AN INTEGRATED PROGRAMME OF HAEMODIALYSIS AND PERITONEAL DIALYSIS: A SINGLE TWO-LITRE EXCHANGE PER NIGHT PLUS HAEMODIALYSIS EVERY FOUR TO SIX DAYS

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Summary

Critical problems of CAPD: (a) protein loss; (b) peritonitis; (c) glucose overload; (d) intra-abdominal pressure, can be rationally managed by an integrated intracorporeal and extracorporeal approach. A single two-litre peritoneal exchange performed during the night in addition to haemodialysis every four to six days (HD-PD) reduces a, b, c and eliminates d. This HD-PD technique has been evaluated in eight uraemic patients over a total period of 20.5 patient months. Preliminary results show that this procedure can provide adequate biochemical control, with low protein losses and limited interdialysis weight gain.

Introduction

Continuous ambulatory peritoneal dialysis (CAPD), proposed as an alternative to standard haemodialysis, is associated with: protein losses, peritonitis, glucose overload, and intra-abdominal pressure [1, 2].

On the other hand haemodialysis (HD) presents, even if in a limited population, problems of vascular instability, of multifactorial origin, difficult to manage in spite of the present variety of methods of treatment.

An integrated intracorporeal and extracorporeal approach, associating a nightly two-litre peritoneal exchange with HD performed every four to six days, could improve the patient’s tolerance to standard HD and reduce CAPD-related complications.

This paper presents a preliminary evaluation of the flexibility and the limits of this treatment.

Methods

Technique

The HD-PD technique associates a single two-litre peritoneal exchange nightly (eight hours dwell time) with four to five hours standard HD every four to six
days.

Peritoneal dialysis (PD) exchange was performed through an indwelling Tenckhoff catheter using a commercial dialysate available in two-litre plastic bags. At the beginning of the PD exchange, the plastic bag with a capped needle at its end is connected to the peritoneal catheter via a Y adapter closed by a pararubber material allowing multiple punctures [3]. The Y adapter is connected to the peritoneal catheter by a Luer-lock system and is changed twice a month. When it is empty, the bag is rolled up and carried at the waist. In the morning, when drainage of the dialysate is completed, the bag is easily disconnected and discarded. Thus, during the daytime the patient is free of the bag; furthermore, only one puncture is required for each PD exchange. The average time for a complete exchange (infusion and drainage) is about 40–50 minutes.

HD session was performed using 1m² cuprophane membrane dialysers. With adequate nutrition, the haemodialysis interval was determined on the basis of pre-HD serum urea nitrogen (SUN) values.

**Mathematical analysis**

To evaluate the overall efficiency of the system, the single pool mathematical model applied to urea kinetics was employed [4, 5] (Figure 1).

Assuming a negligible convective transport and a constant SUN generation rate (G-SUN), pre-HD concentrations (Sbo) of SUN were predicted from the following:

\[ S_{bo} = \frac{b \left[ (1-a^n)/(1-a) \right] + a^n \cdot y}{1-a^{n+1} \cdot e^{-CT/Vb}} \]

where:

\[ y = \left[ \frac{G}{(Vb + Vd)} \right] \cdot \left\{ \left( T_1 + T_2 - T \right) + \left[ Vb (1 - e^{-CT/Vb}) \right] / C \right\} \]

\[ a = Vb / (Vb + VD) \]

\[ b = \left[ \frac{G}{(Vb + Vd)} \right] \cdot \left( T_2 + T_3 \right) \]

\[ Vb = \text{urea distribution volume (assumed equal to total body water)}; \ Vd = \text{dialysate volume}; \ n = \text{number of days without HD}. \]

The patient’s rate of urea generation was calculated from the rate of increase in body urea content between haemodialyses.

The above predictions suggest (Figure 2) that in the HD-PD programme a haemodialysis interval of four to six days will be adequate to achieve acceptable SUN values, if G-SUN is 3mg/min. However, a haemodialysis interval of three days is required, if the G-SUN is 5mg/min. For comparison, SUN values predicted on HD (4hrs × 3/week) are illustrated.

