THE ADEQUACY OF SIX LITRE DAILY CONTINUOUS AMBULATORY PERITONEAL DIALYSIS

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Summary

The early clinical, biochemical and haematological response of 14 patients to 6L daily continuous ambulatory peritoneal dialysis (CAPD) is described. Clinical and biochemical control is adequate and the improvement of haemoglobin levels is excellent. Provided the patients are closely monitored, a significant proportion of patients can be managed with three exchanges daily.

Introduction

Since the introduction of continuous ambulatory peritoneal dialysis (CAPD), this therapy has been adopted enthusiastically by many centres. This enthusiasm has yet to be justified by long term morbidity and mortality data, although convenience for the patients and reduced cost may be reasons for preferring CAPD to conventional dialysis. The standard CAPD regime for adults consists of four or five 2L exchanges per day with occasional patients given a trial of three exchanges daily only if biochemical control is excellent [1, 2]. In our unit, we attempt to manage all CAPD patients with three exchanges daily. So far, only one patient, a tall muscular young man, has required more than 6L dialysate daily. This paper follows the early clinical and biochemical progress of all our patients on three exchanges daily.

Patients

We have studied 14 patients, 9 female and 5 male. At the time of starting CAPD, their mean age was 51.8 ± 11.9 years and mean body weight 57 ± 7.2kg. During the period immediately before CAPD, 13 had been managed with intermittent peritoneal dialysis (mean = 82L/week — three sessions of 12 hours duration weekly) and one with diet alone.

The underlying renal pathology varied: only one patient had polycystic renal
disease and two diabetes mellitus. Urinary creatinine clearance before CAPD was \(1.38 \pm 1.53\text{ml/min} \) (range 0–4.7) and on CAPD \(0.82 \pm 0.76\text{ml/min}\). Urine volumes on CAPD averaged \(184 \pm 167\text{ml/24 hours} \) (range 0–590ml).

Patient selection was determined by unsuitability for home haemodialysis. The precise reasons cover a wide range of medical and social problems.

**Methods**

Our patients perform their three bag changes in much the same way as described by Oreopoulos [2]. The first and third daily bags are changed immediately after rising and before retiring to bed. Patients are allowed to select the timing of their intermediate bag change, the only stipulation being that it must be separated from the others by at least three hours. This flexible regime permits a full working day without concern for dialysis.

**Results**

The following results are derived from 83 patient months but are essentially preliminary. Only two patients have been on CAPD for more than one year and five for more than six months.

Pre CAPD blood samples were taken before intermittent PD sessions (in the 13 patients on intermittent PD). This must be considered when interpreting the changes from pre CAPD to CAPD biochemical values.

Table I displays the mean latest values for a variety of biochemical, haematological and clinical parameters on 6L daily CAPD. Mean changes from pre CAPD values and the significance of these changes are also listed. Two tailed \(p\) values were calculated using the Student’s \(t\)-ratio.

Except for the one patient managed with a low protein diet during the pre CAPD period, all biochemical measurements, both in the pre CAPD and CAPD periods, were made while the patients were encouraged to eat a 100g protein diet. High potassium foods were strictly limited on intermittent PD but there was gradual liberation to an almost unrestricted potassium diet on CAPD.

Dietary phosphate has not been specifically limited and the fall of serum inorganic phosphate from pre CAPD to CAPD levels occurred in spite of a reduction in the prescription of phosphate binders. No patient on CAPD has been prescribed allopurinol, potassium supplements or salt supplements.

The marked haematological improvement was achieved without routine iron or vitamin supplements. No patient required androgen therapy and only two units of blood have been given (the first following a severe haemorrhage from an arterio-venous fistula during a period of haemodialysis to permit eventual insertion of a second soft PD cannula, and the second to replace blood loss during repair of an incisional hernia).

Control of hypertension has been accompanied by a marked reduction of antihypertensive therapy. There have been only two episodes of postural hypotension sufficiently severe to require hospitalisation, and in no patient has this problem been sustained. Reduction in the electrocardiographic left ventricular complex size just fails to reach statistical significance. Control of acid-base status has not
TABLE I. Laboratory and clinical changes observed with 6L daily CAPD

