Home peritoneal dialysis

Alternative to chronic hemodialysis

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The impetus for the successful performance of chronic peritoneal dialysis was made possible by Boen et al,[1] with the development of a closed, automated system for peritoneal dialysis which reduced the incidence of peritonitis. It was subsequently demonstrated that patients could be maintained in excellent functional states for prolonged periods without protein or other depletional syndromes. The development of implantable, bacteriologically safe dialysis catheters has made it possible to treat patients successfully for as long as 7 years.

Chronic peritoneal dialysis is not only a suitable alternative to hemodialysis, but in some instances it may be preferable to hemodialysis or transplantation. The success of chronic peritoneal dialysis is a direct result of our ability to prevent peritoneal infection with a closed system of dialysis.

Selection of patients for home peritoneal dialysis

Selection criteria for chronic peritoneal dialysis vary depending on the dialysis and transplantation situation at a given institution. Although active transplantation and maintenance dialysis programs are available at the Cleveland Clinic, chronic peritoneal dialysis has evolved as a suitable alternative therapy for selected patients. Every patient accepted for chronic dialysis is carefully evaluated for possible training in home dialysis.

Based on experience at the Cleveland Clinic and other centers employing peritoneal dialysis, the conditions favoring chronic peritoneal dialysis may be listed as follows:

1. Patients without a spouse or responsible family member.
2. Patients unable to learn the technically more demanding home dialysis procedures.
3. Patients considered unsuitable for hemodialysis for medical reasons: advanced cardiovascular disease, old age, poor response to hemodialysis, complications from hemodialysis, malignancy (when prolongation of life is deemed desirable), and blindness.
4. Patients in whom anticoagulation is considered hazardous.
5. Inability to maintain reliable access to the circulation for hemodialysis.
6. As a holding procedure to await maturation of arteriovenous fistulae for hemodialysis.
7. Patients who refuse blood transfusions.
8. Young children.

The only absolute contraindications to peritoneal dialysis are an infected abdominal wall or known, extensive intraabdominal adhesions; however, several situations favor hemodialysis rather than peritoneal dialysis. Although peritoneal dialysis is technically possible despite adhesions, this procedure may be technically inadequate due to the limitation in available peritoneal dialyzing surface area. Because of the inefficiency of peritoneal dialysis, young, muscular men may require more effective dialysis time than is compatible with emotional or occupational rehabilitation. Finally, the inability to maintain adequate caloric and protein intake, despite adequate dialysis, mitigates against successful, long-term peritoneal dialysis.

Patient profiles

Since March 1972, nine patients have been trained for home peritoneal dialysis at the Cleveland Clinic.

Case 1. A 22-year-old woman with hereditary oxalosis, oxalate lithiasis, and chronic renal failure was referred for home peritoneal dialysis training after several unsuccessful attempts to establish vascular access. Her clinical course has been marked by progressive increase of oxalate deposits in the skeletal muscle, bone, blood vessels, and probably in myocardial tissue suggested by recurrent acute arrhythmias. Home peritoneal dialysis was first performed on March 18, 1972.

Case 2. A 49-year-old woman had chronic renal failure and mild arterial hypertension secondary to chronic pyelonephritis. Peritoneal dialysis was started as a holding procedure while an arteriovenous fistula matured. At the patient's request she and her husband were trained for home peritoneal dialysis which was initiated on October 30, 1973.

Case 3. A 48-year-old man had chronic renal failure and moderately severe arterial hypertension, secondary to arterial and arteriolar nephrosclerosis, peripheral neuropathy, and mental depression. He also had arteriosclerotic heart disease with angina pectoris and a remote myocardial infarct. Home peritoneal dialysis was first performed on September 12, 1973.

Case 4. A 23-year-old man with a history of congenital urethral valves, hydronephrosis and chronic renal failure underwent bilateral cutaneous ureterostomies in 1968, but progressive renal failure necessitated the institution of hemodialysis in December 1968. He was subsequently maintained on home hemodialysis until December 1973, when he was referred for peritoneal dialysis training because of inadequate vascular access for hemodialysis. Home peritoneal dialysis was first performed on February 18, 1974.

