Although the use of continuous ambulatory peritoneal dialysis (CAPD) to treat refractory heart failure is not new, in combination with current medical treatment it improves patients’ symptoms as well as their cardiac function. We started 16 patients (13 men with a mean age of 66.3 ± 2.8 years, and 3 women with a mean age of 72 ± 4.2 years) on CAPD. All patients were symptomatic with congestive heart failure. Mean left ventricular ejection fraction (LVEF) before the start of CAPD was 31% ± 3%. Introduction to CAPD was associated with a significant improvement in LVEF (to 44% ± 6%, p < 0.05) and in blood pressure control at 1 year. Also at 1 year, 87% of patients were classified as New York Heart Association grade I or II (maximum possible grade is grade III). These results suggest that CAPD is a treatment of choice for patients suffering from a combination of congestive heart failure and chronic renal insufficiency.

Key words
Congestive heart failure, ejection fraction, residual renal function

Introduction
The kidneys and the heart function in tandem to physiologically regulate extracellular fluid volume, natriuresis, blood pressure (BP), cardiac output, and glomerular filtration rate (GFR). The intimate relationship between these two organ systems is also apparent in disease states in which renal and cardiac dysfunction frequently coexist (1), reflecting common pathogenic factors that include diabetes, hypertension, fluid overload, aging, left ventricular hypertrophy, and atherosclerotic vascular disease (2).

Patients and methods
From April 2000 to March 2003, 124 patients started CAPD at our center. Before initiation of renal replacement therapy, echocardiography was performed in all patients for evaluation of cardiac function. From among the 124 patients, 16 patients (13 men of mean age 66.3 ± 2.8 years, and 3 women of mean age 72.0 ± 4.2 years) with a left ventricular ejection fraction of less than 40% were eligible for the study. Functional status was defined according to the criteria of the New York Heart Association (NYHA). All patients included in the study gave informed consent.
for participation, and the study was performed in accordance with the principles of the second Helsinki Declaration.

The causes of ESRD in the study patients were diabetic nephropathy (n = 6), immunoglobulin A nephropathy (n = 2), nephrosclerosis (n = 1), autosomal dominant polycystic kidney disease (n = 1), and unknown (n = 6). The primary cause of the CHF was considered to be ischemic heart disease in 11 patients (69%), hypertension in 2 patients (13%), valvular heart disease in 1 patient (6%), idiopathic cardiomyopathy in 1 patient (6%), and unknown in 1 patient (6%).

The patients’ CAPD treatment consisted of 4 daily 2-L exchanges using dialysate containing lactate and 1.5 g/dL or 2.5 g/dL dextrose. All patients were treated using a disconnect system. During the study, all subjects were asked to continue the same dietary and dialysis regimen. Mean daily dietary intake was determined from individual 24-hour food records during a 3-day period. Daily dietary protein intake was estimated to be 0.5 – 0.8 g/kg, and daily energy intake, more than 25 kcal/kg. Salt intake was restricted to about 7 g daily.

Patients were instructed to visit the outpatient CAPD clinic every month, where body weight, urine volume, and dialysate drain volume were checked. Before and after the start of the study, urine volume and dialysate drain volume were both measured. Additionally, body weight and BP (by mercury sphygmomanometer) were recorded, and blood samples were analyzed for serum chemistry and hemoglobin.

Echocardiograms were recorded within 1 week before the start of treatment and at 12 months. All echocardiographic measurements were performed according to the recommendations of the American Society of Echocardiography (9). The measurements included the end-diastolic and systolic diameters of the left ventricular chamber (LVDd and LVDs), the interventricular septum thickness (IVST), and the thickness of the left ventricular posterior wall (PWT).

Residual GFR was assessed at 0, 6, 12, 18, and 24 months by 24-hour urine collection (10). Indices of the adequacy of dialysis, including Kt/V and weekly creatinine clearance were calculated using the PD Adequest 2.0 computer program for Windows (Baxter Healthcare, Deerfield, IL, U.S.A).

Exclusion criteria
Exclusion criteria included pregnancy or lactation; secondary glomerular disease such as systemic lupus erythematosus, Wagener disease, and myeloma, among others; proteinuria in the nephrotic range of more than 3.0 g daily; and use of sedative or hypnotic drugs or any other drug that might potentially affect BP during ambulatory monitoring (for example, corticosteroids).

BP control
For all patients enrolled in the study, trained nurses encouraged the recording of home BP measurements. Daytime home BP below 130/80 mmHg was the target. When the patients’ systolic BP exceeded 130 mmHg or when their diastolic BP exceeded 80 mmHg, therapy with antihypertensive agents was started.

Correction of anemia
Recombinant human erythropoietin was administered subcutaneously every week or every other week, and the doses were adjusted monthly. Patients were given oral iron supplementation if they were determined to be iron-deficient. Hemoglobin levels were maintained at approximately 10.0 g/dL.

Biochemical data evaluation
At the beginning of each month, we measured these parameters in the patients: body weight, serum creatinine, blood urea nitrogen, total protein, serum albumin, serum electrolytes, and alkaline phosphatase. Parathyroid hormone levels (intact molecule assay), serum cholesterol, and triglycerides were measured once every 6 months.

