CONTINUOUS AMBULATORY PERITONEAL DIALYSIS (CAPD) IN THE TREATMENT OF END-STAGE RENAL FAILURE

N M Thomson, R G Walker, G Whiteside, D F Scott, R C Atkins

Prince Henry’s Hospital, Melbourne, Victoria, Australia

Summary

Our experience of CAPD in 21 patients over a total period of 118 patient months has been evaluated and compared with intermittent peritoneal dialysis (IPD). CAPD was associated with greater clearance of urea creatinine and phosphate, higher concentrations of haemoglobin, improved control of hypertension and saline overload, and better patient acceptance than IPD. It is concluded that CAPD is an effective form of dialysis with many advantages over IPD, although the incidence of peritonitis is still twice that of IPD.

Introduction

The value of conventional intermittent peritoneal dialysis (IPD) in the management of end-stage renal failure is now well established [1, 2]. We have recently reported our experience with maintenance IPD in 54 patients [3]. The major disadvantage of IPD is the long period of relative immobility required for dialysis. In 1976 Popovich et al [4] described the technique of continuous ambulatory peritoneal dialysis (CAPD) by which patients could be dialysed continuously 24 hours a day, seven days a week whilst still conducting their day to day activities. Subsequent studies by Popovich [5] and Oreopoulos [6–9] have highlighted several major advantages of CAPD over IPD and haemodialysis. These include: continuous steady-state biochemistry; better clearance of urea and creatinine; short patient training period and cheaper dialysis. However, a major disadvantage has been a relatively high incidence of peritonitis.

In this paper we have reviewed our experience with CAPD in 21 patients over a total period of 118 patient months. In 12 of these patients, preceding IPD has been compared with subsequent CAPD.
Methods

Patients

Since June 1978, 22 patients (13 males, 9 females) have been trained in the technique of CAPD and have continued CAPD for at least one month. The data of 21 patients have been reviewed; the remaining patient having transferred to another city. Nine of these patients received CAPD as their first type of dialysis. Twelve patients had previously been on IPD and we have compared their experience on IPD with subsequent CAPD. The mean age of the patients was 43.9 years (range: 6–68 years). However four patients were under 14 years and 11 patients over 50 years. One patient was a diabetic.

Technique of CAPD and IPD

All patients on CAPD or IPD were dialysed through an indwelling chronic peritoneal catheter (Tenckhoff). Patients on CAPD received 2 litres (1 litre in two children) of dialysate containing 1.5g/100ml (occasionally 4.5g/100ml) dextrose at four hourly intervals (eight hours overnight), the previous instillation being drained by gravity immediately prior to the next instillation. The empty plastic dialysate bag was left strapped to the abdomen between exchanges. The patients were taught to connect the connection tubing to the dialysate bag and perform the weekly change of connecting tubing, by a strict aseptic, non touch technique. IPD was performed as previously described [3].

Patients on CAPD were encouraged to eat a high protein diet. Salt and potassium intake was restricted only in patients who developed hypertension, oedema or hyperkalaemia on free intake.

Patient Observations and Chemistries

Patient weight, blood pressure, dialysate drainage volume and clinical saline status were closely monitored. Once stabilised on CAPD or IPD, the serum concentrations of urea, creatinine, electrolytes, glucose, albumin, calcium and phosphate, lipids and the haemoglobin concentration were assessed monthly. In addition losses of protein from the peritoneum were determined. In five patients on CAPD, studies of peritoneal clearance of urea and creatinine and radiolabelled vitamin \( B_{12} \) were undertaken by the Centre for Biomedical Engineering of the University of New South Wales, as part of an Australia-wide study of peritoneal clearance on CAPD. Finally, the acceptance of CAPD by patients was assessed.

Peritonitis

Effluent dialysate fluid was routinely cultured each month in all patients as well as when peritonitis was suspected. Peritonitis was diagnosed when patients developed abdominal pain (with or without fever) associated with cloudy outflow dialysate containing increased numbers of polymorphonuclear leucocytes with or without positive (including anaerobic) bacterial culture. Whilst awaiting the results
of bacteriological culture, the patients were hospitalised and treated with continuous peritoneal lavage containing antibiotics, (ampicillin 100mg/L or methicillin 100mg/L or gentamicin 20mg/L), for three to five days, followed by resumption of CAPD and antibiotics for a further five to ten days.