Case 5. A 61-year-old woman with chronic glomerulonephritis had a history of hypothyroidism and myxedema secondary to thyroiditis. Initially the patient was considered for home hemodialysis, but it was felt that neither she nor her husband could learn the more technical aspects of the procedure. Home peritoneal dialysis was first performed on August 1, 1974.

Case 6. A 31-year-old woman had chronic renal failure secondary to arteriolar nephrosclerosis and malignant hypertension. Her clinical course has been complicated by recurrent congestive heart failure, pancreatitis, and toxic hepatitis. Hemodialysis had been instituted in August 1968, and the patient had been maintained on home hemodialysis until problems with vascular access necessitated peritoneal dialysis training in May 1974. Home peritoneal dialysis was first performed June 12, 1974.

Case 7. A 32-year-old man with systemic lupus erythematosus, remote duodenal ulcer, and progressive renal insufficiency had also undergone splenectomy for thrombotic thrombocytopenic purpura. His religious affiliation would not allow blood transfusions, and he was referred for peritoneal dialysis training. Home peritoneal dialysis was first performed on September 2, 1974.

Case 8. A 59-year-old woman with chronic glomerulonephritis had a history of nephrotic syndrome and progressive renal failure, secondary hypertension, and congestive heart failure. Peritoneal dialysis was instituted as a holding procedure, and the patient and her husband requested home training. Home peritoneal dialysis was first performed on July 26, 1974.

Case 9. A 46-year-old woman had a 23-year history of insulin dependent diabetes mellitus, retinopathy, peripheral neuropathy, and renal failure. She also had orthostatic hypotension secondary to an autonomic neuropathy. Home peritoneal dialysis was first performed on February 13, 1975.

Access to the peritoneal cavity

In all cases, access to the peritoneal cavity was obtained with indwelling silastic catheters (*Fig. 1*). Single cuff catheters were inserted under local anesthesia, usually in a midline position approximately 2 cm below the umbilicus. In patients who have had abdominal surgery and midline scarring, a position lateral to the rectus muscles may be chosen at the level of the umbilicus. The catheter is inserted through a stab incision in the skin with a trocar designed for insertion of cuffed catheters. Once through the peritoneum, the catheter is directed toward the left pelvic gutter and advanced until the Dacron felt cuff is seated in a subcutaneous location. Care is taken to suture skin and subcutaneous fat snugly around the catheter. Leaving the subcutaneous fat adherent to the skin helps to cushion the skin over the Dacron felt cuff. Careful attention must be given to aseptic technique when the catheter is inserted at the

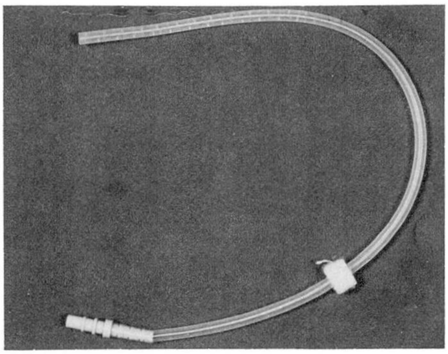

Fig. 1. Silastic catheter with single Dacron felt cuff and plastic adapter.

bedside. Two to 3 liters of heparinized dialysate is inserted into the peritoneal cavity before insertion of the catheter. Priming the abdomen with fluid makes trocar insertion easier and safer and facilitates subsequent positioning of the catheter.

A silastic catheter with a single Dacron felt cuff is preferred to catheters with two Dacron felt cuffs, because single cuff catheters are easier to implant and remove. Double cuff catheters require the construction of a subcutaneous tunnel between the two cuffs, thus complicating both initial insertion of the catheter and its subsequent removal if there are dialysis related catheter problems.