**Patient selection**

Eight uraemic patients (five males and three females), aged 50–72 years (average: 59 years), weighing 48–83kg (average: 65kg) were trained in HD-PD technique.
Figure 1. Single pool kinetic model for a solute like urea during HD-PD treatment. Sbo = pre-HD solute concentration; Sbe = post-HD solute concentration; T = time of HD; T₁ = time between HD and nocturnal peritoneal dialysis exchange; T₂ = time of peritoneal dialysis exchange; T₃ = time between two nocturnal peritoneal dialysis exchanges
Figure 2. Sbo-SUN values predicted on HD-PD technique (step line). Time in days indicates the interdialytic periods. For comparison, Sbo-SUN values predicted on three four-hour haemodialyses per week, with 52-hour interdialytic periods, are illustrated (straight line). System parameters: Vb = 42L; Vd = 2L; C = 170ml/min; T = 4hrs; T₁ = 12hrs; T₂ = 8hrs; T₃ = 16hrs; G-SUN = 5mg/min (-----) and 3mg/min (-----)
Their residual renal function (endogenous creatinine clearance) varied from 0–5.3ml/min (average: 2.7ml/min) and their daily urine volume ranged from 0–1250ml (average: 649ml). Two patients had cystic kidney disease and one each had chronic glomerulonephritis, chronic pyelonephritis, diabetic nephropathy, hypertensive nephroclerosis. In two the cause of kidney disease was unknown.

Three patients were previously treated on HD, one came from CAPD and one from intermittent peritoneal dialysis (IPD). The remaining were new patients. All were trained in HD-PD technique for a minimum of one week (average: 12 days).

Patients were given the same diet suggested to HD patients (1.0g protein/kg body wt/day) with limited phosphate intake. Total time on HD-PD ranged from 8–16 weeks (average: 11 weeks). Cumulative patient experience was 20.5 months.

Results

Biochemical and clinical data (Table I)

In all patients mean SUN and serum creatinine values were well controlled below 100mg/100ml and 15mg/100ml, respectively. Restriction of phosphorus and potassium intake were required to control hyperphosphataemia and hyperkalaemia. No patients received potassium exchanging resins.

A mild degree of metabolic acidosis was observed. This could be avoided by increasing the present 35mEq/L lactate concentration in the dialysis fluid.

| TABLE I. Biochemical and clinical assessment of eight patients treated with HD-PD (mean ± SD) |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| | Start | Months on HD-PD* | Months on HD-PD* |
| | | 2 | 3 |
| **SUN (mg/100ml)** | 85 ± 27 | 77 ± 18 | 76 ± 7 |
| **Creatinine (mg/100ml)** | 12.4 ± 3.1 | 12.0 ± 1.6 | 11.8 ± 1.0 |
| **Ca (mg/100ml)** | 9.6 ± 0.7 | 9.5 ± 0.4 | 9.2 ± 0.9 |
| **P (mg/100ml)** | 4.8 ± 0.9 | 5.3 ± 0.7 | 5.0 ± 0.7 |
| **K (mEq/L)** | 5.2 ± 0.9 | 5.6 ± 0.8 | 5.9 ± 1.0 |
| **Total proteins (g/100ml)** | 6.5 ± 0.6 | 6.5 ± 0.5 | 6.5 ± 1.2 |
| **Albumin (g/100ml)** | 3.7 ± 0.4 | 3.6 ± 0.1 | 3.8 ± 0.4 |
| **Cholesterol (mg/100ml)** | 194 ± 40 | 228 ± 50 | 249 ± 67 |
| **Triglycerides (mg/100ml)** | 270 ± 131 | 244 ± 105 | 295 ± 117 |
| **HCO$_3^-$ (mEq/L)** | 21.5 ± 1.9 | 21.9 ± 2.6 | 21.0 ± 1.4 |
| **Haematocrit (%)** | 27.6 ± 5 | 28.1 ± 3 | 29.5 ± 4.3 |
| **Systolic blood pressure (mmHg)** | 158 ± 27 | 164 ± 22 | – |
| **Diastolic blood pressure (mmHg)** | 86.5 ± 7 | 87 ± 9 | – |
| **Number of patients** | 8 | 8 | 4 |

* Data were recorded at fifth day prior to haemodialysis session
Increase in serum triglyceride concentrations did not occur on HD-PD treatment. The haematocrit improved in six patients and decreased slightly in one anuric patient. No blood transfusions were given. The mean serum protein and albumin values remained close to the normal range. Two of five patients remained hypertensive and on antihypertensive drugs.