Results

Period of CAPD and Outcome

The mean time spent on CAPD was 5.6 months (range: 1-9.5 months). All patients were successfully trained for home CAPD, most within a week. Fourteen patients are still on CAPD (mean time 6.7 months). Seven have ceased CAPD, only one because of repeated episodes of peritonitis. Three patients received a successful renal transplant, one was transferred to haemodialysis for elective hip surgery, one died of myocardial infarction and one was transferred to IPD because of abdominal discomfort.

Biochemistry, Haematology and Peritoneal Clearance

As shown in Table I, mean serum creatinine and urea concentrations on CAPD were 0.71mmol/L and 17.4mmol/L respectively, indicating very adequate dialysis. In the 12 patients changed from IPD to CAPD, the mean concentrations of

Table I. Biochemical and Haematological Assessment of all CAPD Patients and 12 Patients Comparing IPD with CAPD

<table>
<thead>
<tr>
<th>Patients changed from IPD to CAPD (N = 12)</th>
<th>All patients on CAPD (N = 21)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea mmol/L (Normal 1.7-6.7)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>25.3 (17-31)</td>
</tr>
<tr>
<td>Creatinine mmol/L (Normal 0.03-0.12)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>0.92 (0.70-1.31)</td>
</tr>
<tr>
<td>Albumin g/L (Normal 28-45)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>34.9 (27.41)</td>
</tr>
<tr>
<td>Calcium mmol/L (Normal 2.10-2.65)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>2.33 (2.01-2.46)</td>
</tr>
<tr>
<td>Phosphate mmol/L (Normal 0.90-1.35)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>1.76 (1.21-2.20)</td>
</tr>
<tr>
<td>Haemoglobin g/dl (Range)</td>
<td>7.1 (4.1-9.5)</td>
</tr>
<tr>
<td>Cholesterol mmol/L (Normal &lt;6.5)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>5.5 (3.3-8.2)</td>
</tr>
<tr>
<td>Triglycerides mmol/L (Normal &lt;1.8)</td>
<td></td>
</tr>
<tr>
<td>Mean (Range)</td>
<td>2.68 (1.1-4.7)</td>
</tr>
</tbody>
</table>
creatine and urea fell by 24% and 26% respectively when compared with pre-dialysis concentrations in IPD. The control of hyperphosphataemia was significantly better on CAPD than on IPD (26% reduction). Serum calcium rose by 6% on CAPD but this rise was not significant. Haemoglobin concentration rose in ten of the twelve patients on conversion to CAPD (mean rise 16%). None of these patients have been transfused whilst on CAPD. A small but significant increase in serum triglyceride concentrations occurred on CAPD. Hyperglycaemia was seen in only one patient, a diabetic. Hyperkalaemia has not occurred despite minimal dietary restriction of potassium; plasma bicarbonate concentrations have been normal in all patients. Serum urea and creatinine concentrations did not significantly change with time on CAPD (Figure 1) indicating that the peritoneal clearance of the molecules has not been impaired with time.

In the five patients examined, the mean peritoneal clearance of creatinine was 6.4ml/min (range: 5.3–7.1ml/min) and of urea, 7.6ml/min (range: 7.2–8.2ml/min). The clearance of radiolabelled vitamin B₁₂ was 5.4ml/min (range: 4.3–6.7ml/min).

The mean excretion of protein from the peritoneum was 2.4g/2L exchange (range: 1.5–4.5g/2L) indicating a mean loss of 12g of protein per day. Serum albumin concentrations on CAPD were not significantly different from concentrations on IPD, though both types of PD were associated with significant reductions in albumin concentrations when compared with concentrations prior to commencing dialysis (mean pre-dialysis albumin: 39.6g/L).

![Graph showing mean concentrations of creatinine, urea, albumin and haemoglobin with time on CAPD](image-url)
**Hypertension and Saline Control**

The mean 24 hour peritoneal fluid loss was 1.6L (range: 0.8–2.5L). Only three of the 21 patients on CAPD developed oedema or hypertension (diastolic pressure >95mmHg) and this was readily controlled with salt restriction. Two patients developed significant saline depletion which was also easily controlled by increasing salt intake or reduction of exchanges from five to four per day. These findings contrast with the chronic saline retention and hypertension seen in five of the 12 patients whilst on IPD.