Following catheter placement, dialysis with heparinized dialysate is started immediately and continued for 1 to 2 days. If dialysate drainage is clear the procedure is terminated and a heparin lock is placed in the catheter, which is subsequently capped, using careful aseptic technique. Between

Table 1. Indwelling silastic catheter experience in nine patients on home peritoneal dialysis

Case	Catheter life* Date inserted	Date removed	No. of days	Reason for removal
1	(1) 2-19-72	6-12-73	477	Catheter cuff infection; elective replacement
	(2) 6-12-73	12-24-73	195	Protrusion of Dacron cuff through skin; elective replacement
	(3) 12-24-73	...	523	Functioning
2	(1) 8-31-73	2-15-74	168	Catheter cuff infection, subsequent peritonitis, drainage difficulties
	(2) 2-20-74	2-26-74	6	Separation of incision, protrusion of Dacron cuff
3	(1) 8-28-73	1-14-74	139	Catheter cuff infection, subsequent peritonitis
	(2) 2-8-74	...	97	Patient died at home of acute myocardial infarction; catheter functioned until death
4	(1) 12-24-73	4-24-75	485	Fibrin encasement of catheter, poor drainage
	(2) 4-24-75	...	37	Functioning
5	(1) 4-23-74	...	282	Mental deterioration, possible cardiovascular accident; catheter functioned until death (1-30-75)
6	(1) 5-2-74	4-30-75	363	Peritonitis followed by occlusion of catheter due to fibrin encasement
	(2) 5-1-75	...	30	Functioning
7	(1) 5-29-74	...	367	Functioning
8	(1) 6-10-74	...	351	Functioning
9	(1) 10-1-74	...	242	Functioning
Total			3,762	

* Insertion dates do not correspond to date of first peritoneal dialysis and precede by variable period the date of first home dialysis.

dialyses the catheter is protected by a small dry dressing taped to the skin of the abdominal wall.

During the period of observation, 15 catheters were placed in nine patients (*Table 1*). Of the seven catheters removed, replacement of three was necessary because of infections of the subcutaneous Dacron felt cuff, and two required replacement because of protrusion of the cuff through the skin. In two others, replacement was necessary because of catheter encasement and poor drainage.

The average catheter life of the seven catheters requiring replacement was 262 days. When infection was not a problem, the catheter was replaced at the time the prior indwelling catheter was removed. In complicating peritoneal infection, catheter replacement was delayed until the infection had been controlled with appropriate antibiotic therapy with one exception. One patient (case 6) received antibiotics for peritonitis, which was apparently controlled prior to encasement and obstruction of her catheter. In this patient catheter replacement was accomplished 24 hours after removal of the prior catheter at a time when dialysate drainage was sterile. She subsequently received an additional 3 weeks of antibiotic therapy.

Dialysis equipment

Our home training program was initiated utilizing Cobe Laboratory's automatic peritoneal dialysis proportioning machine (*Fig. 2*). Water of acceptable purity was provided by reverse osmosis water purification. The water, sterilized by heat and pressure and cooled to body temperature, undergoes proportion mixing with a sterile sugar-electrolyte concentrate prior to delivery.

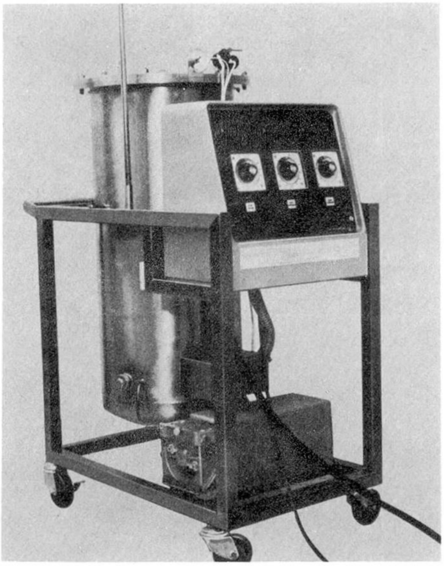

Fig. 2. Cobe automatic peritoneal dialysis machine with 80-liter stainless steel tank and proportioning unit complete with conductivity and temperature alarms. (This unit no longer in production.) Water provided by a separately purchased reverse osmosis water purification system.

