated puncture technique has been used. During the last 14 months not a single episode of peritonitis has occurred and all cultures of the peritoneal fluid have been sterile.

The hematocrit remained at a low level; until now only 8 units of packed cells have been given. As long as she is asymptomatic, no blood is transfused. Her urine volume is now about 500 ml a day with a creatinine clearance around 1 ml./min.

The duration of once weekly dialysis has been about 22 hours during recent months. The rate of dialysis is 3 l./hr. and the peritoneal clearance between 20 and 35 ml./min. Ten to 70 grams of protein are removed with each dialysis, the larger amount coincided with removal of 1 to 1½ l. of ascitic fluid before the start of dialysis. Blood pressure has been between 130/80 and 150/90 during the last 6 months.

The general condition of the patient is remarkably good. She is able to do all her normal household work in a family with one child and she enjoys a normal social life. There is no muscle wasting or metastatic calcifications. Nerve conduction time is only slightly prolonged; clinically there are no signs of neuropathy. Repeated peritoneal puncture is tolerated very well. Most important is the fact that she can live a completely normal life on 6 out of 7 days of the week, now more than 16 months since the first peritoneal dialysis. This summer she was able to take a 10-day vacation trip to California with her family, enjoying the sunshine, swimming, etc.
REFERENCES


Patient | Age at onset | Diagnosis | Urine vol. ml/day | Months of dialysis | Rehabilitation
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1 | C.S. | 39 | Chronic G.N. | 0 | 54 | Full time machinist
2 | H.G. | 22 | Chronic G.N. | 100 | 54 | Full time shoe salesman
3 | R.H. | 29 | Chronic G.N. | 0 | 53 | Severe neuropathy
4 | K.C. | 38 | Chronic G.N. | 30 | 35 | Normal household
5 | D.S. | 16 | Chronic G.N. | 100 | 24 | Attends school
6 | C.H. | 17 | Chronic G.N. | 550 | 4 | Attends school
7 | McH. | 32 | Chronic G.N. | 400 | 4 | Part time office work

*Home hemodialysis patients

Figure 1. Patients on the hemodialysis program.

Nerve Conduction Time

| Patient | Common peroneal | Tibialis post | Months of dialysis |
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1 | C.S. | 25.6 | 22 | 42 |
2 | H.G. | 28.6 | 31 | 42 |
3 | R.H. | 0 | 0 | 40 |
4 | K.C. | 29.6 | 30 | 33.4 | 35 | 22 | 32 |
5 | D.S. | 36.3 | 37 | 32 | 38 | 12 | 23 |
6 | C.H. | 43 | 42 | 45 | 40 | 0 | 3 |
7 | McH. | 31 | 19 | 30 | 2 | 3 |
8 | P.S. | 27 | 43.5 | 28.8 | 38 | 2 | 9 after transplant |
9 | J.D.* | 40 | 39 | 36.8 | 37 | 4 | 14 |
10 | M.O.* | 37 | 40 | 3 |

Normal 40 m/sec or more
*On periodic peritoneal dialysis

Figure 2. Nerve conduction times. For both nerves there are 2 determinations, corresponding to the months of dialysis shown in the right hand columns.

Figure 3. Multiple soft tissue calcifications (1962).

Figure 4. Disappearance of calcifications (1964).
Figure 5. Peritoneal cycling machine.

Figure 6. Schematic drawing peritoneal cycling machine.

Figure 7. Cam-cycler peritoneal machine.

Figure 8. Patient J.D. First 16 months of once weekly peritoneal dialysis.