Body weight was stable in four patients, decreased in three and increased in one.

The mean values of peritoneal mass transfer-area coefficient (MTAC) were 23.6ml/min (range: 33.5–18.5ml/min) for urea; 10.9ml/min (range: 23.6–7.6 ml/min) for creatinine; 9.8ml/min (range: 22.2–5.3ml/min) for glucose. Ultrafiltration (UF) was correlated with dialysate tonicity and glucose MTAC. With an average dialysate glucose concentration of 2.8g/100ml the drainage volume varied from 2867–2245 (mean: 2507ml).

Mean (± SD) protein and albumin losses in the peritoneal fluid were 4.7 ± 1.2g and 3.7 ± 1.4g respectively.

Mean interdialysis weight gain was 1.7kg (range: 0.9–2.4kg).

Complications

One episode of culture-negative peritonitis was observed. This corresponds to an incidence of one episode/20.5 patient months.

One catheter had to be removed because of dislodgement.

Discussion

The comparison, made on preliminary data between standard HD, and HD-PD with a five day interval, confirms the predictions of the mathematical model.

The RRF and the limited number of patients does not permit a definite answer concerning the longest achievable haemodialysis interval. However, the short term results deserve a few comments on both modalities of treatment.

A protein loss limited to 3–5g/day allows more equilibrated nutrition: in fact it seems very difficult to combine high protein intake (as required by high protein loss on CAPD) without a proportional high phosphate and saturated fats intake. The observation that CAPD patients eat less than those on haemodialysis [6] raises the possibility that the apparently better phosphate control is only an indication of insufficient protein intake.

UF of about 500ml/day has been obtained with a relatively low dialysate glucose concentration. If we consider that the control of weight gain is of paramount importance for an adequately tolerated HD session, the HD-PD technique may become a very simple preferential choice for patients with vascular instability. In fact, the relationship between haemodialysis interval and consequently vascular stability during HD session appears strictly connected to electrolyte and acid-base balance as well as normal glucose MTAC, responsible for an adequate ultrafiltration.

An approximately oriented dialysate composition can easily deal with these problems; in particular a single daily bag exchange can simultaneously prevent electrolyte, acid-base imbalance and, in addition, correct amino acid deficiencies
(peritoneal cavity = artificial gut).

Finally, considering HD-PD in comparison to CAPD or haemodialysis, the following advantages should be stressed: a) good biochemical control, with adequate removal of small and middle molecules; b) no glucose overload; c) low financial burden; d) more dialysis stations available in dialysis centre; e) longer survival of vascular access; f) more freedom for the patient; g) different available treatment options if needed; h) improvement of vascular stability.

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References


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Open Discussion

RINGOIR (Chairman) Professor Cambi for many years you have been at the forefront of dialysis with new techniques and again you have brought us a new approach. Do you think this approach is going to replace other techniques? Are all your patients at this time on this technique?

CAMBI The main goal of this approach is not to replace, but to 'modulate' in a more personalised way the therapy of advanced renal failure. Very often, within a GFR range of 5–10ml/min, conservative therapy is insufficient and, on the other hand, standard HD is too aggressive. In this case a single PD exchange per night, integrated with amino acids may be a softer and more correct approach. A further deterioration in GFR can be later managed by HD with a frequency calculated from the actual urea generation rate.

LOWRIE (Boston) I wondered about the nutritional state of these eight patients and the diet prescription, and particularly the four patients who made it to three or four months. The reason that I ask the question is that urea generation rates in the range of three to five mg/min would correspond with daily protein intake of between 35 and 55 grams. In our experience that is really rather low.
CAMBI  The basic protein intake was around 1.0g/kg body weight. Do not forget that the protein loss is much less than in CAPD. A more precise choice of a correct nutritional state is still to be made and will not necessarily be a higher protein intake but perhaps a diet of proteins and amino acids. It is not correct to try to feed the patient just to cover the great protein loss of CAPD. This is one of the reasons we tried to adopt this approach instead of CAPD.