That reverse osmosis may also serve as a means of water sterilization has led to the development of "second generation" dialysis proportioning machines, in which sterile, pyrogen-free dialysate is prepared from tap water and sterile sugar-electrolyte concentrate at the time dialysis is in progress. Patients in our program are presently trained on the Drake-Willock automatic peritoneal dialysis machine (*Fig. 3*). Peritoneal dialysis has lost some of its simplicity as sophisticated, automated proportioning systems have been developed; this is more than compensated by the protection from infection offered by a closed automated delivery system. Automation enables patients to carry out unattended, over-

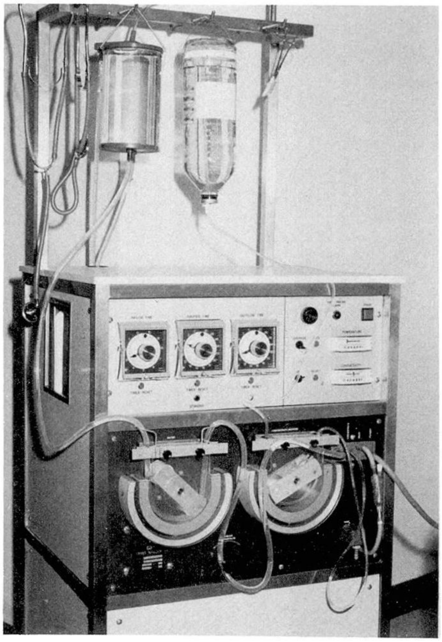

Fig. 3. Drake-Willock automatic peritoneal dialysis machine. This unit contains a reverse osmosis water purification system and proportioning system.

night self-dialysis at home and significantly reduces operating costs.

Complications

Peritonitis is the most serious complication of peritoneal dialysis, but of the nine patients in this study, only three had peritoneal infections; in two, the cause of peritoneal infection was infection of the subcutaneous catheter cuff; the same organism was isolated from dialysis fluids and catheter exit site. In only one patient (case 6) was peritonitis presumed to be due to a break in dialysis technique.

Catheter cuff infections were noted in three instances and were complicated by peritonitis in two patients in the later stages as noted above. In one instance of catheter erosion through the skin, infection was not a precipitating factor and the catheter was replaced electively.

In two instances, catheter encasement, presumably by fibrous adhesions, occurred, and in one, peritonitis was the initiating factor. Catheter encasement can be demonstrated by injection of x-ray contrast material. Puddling and poor diffusion of dye will be noted under fluoroscopy, with a double contour outlining the catheter and surrounding fibrous sheath. The catheter must be removed and replaced at a different site to reestablish adequate drainage.

Other unusual complications have been of little consequence. Transient inflow pain can be related to the position of the intraabdominal portion of the dialysis catheter; this portion of the catheter may move about within the peritoneal cavity. Transient catheter obstruction is caused by small blood clots or fibrin plugs. Except for the first several dialyses after implantation of a catheter, heparin is not routinely added during subsequent dialyses, although a heparin lock is left in the catheter at the termination of each dialysis. A plugged catheter may be cleared by vigorous irrigation, but occasionally will require careful passing of a Fogarty catheter under sterile conditions to dislodge a blood clot or fibrin plug.

Functional obstruction occurs occasionally and may be due to a number of mechanisms: kinking of the catheter, tissue incarceration into the side holes of the catheter, or omental or bowel entanglement. Catheter function may be improved by repositioning the catheter with a stiff guidewire or by simple measures such as ambulation, bowel stimulation with laxatives, or merely a delay of 12 to 24 hours before resuming dialysis.

Replacement of catheters

Catheter replacement can be performed on an outpatient basis. The skin is prepared as for implanting the catheter, and following generous infiltration of the skin and subcutaneous tissues with a local anesthetic around the Dacron felt cuff, small radial incisions are made through the skin 1 to 2 cm from the catheter. The felt cuff is easily freed by blunt dissection and the catheter can be removed. If a new catheter is to be inserted at this time, 2 to 3 liters of heparinized dialysate are left in the peritoneal cavity and the catheter is inserted in a new location. Implantation of the new catheter is followed by 1 to 2 days of lavage with heparinized dialysate. When catheter replacement is necessitated by peritoneal infection, we prefer to irradicate the infection before replacing a new indwelling catheter. Patients are maintained by "single stick" catheter placements with commercially available, semi-rigid plastic catheters and intermittent dialysis until a new indwelling catheter can be inserted.

