CONTINUOUS AMBULATORY PERITONEAL DIALYSIS
WITH ONLY THREE DAILY FLUID EXCHANGES

by

H. J. GOLDSMITH, ALAN FORBES AND VIVIEN REED
Sefton General Hospital, Liverpool

IT is probably premature to assess the ultimate place of continuous ambulatory peritoneal dialysis (CAPD) in the treatment of chronic renal failure. However, of the fact that it has come to stay, there can be little doubt.

This discussion will be divided into two parts: the first, a short description of the state of the art in the United Kingdom in 1980. The second, a brief account of CAPD experience in Liverpool, where we are trying to treat patients as cheaply as is compatible with a good quality of life.

Drs. Ward and Gokal have kindly allowed me to quote, prior to publication, from their United Kingdom data on CAPD, which they collected during the summer months of 1980. Of the 44 units replying before the end of the survey, 27 are already doing CAPD. It is thought that by the end of 1980, the majority of United Kingdom dialysis units will hope to offer this form of treatment. Between them, these 44 units have already trained 220 patients, but half come from only three units. Thus, a large number of units will be cutting their teeth on CAPD during the next year. The units now experiencing an unduly high infection rate with intermittent peritoneal dialysis (IPD) may well be discouraged by their initial CAPD results: recent literature warns that proficiency with IPD is a pre-requisite for successful CAPD.

The outcome in the first 220 patients is shown on table I.

|                          |       |
|--------------------------|-------|
| Transplanted             | 18    |
| Deaths                   | 13    |
| Technical or Training    | 15    |
| Failure                  |       |
| Failure due to Peritonis | 14    |
| Biochemical Failure      | 1     |

REMAINING ON CAPD 159
Bearing in mind that in only 17 of the 44 units was CAPD the first choice of treatment and that in 20 centres CAPD was used primarily on account of vascular access difficulty with haemodialysis (HD), these results are creditable in a difficult group of patients.

Theoretically, CAPD would seem to be particularly appropriate for patients awaiting a transplant, since this treatment avoids heavy capital investment in machinery and home conversion, as well as the lengthy hospital training period necessitated by home dialysis. The results of transplantation following CAPD appear comparable to those obtained following haemodialysis. However, in the view of many, it is too early to assess the place of CAPD in the long-term management of renal failure.

The units in the United Kingdom were asked what their requirements would be for an expansion of CAPD. Nearly half replied that they would need extra space and nurses. One suspects that neither will materialise in the near future and this will retard the immediate expansion of CAPD in the British Isles. In this context, it is difficult to establish whether CAPD is less nurse-intensive than HD. Oropoulos can train up to 35 patients per year in two training beds as well as supervising his patients at home with a staff of 3½ nurses and a part-time doctor, but additional space and nurses are required for any hospital readmission. The question of funding provides great difficulty: in a non budget-holding renal unit in the NHS there is a lag period of 6-18 months before increased expenditure reaches the consciousness of the area treasurer. I fear that this honeymoon period of 6-18 months is now almost over and that the increased cost of taking on additional patients over and above those funded officially will soon pre-occupy our financial masters. In this context, it would obviously be helpful to be able to demonstrate that CAPD is cheaper than intermittent PD or home dialysis.

| TABLE II | Annual Costs of CAPD |
|-----------|-----------------------|
| Disposables | £2500 |
| Guesstimates | |
| Hospital Training & Readmissions | £1200 |
| Medical & Nursing Salaries | £1000 |
| Transport | £100 |
| Investigations | £1000 |
| **Total** | **£5800** for first year |
| Subsequent maintenance | £4300 per annum |
Table II shows some cost estimates based on requisitions by a number of patients well-established on home CAPD. We have allowed for the salary of a research fellow and one research sister, who are now looking after more than nineteen patients. Our figures are based on an initial training period of 2-3 weeks and a readmission period of 1-2 weeks per annum, but we have not allowed for the period prior to commencing CAPD. These figures, even were they shown to be significant underestimates — which we do not think is likely — compare very favourably with all other forms of dialysis, whether in hospital, self-care units or at home.

As our experience grows, the cost of investigations should decrease. It is also hoped that the economics of mass production and commercial competition will enable manufacturers to hold present prices of dialysate for a period.

What then are the requirements for successful CAPD? Experience with intermittent peritoneal dialysis is essential. In CAPD there is little room for error, such as inadequate catheter handling or any other lapse of sterile technique. To obtain the necessary degree of perfection, there must, at this early stage, be some degree of specialisation amongst dialysis nurses. A nurse adept at managing several concurrent haemodialyses single-handedly, has not necessarily the qualities to execute and teach aseptic technique repeatedly and without fail and vice versa. Ideally, the required organisation and attention to detail are best provided by a doctor and one or more full time nursing sisters.