<table>
<thead>
<tr>
<th></th>
<th>Mean latest value</th>
<th>Mean change from</th>
<th>Number of patients</th>
<th>Significance of change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>on CAPD ± SD</td>
<td>pre CAPD value</td>
<td>compared</td>
<td></td>
</tr>
<tr>
<td>Plasma urea (mmol/L)</td>
<td>22.53 ± 4.65</td>
<td>- 5.02</td>
<td>13*</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Plasma creatinine (µmol/L)</td>
<td>916 ± 189.5</td>
<td>- 188.5</td>
<td>13*</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Plasma potassium (mmol/L)</td>
<td>4.79 ± 0.65</td>
<td>+ 0.1</td>
<td>14</td>
<td>NS</td>
</tr>
<tr>
<td>Serum inorganic phosphate (mmol/L)</td>
<td>1.61 ± 0.36</td>
<td>- 0.79</td>
<td>10†</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Serum uric acid (µmol/L)</td>
<td>402 ± 35</td>
<td>- 150</td>
<td>8‡</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>59.5 ± 6.83</td>
<td>+ 3.2</td>
<td>10†</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Plasma albumin (g/L)</td>
<td>36.93 ± 3.5</td>
<td>+ 1.74</td>
<td>14</td>
<td>NS</td>
</tr>
<tr>
<td>Haemoglobin (g/dl)</td>
<td>10.47 ± 0.93</td>
<td>+ 3.42</td>
<td>10†</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Red cell mass (L)</td>
<td>1.39 ± 0.348</td>
<td>+ 0.455</td>
<td>4◊</td>
<td>NS</td>
</tr>
<tr>
<td>Standing systolic blood pressure (mmHg)</td>
<td>132 ± 29.9</td>
<td>- 27</td>
<td>10†</td>
<td>p &lt; 0.05</td>
</tr>
<tr>
<td>Standing diastolic blood pressure (mmHg)</td>
<td>84.5 ± 18.4</td>
<td>- 16</td>
<td>10†</td>
<td>p &lt; 0.01</td>
</tr>
<tr>
<td>Size of left ventricular complex (V1S + V5R or V6R) (mm)</td>
<td>30.8 ± 13.8</td>
<td>- 11.8</td>
<td>5♦</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS Not significant  
∗ One patient excluded (not on dialysis pre CAPD)  
† Comparison confined to those on CAPD for ≥ 3 months  
‡ Patients on CAPD for ≥ 3 months minus 2 patients on allopurinol pre CAPD  
◊ Comparison after 6 months CAPD in a haematological study sub group  
♦ Comparison confined to those on CAPD for ≥ 6 months

been a problem on 6L daily CAPD. Only one of the monthly plasma bicarbonate values was outside the normal range. The 24 hour protein loss in the dialysate was 6.43 ± 2.25g.

There has been no pericarditis and no clinical progression of peripheral neuropathy. Peritonitis has been a problem, but only seven episodes occurred during 83 patient months (one episode/11.9 patient months). Of these, four were pyogenic, one fungal and two ‘sterile’. Eight of the 14 have not had peritonitis.
Rehabilitation has been reasonable considering the patients’ age and multiple medical and social problems. Three are working full-time, five part-time and one is able to work part-time but cannot find suitable work. Their general fitness has been good although one young diabetic weighing 67kg who is now a successful transplant recipient was managed for two weeks pre transplant with four exchanges daily and noticed a small improvement of his energy during that period. He says, however, that this would have been insufficient for him to select four instead of three exchanges daily while working full time.

After developing strokes — occurring at a time when blood pressure control was satisfactory — two of the patients have had dialysis discontinued and have subsequently died. The first, a young girl with diabetes mellitus, had been placed on CAPD as a last resort when renal transplantation, haemodialysis and intermittent PD had all failed to provide a reasonable quality of life. During an episode of candida peritonitis, she developed a candida septicaemia and then a facial and bulbar palsy. After discussion with the patient’s family, dialysis was withdrawn. The second death was of a middle aged woman with hypertensive nephrosclerosis. During her four months CAPD, she was always above her ideal weight. She eventually became normotensive under the influence of three days all high dextrose dialysis and then developed a complete hemiplegia. Post-mortem examination demonstrated an extensive cerebral infarct and widespread fibrotic and calcified cerebral thrombi.

Discussion

Biochemical control by 6L daily CAPD, as measured by the parameters shown, seems adequate for the group of patients described. These indices cover only a narrow range of small molecular weight uraemic toxins. The peritoneal membrane is markedly inferior to standard haemodialysis membranes at clearing this size of molecule, but as molecular size increases peritoneal clearance approaches haemodialysis clearance [3, 4]. Popovich has estimated a B12 clearance of 36L/week through 6L daily CAPD and of 28L/week through 15 hours weekly haemodialysis [5]. Therefore, any biochemical evidence of under-dialysis on 6L daily CAPD is likely to be found using small molecule blood levels or clearance data.

The significant and consistent improvement of haemoglobin testifies to the adequacy of dialysis, compares favourably with reported data for 8 or 10L daily CAPD [1, 6, 7] and is similar to the rises described by Flynn et al using 6L daily CAPD for a diabetic population [8]. All our patients have shown a marked rise in haemoglobin including two anuric patients and the degree of improvement seems to be independent of the renal pathology, the residual renal function or the weight of the patient.

The patients described are older and lighter than most dialysis populations. However, until long term morbidity and mortality data from comparative studies of CAPD and haemodialysis become available, we can feel fully justified in using CAPD only for patients for whom home haemodialysis is contraindicated. Many such patients will be undernourished and may not (at least initially) require intensive dialysis.