Back-up dialysis requirements

Most centers caring for large groups of patients on home hemodialysis estimate that 5% to 10% of total dialysis time each year will be spent in the hospital for management of dialysis related complications or medical problems. A total of 932 peritoneal dialyses were performed on the nine patients reported here, after home training (*Table 2*). Of the total, 122 dialyses were performed in the hospital. Although the number is somewhat higher than reported in larger hemodialysis programs, 13.1% of dialyses performed, it must be appreciated that the patients selected for home peritoneal dialysis have been less than optimal dialysis candidates. Most patients trained for home peritoneal dialysis were considered unsuitable for

Table 2. Total dialysis experience from initiation of home dialysis

			Location of dialysis		Type of problem		
Case	Age/sex	Total dialyses	At home	In hospital	Dialysis related	Non-dialysis (medical)	Current status
1	22 F	342	302	40	17	23	Home peritoneal dialysis
2	49 F	28	18	10	10	0	Hemodialysis
3	48 M	65	27	38	38	0	Died
4	23 M	151	141	10	4	6	Home peritoneal dialysis
5	61 F	48	38	10	0	10	Died
6	31 F	127	120	7	7	0	Home peritoneal dialysis
7	32 M	59	59	0	0	0	Home peritoneal dialysis
8	59 F	91	84	7	4	3	Home peritoneal dialysis
9	46 F	21	21	0	0	0	Home peritoneal dialysis
Total		932	810	122	80	42	

hemodialysis. Of the 122 dialyses performed in the hospital, 80 were the result of dialysis-related complications including peritonitis or catheter cuff infections, drainage difficulties, or mechanical breakdown of home dialysis machines. Intercurrent medical complications resulted in 42 dialyses being performed in the hospital during the management of such problems as pulmonary infections, cardiovascular complications (chest pain, acute arrhythmias), musculoskeletal pain, elective surgical procedures (parathyroidectomy, nephrectomy), or mental deterioration with depression.

The extremely low incidence of peritonitis related to faulty technique or to dialysis equipment (one episode in 932 dialyses) must be credited to the availability of closed, automated dialysis delivery systems, to the technical ability demonstrated by patient and spouse, and to the care taken by the hospital dialysis staff in teaching aseptic techniques during home training. Every center involved in home peritoneal dialysis training has been impressed with the low risk of peritonitis associated with home peritoneal dialysis. It is widely appreciated that repeated peritoneal dialyses performed in the hospital with commercially available dialysate and necessitating frequent bottle changes carry a risk of peritoneal infection as high as 15%. Variance in this risk of infection is contingent upon whether hospital dialysis teams rely upon prophylactic antibiotics added to each bottle of dialysate. The low risk of infection in our home dialysis patients is even more impressive when it is considered that prophylactic antibiotics are not part of our home dialysis routine.

Adequacy of dialysis

Table 3 lists values for the blood urea nitrogen (BUN) and serum creatinine concentrations. Additional values were obtained each time the patient started home peritoneal dialysis and, therefore, represent variable periods of time on dialysis prior to determination of these values. At the time recent values were obtained, patients were receiving from 120 to 160 liters of dialysate per week depending upon body size and build. At flow rates of 4 to 5 liters per hour, this represented from