I would now like to turn to some facets of our Liverpool CAPD experience, which to date, consists of 23 patients of whom 10 are male, averaging 50 years of age. The indications for CAPD — often multiple — in the first 14 patients are shown in Table III.

| MAJOR INDICATIONS FOR CAPD |
|-----------------------------|
| SOCIAL                      | 4 |
| LOW INTELLIGENCE            | 4 |
| OLD AGE                     | 3 |
| ACCESS PROBLEM              | 2 |
| FAILED HD AND TRANSPLANT    | 2 |
| DIABETES MELLITUS           | 2 |
| ANEURYSM (CEREBRAL AND AORTIC) | 2 |
| DEAFNESS                    | 1 |
Lindsay, from Canada, in a comparative study of how patients adapt to home dialysis by haemodialysis or CAPD wrote as follows: "There is no doubt that those patients who are working, find CAPD interferes with both job and housework". Partly for this reason, partly for reasons of economy and partly because we hoped for a lower incidence of peritonitis, we thought we would try to treat all our patients with only three daily exchanges. To date, we have managed this in all of them though in the case of one tall muscular young man awaiting his first transplant, we have had to increase the content of his low dextrose bags to three litres whilst leaving his high dextrose exchanges at two litres.

It is generally acknowledged that peritonitis is the most serious complication of CAPD. Amongst our 23 patients there have been 10 episodes of peritonitis in a total of 154 patient months. The ten episodes were contributed by seven patients, one of whom, an elderly lady, who could not ultimately master a sterile technique, contributed three episodes. She has since reverted to hospital IPD. With only three daily exchanges, we have achieved a satisfactory degree of rehabilitation, comparable to that obtained with four daily exchanges.

Our method has the enormous advantage of allowing an uninterrupted eight hour work schedule. PD exchanges take place on first rising, on returning home from work and lastly before retiring. This permits fluid dwell periods of approximately eight, five and ten hours respectively over 24 hours. Our method entails a 25 per cent cost reduction on disposables, amounting to approximately £600 per annum. In addition, we are hoping to achieve a reduction in the hospital readmission rate for peritonitis, due to a 25 per cent reduction in the tubing disconnection rate and the fact that exchanges take place in the comfort of the home.

The patients who died consisted of a blind diabetic girl who had exhausted all other treatment methods including transplantation and who developed terminal generalised candidiasis. Secondly, a patient who developed cancer in his only kidney which could not be replaced after bench surgery. His subsequent blood transfusion requirements rendered him Australia antigen positive and he was placed on CAPD in a fever hospital. He died of a pulmonary embolus. Thirdly, a male patient with severe ischaemic heart disease, who following a further infarct, went into irreversible congestive failure. Lastly, a patient with hypertensive renal failure who developed cerebral infarction coinciding with her becoming "normotensive" under the influence of high dextrose dialysate. Thus only one of these four deaths, the last, could reasonably have been averted.

Control of hypertension was achieved despite a marked reduction of hypotensive therapy, with ECG evidence of reduction in left ventricular activity apparent in those on CAPD for more than six months.

Control of plasma, urea and creatinine levels has been satisfactory on unrestricted protein diets with avoidance only of large amounts of high potassium foods. A fall of serum inorganic phosphate occurred when changing from IPD to CAPD in spite of a lessened intake of phosphate binders, Fig. 1. Significantly, there have been no incidences of pericarditis or of clinical progression of peripheral neuritis. Dry body weight and plasma albumin levels have risen. Peritoneal protein loss has averaged about 6 g/day.
Biochemistry after at least 3 months CAPD

|                      | pre CAPD | CAPD 6 L daily |
|----------------------|----------|----------------|
| Serum inorganic      |          |                |
| phosphate (mmol/l)   |          |                |
| 3.0                  |          | N=10           |
| 2.5                  |          |                |
| 2.0                  |          |                |
| 1.5                  |          |                |
| 1.0                  |          |                |
| 0.5                  |          |                |
| 0.0                  |          |                |
| Serum uric acid      |          |                |
| (μmol/l)             |          | N=8*           |
| 500                  |          |                |
| 400                  |          |                |
| 300                  |          |                |

*2 patients on allopurinol excluded

Lest it is felt that this group of patients did not really need dialysis yet, the mean urinary creatinine clearance prior to CAPD was 1.38 ml/min, and during CAPD 0.82 ml/min in our first fourteen patients. The mean urine volume while on CAPD was 184 ml/24 hours.