Using three exchanges daily limits the cost of disposables to less than £2,800/
year. Any cost comparison should include the consideration that, because of the nature of the patients, the alternative to CAPD is often hospital — based dialysis, a more costly system than home haemodialysis. Restriction of the number of exchanges should improve the incidence of peritonitis with a resultant reduction of additional expenses.

Rehabilitation has been reasonable and we believe that a significant factor in this and in patient acceptance of this treatment has been the avoidance of a mid-working day exchange. CAPD using four exchanges per day is not obviously more convenient for the patients than intermittent dialysis regimes [9]. In the absence of under-dialysis, limitation to three exchanges per day allows the patient more freedom for both work and leisure.

Acknowledgments

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References

2 Oreopoulos DG, Robson M, Izatt S, Clayton S, de Veber GA. *Trans ASAIO* 1978; 24, 484
3 Henderson LW. *Kidney International* 1973; 3: 409
5 Popovich RP. *Dialysis and Transplantation* 1978; 7: 823
8 Flynn CT, Hibbard J, Dohrman B. *Proc EDTA* 1979; 16: 184
Open Discussion

BOEN (Chairman) You may remember that in 1963 it was suggested we use the average creatinine clearance as an index of adequacy of peritoneal dialysis. The observations in the early sixties were that the average creatinine clearance in patients with peritoneal dialysis was about 4ml/minute against an average creatinine clearance for haemodialysis patients of 10ml/minute. In the two situations the health of the patients were comparable. I believe that in patients using 6 litres/day the creatinine clearance, if you calculate it, is about 3ml/minute, so they have 3ml/minute plus their own residual renal function. I am very happy that you have shown it is possible to treat patients with fewer exchanges and still treat them as well as can happen. I would like to ask you one question though about the difficulty of decreasing the number of exchanges and removing of fluid by ultrafiltration. If you keep the fluid in longer than 6 to 8 hours, this will be reabsorbed again. Can you tell me what kind of hypertonic solution you are using for the long period of stay in the abdominal cavity?

FORBES We use Travenol solutions, so the high dextrose solution is 3.86% anhydrous dextrose solution. We do have one or two patients who routinely gain fluid from the low dextrose exchanges, but they usually can manage by using extra high dextrose exchanges. On 2 occasions over the last 18 months I have had to suggest that one patient occasionally uses a fourth bag if they are having difficulty maintaining their weight, but this was required only as a temporary measure.

BOEN Well I think this is very surprising.

LEGRAIN (Paris) We should be very cautious about thinking that 3 exchanges a day will be enough. We have learned from a long experience with haemodialysis, that haemodialysis should be adapted to each case and our experience with CAPD shows the same. Some patients will do very well with 3 exchanges per day. Your group is only 55.7Kg mean weight and you have a 1.6 creatinine clearance as residual renal function, so this is okay, but some patients do require 4 exchanges, some do require 5 and some require 2 only, and this has been well demonstrated by the group in Toronto. So I think we must state clearly that CAPD should be adapted to each case. You have proven in your data excellently that some patients will do very well with 3 exchanges, but we must be afraid that many patients will be wishing to move from 4 to 3 and some will be under-dialysed. CAPD can lead to under-dialysis as with any other techniques.

FORBES I am not suggesting that every patient should be managed with 3 exchanges per day, but the data presented earlier suggested that only 10% of the European CAPD population are being treated in this way. I think that our data has shown that perhaps it should be larger than 10%.

WOLF (Vienna) You showed in one of your slides that among the indications for CAPD are high age and low intelligence. I wonder if there is any difference in the incidence of peritonitis between the older patients with low intelligence and the remainder of the patients.

FORBES I have not got enough patients or enough data to answer that in any scientific way.

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KHANNA (Toronto) We have 22 patients having 3 exchanges per day using 6 litres and there are 10 patients who have gone over one year. Biochemically they did have a higher BUN, serum creatinine and phosphorus as a group and their haemoglobins have dropped. None of these values were significant statistically. The significant problem which we have noticed in these patients is that they have a higher mean blood pressure and they tend to retain fluid more than they did when they were on 4 exchanges.

FORBES There may be a tendency for the haemoglobin to drop after one year irrespective of whether you change them from 4 to 3 exchanges per day or keep them on 4 exchanges per day.

KHANNA This fall in haemoglobin was greater than it was for those who were on 4 exchanges after 1 year.

BOEN I think we should watch the residual renal function whatever schedule you use because this is like haemodialysis; you have to adapt the duration of dialysis to the renal function.

RIAZI (Abadan) While using the solutions with dextrose 4.25% in some of my patients, not one, but several cases, they have become overloaded and we have had to add dextrose to make an even higher osmolality solution. Have you had any experience in this matter?

FORBES No.