Table 3. Blood chemistry values during peritoneal dialysis

Case	Blood urea nitrogen (BUN) mg/100 ml		Serum creatinine mg/100 ml		Albumin/total serum proteins mg/100 ml	
	Initial	Recent	Initial	Recent	Initial	Recent
1	51	60	12.6	9.4	2.3/4.9	2.7/4.7
2	77	101	10.8	12.2	3.6/5.8	4.0/6.6
3	103	40	20.9	8.9	2.1/5.2	2.9/5.5
4	132	30	22.6	9.7	3.3/6.2	3.6/6.3
5	67	52	12.8	10.0	3.5/5.2	3.3/5.9
6	55	33	8.2	7.3	2.8/5.6	3.6/7.0
7	111	111	16.0	19.8	3.6/6.3	2.8/5.3
8	132	86	13.8	13.4	2.8/5.0	2.8/5.1
9	185	138	10.1	9.9	3.4/6.1	3.7/6.3
Averages	101	72	14.2	11.1	3.0/5.6	3.3/5.9

24 to 40 hours of dialysis per week and was often accomplished as unattended overnight dialysis.

Adequacy of dialysis is difficult to define. The control of uremia and blood pressure are probably the best determinations for adequacy of dialysis. The control of uremia was judged by BUN and creatinine values, general well-being of the patient, maintenance of adequate dietary intake, and the absence of uremic gastrointestinal symptoms, pericarditis, or progressive peripheral neuropathy.

By the criteria listed here, eight of nine patients in this study were considered to be adequately dialyzed. One patient (case 7) experienced progressive sensory motor neuropathy in the early months of dialysis. Because of a difficult home situation he was receiving only 80 liters of dialysate per week which was not considered adequate, and a careful dietary history revealed a questionable protein and total caloric intake. His peripheral neuropathy stabilized when dialysate was increased to 160 liters per week and dietary intake was improved. Recent values of BUN and creatinine for this patient remain high but are believed to reflect mechanical difficulties with the machine (Cobe APD machine), which has necessitated recent retraining of this patient with a newer Drake-Willock APD machine. Eight patients were considered to be receiving adequate dialysis during the period of observation. Recent BUN and creatinine values were generally lower; patients were ambulatory, maintained adequate dietary protein and total caloric intake without complaints of anorexia, nausea, or vomiting, and had no clinical evidence of pericarditis or progressive neuropathy.

One patient (case 2) whose catheter problems necessitated a transfer to hemodialysis, had higher BUN and creatinine values when last checked prior to institution of hemodialysis; yet she, too, apparently had received adequate dialysis until the time of transfer to hemodialysis.

Protein and amino acid losses were not of a magnitude to cause problems with maintenance of adequate nutrition with the possible exception of one patient (case 7). Depletional syndromes, which have been noted in patients undergoing prolonged peritoneal dialysis, tend to occur as a result of poor nutritional intake, and such patients appear to be susceptible to peripheral neuropathy. This patient (case 7) was the only one in the study to have decreased serum protein levels during his clinical course, and was also the only patient to experience progressive peripheral neuropathy.

Protein intake of at least 1 g/kg of body weight per day is encouraged in all patients, and all received supplementary therapeutic vitamins and folic acid. There is evidence that many patients on chronic dialysis are in a chronic state of negative protein balance or lack sufficient amounts of specific amino acids. Adequate dietary intake of high biologic value protein and calories must be assured and, when indicated, should be supplemented with essential amino acids.

Transfusion requirements have been significantly lower in patients undergoing chronic peritoneal dialysis than in patients on hemodialysis, partly because the former do not experience obligatory blood losses with each dialysis. Nine patients in this study received 37 transfusions during the period of observation, representing more than 10 patient years of peritoneal dialysis, an average of fewer than four transfusions each year in this patient group. Folic acid, 2 mg per day, is prescribed routinely and iron is administered orally if periodic serum iron saturations fall below 20%.

Summary

Peritoneal dialysis, performed independently in the home, is a suitable alternative to chronic hemodialysis for patients with end-stage renal disease. Treatment out of hospital has been made possible with the development of indwelling silastic catheters and automatic peritoneal dialysis delivery systems.

Patients selected for home peritoneal dialysis can be provided adequate dialysis with a minimal risk of peritonitis or other dialysis related complications. It is expected that the relative ease and safety of peritoneal dialysis and the ready availability of sophisticated dialysis delivery systems will result in increasing numbers of patients being accepted and trained for home peritoneal dialysis.

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