**Patient Acceptance of CAPD**

CAPD was well tolerated by 19 of the 21 patients; one found CAPD unacceptable because of abdominal discomfort and one because of repeated episodes of peritonitis. Eleven of the 12 patients previously on IPD, preferred CAPD. Their reasons were greater freedom of movement, more liberal diet, salt and fluid intake and feeling of greater well-being.

**Cost of CAPD**

We have found CAPD to be the cheapest of all types of dialysis, the annual cost being $A5,600.

**Peritonitis**

Twenty-nine episodes of peritonitis have occurred indicating an infection rate of one per 4.1 patient months. This compares with a rate of one per 8.8 patient months for our 54 patients on IPD [3]. Six patients (29%) have had no episodes of peritonitis, 7 (32%) one episode, 4 (19%) two episodes, 2 (10%) three episodes and two patients, four episodes. Nineteen (66%) episodes have been 'sterile' despite extensive aerobic and anaerobic culture for bacteria. Thus the incidence of bacterial peritonitis was only one episode per 11.8 patient months. The most common organism was Staphylococcus epidermidis (50% of all positive cultures).

All episodes of peritonitis except one (associated with catheter tract infection which required removal of catheter) settled rapidly with peritoneal lavage and peritoneal antibiotics. The mean time spent in hospital with peritonitis was 7.0 days (range: 3–22 days). No serious or life-threatening complication occurred and on only one occasion did the peritoneal catheter become irreversibly blocked. On IPD, 48% of episodes of peritonitis have resulted in irreversible block of peritoneal catheter [3].

**Discussion**

Since the introduction of CAPD in 1976, only two groups have reported their experience with the technique in significant numbers of patients [5–8]. Like these two groups we have found CAPD to be an effective method of peritoneal dialysis with many advantages over conventional IPD.
Adequacy of dialysis on CAPD as assessed by serum concentrations of urea, creatinine, calcium, phosphate and potassium and the haemoglobin concentration was superior to IPD. Saline overload and hypertension were significantly less on CAPD compared with IPD. CAPD was also associated with steady state biochemistry avoiding the fluctuations seen on IPD or haemodialysis. Peritoneal urea and creatinine clearances were of the order of 6–8ml/min, results similar to those of Popovich [10], and superior to those obtained by IPD [10]. Moreover, the clearance of 'middle molecules' on CAPD as assessed by clearance of vitamin B<sub>12</sub>, was 80% of that for the smaller molecules urea and creatinine, results superior to IPD and haemodialysis [10]. Finkelstein has reported that peritoneal clearance falls with time on CAPD [11]. We have not found such a reduction on CAPD, though patients have only been followed for up to nine months.

In our study, CAPD was well accepted by patients and preferred to IPD. CAPD was also cheaper and home training was easier and more rapid. The latter point has allowed us to treat patients in the home when home IPD or haemodialysis seemed an impossible or very difficult task.

We have not found hypoproteinaemia, saline depletion, gastrointestinal intolerance or abdominal pain to be significant problems on CAPD. The small increase in serum triglyceride concentrations on CAPD requires further studies.

Like other groups, [5–9] we have found the incidence of peritonitis on CAPD to be twice that of IPD. Aseptic peritonitis accounted for about two thirds of all episodes. The cause of aseptic peritonitis is still largely unknown, though possible causes include difficult-to-grow organisms, endotoxin from bowel flora or dialysate contamination and chemical irritants in the dialysate. However, we have found the morbidity of peritonitis on CAPD to be minimal and episodes have been easy to treat. Only one patient has ceased CAPD because of recurrent peritonitis. Undoubtedly, our relatively good experience with peritonitis is largely due to the obsession- al way patients have been instructed in aseptic techniques, and our long experience with IPD [3]. Nevertheless, the incidence of peritonitis is still a cause for concern and remains a barrier to the acceptance of CAPD by many other dialysis units.

Acknowledgments

We are indebted to Mr David Randerson and Assoc. Professor Peter Farrell of the Centre for Biomedical Engineering, University of New South Wales, for the peritoneal clearance data.

References

1 Tenckhoff, H and Curtis, FK (1974) Nephron, 12, 420
6 Robson, MD, and Oreopoulos, DG (1978) Dialysis and Transp., 7, 999
8 Oreopoulos, DG (1979) Dialysis and Transp., 8, 460
11 Finkelstein, FO, Kilger, AS, Bastl, C and Yap, P (1977) Nephron, 18, 342