Since one of the most striking and unexpected benefits brought about by CAPD in comparison with haemodialysis has been a sustained rise of the haemoglobin level, we have studied the haematological aspects in some detail. Dr. O. H. B. Gyde and Dr. S. W. Davies from Birmingham and Birkenhead are doing in vitro and in vivo studies on erythropoietin levels, but the results are not yet available. It is hoped that these may throw light on the mechanism of the rise of the haemoglobin occasioned by CAPD in uraemic subjects as shown in Figure 2. The number of patients treated for more than one year is insufficient to predict whether the secondary fall of haemoglobin level observed by some workers after 9-12 months of CAPD will occur in our patients. Since some erythropoietic activity has been demonstrated in spent PD fluid by Dr. Gyde, it could just be that a large number of daily exchanges remove too much erythropoietin.

The rise in the haemoglobin is not due to a permanent state of dehydration, since in spite of a significant fall of plasma volume, the red cell mass also rose.
This rise would have reached statistical significance but for the elderly patient who had three attacks of peritonitis.

To what factors can we attribute the improved haemoglobin levels? CAPD does not, of course, necessitate the obligate blood losses of HD, but a rise of haemoglobin occurred in our patients even during the first month of CAPD when the iatrogenic blood loss for investigational purposes exceeded that normally encountered in HD. The red cell half life lengthened marginally when patients were changed from IPD to CAPD. These haematological changes have been accompanied by some true weight gain, but unlike American experience, this has not yet proved a source of embarrassment.

In order to gain valid laboratory data and without prejudice to long-term nutritional requirements, we have refrained from giving our patients additives to their diet. Thus, no iron, vitamins or androgens have been used. To date only six-month figures are available on iron studies in nine patients, Table IV. Judging from the serum ferritin levels, it looks as if iron supplements may ultimately be required to allow increased erythropoesis as indeed others have found, though iron loss in the peritoneal fluid amounted to less than 1 mg per day.
HAEMATOLOGICAL RESPONSE TO 6 MONTHS CAPD

NO HAEMATINICS (N = 9)

|                      | PRE CAPD | AFTER 6 MONTHS CAPD | SIGNIFICANCE OF CHANGE | NORMAL RANGE |
|----------------------|----------|---------------------|-------------------------|--------------|
| SERUM IRON (umol/l)  | 9 ± 3.2  | 13 ± 5.8            | N.S.                    | 10-24        |
| SERUM T.I.B.C. (umol/l) | 52 ± 11.6 | 57 ± 6.8            | N.S.                    | 45-70        |
| SERUM FERRITIN (ug/l)| 359 ± 460| 145 ± 82            | N.S.                    | 10-250       |

24 HOURS P.D. EFFLUENT IRON CONTENT = 609 ± 413 ug.

As expected, we found a suggestion of a fall in the serum concentration of the water-soluble vitamins C, B12 and folic acid, which reached statistical significance only in the case of the latter vitamin. Nevertheless, to date no rise in the mean red cell volume has occurred.

In conclusion, we feel that CAPD is here to stay but that early expansion in the United Kingdom is likely to be jeopardised by uneven distribution of experience with indwelling peritoneal catheters and by shortage of trained nursing staff.

We hope to have demonstrated that a satisfactory quality of life can be given with three daily fluid exchanges. This treatment, to be cost-effective, must be administered with care, devotion and great attention to detail.

The authors are grateful for financial support from the Merseyside Association for Kidney Research and the Liverpool Regional Dialysis Unit Fund. We would also like to express appreciation of the help given by our medical and nursing colleagues on the unit, as well as the laboratory, radiology and pharmaceutical departments of this hospital and the Department of Nuclear Medicine at the Royal Liverpool Hospital.

REFERENCES
1. OREOPOULOS D G, Selection criteria and clinical results of CAPD. Proceedings of an International Symposium on CAPD, Amsterdam: Excerpta Medica, 1979; 101-06.
2. OREOPOULOS D G, Requirements in the organisation of the continuous ambulatory peritoneal dialysis programme. Nephron 1979; 24: 261-63.
3. LINDSAY R M, OREOPOULOS D G, BURTON H, CONLEY S, WELLS G and FENTON S S A. Adaptation to home dialysis: a comparison of continuous ambulatory peritoneal dialysis and haemodialysis. Proceedings of an International Symposium on CAPD, Amsterdam: Excerpta Medica, 1979: 120-30.