Calcium metabolism
Patients with parathyroid hormone (PTH) levels above 200 pg/mL were treated with 1,25(OH)2D3 and CaCO3 supplements, and patients with levels below 70 pg/mL were treated with CaCO3 to reduce hyperphosphatemia.

Lipid metabolism control
Lipid-lowering drugs (mainly statin derivatives) were administered if serum low-density lipoprotein cholesterol levels were above 120 mg/dL.

Cholesterol levels were maintained at approximately 100 mg/dL.

Chest radiographs were obtained regularly, and cardiothoracic index was calculated according to established methods.
Statistical analysis

All data are presented as mean ± standard deviation. Statistical analyses were performed using the Student t-test (or the Mann–Whitney U-test when applicable) for comparing the means of paired variables. A value of \( p < 0.05 \) was considered statistically significant.

Results

Effects of CAPD on BP

Systolic BP measured at home decreased significantly to 133 ± 6 mmHg from 140 ± 6 mmHg at the start of CAPD (\( p < 0.01 \)), but diastolic BP did not change significantly (to 78 ± 4 mmHg from 79 ± 3 mmHg; Figure 1).

Effects of CAPD on biochemical variables

We observed no significant changes in serum albumin, serum creatinine, calcium, and phosphate. However, hemoglobin levels increased significantly to 10.5 ± 0.5 g/dL from 8.5 ± 0.3 g/dL (\( p < 0.01 \)).

Effects of CAPD on ejection fraction and NYHA functional status

Reduced LVEF at the start of the study increased significantly to 44% ± 3% from 31% ± 3% (\( p < 0.01 \)) after 12 months of treatment with CAPD. The functional status in 11 patients improved from grade III to grade II; in 4 patients, it improved from grade II to grade I; and in 1 patient, it improved from grade III to grade I. These changes were statistically significant (\( p < 0.01 \); Figures 2 and 3).

Changes in echocardiographic variables

The changes in echocardiographic results from the start of study to 12 months after the start of treatment were as follows (all in millimeters): LVDd, to 56.1 ± 2.6 from 58.6 ± 1.5; LVDs, to 43.0 ± 3.0 from 47.2 ± 1.4; IVST, to 11.8 ± 0.6 from 12.1 ± 0.5; PWT, to 11.1 ± 0.4 from 11.1 ± 0.6. None of the changes in these variables achieved statistical significance.

Effects of CAPD on urine volume and weekly CCR

Treatment with CAPD produced significant increases in daily urine volume to 550 ± 72 mL from 470 ± 84 mL (\( p < 0.01 \)) and in weekly creatinine clearance to 60 ± 7 L/1.73 m² from 46 ± 8 L/1.73 m² (\( p < 0.01 \)).

Retrospective analysis of lipid-lowering drugs and antihypertensive drugs

All patients received either angiotensin converting enzyme (ACE) inhibitors (enalapril, benazepril, trandolapril) or angiotensin receptor blockers [ARBs (losartan, valsartan, and candesartan)]. Calcium antagonists were used in 65% of patients and beta-blockers in 35%. Loop diuretics were also used in 38%.
of patients. Lipid-lowering drugs were added in 7 cases at 6 – 12 months after the start of CAPD.

Mortality
No deaths occurred during the 1-year study period, and no patient was transferred to HD therapy.

Discussion
In the present study, CAPD produced improvement in cardiac function in all patients with the combination of CHF and ESRD, as demonstrated by increases in LVEF and life quality as assessed by NYHA class.

Improvement of cardiac performance on CAPD may be related to several factors: continuous ultrafiltration, correction of anemia, use of cardio-renal protective drugs, and treatment of uremia, among other factors.

As a method for ultrafiltration, CAPD has unique advantages. Fluid can be removed continuously, thus avoiding the sudden reduction in BP incurred by rapid fluid removal during intermittent hemofiltration in hemodynamically unstable patients (5,11,12). In a retrospective analysis, Hebert et al. (6) reported that quality of life of patients with severe left ventricular systolic dysfunction and renal failure can be substantially improved by CAPD. In their study, LVEF was reported to significantly influence survival rate. In the present study, during the 1-year study period, none of the patients died from major cardiovascular accidents such as myocardial infarction, stroke, and CHF, indicating that CAPD provides stable BP control with correction of fluid overload by continuous ultrafiltration.

We cannot precisely assess quality of life in the present study; however, judging from the improvement in NYHA functional status, our results accord well
with several previous reports, including that of Hebert et al. (6,13,14), who described improved quality of life with CAPD in patients with the combination of CHF and ESRD.

Anemia is a common finding in patients with both CHF and ESRD, and the related adverse consequences have been well documented (15). Conversely, there is some evidence that correction of anemia is associated with both a slowing of the progression to renal failure (16) and an improvement in exercise in patients with CHF (17). In the present study, anemia was corrected with erythropoietin and iron supplementation after the start of CAPD, and this therapeutic combination was associated with an improvement in CHF. Thus, it appears that treatment of anemia in patients with CAPD helps to improve CHF.

Considerable clinical trial data provide important evidence for the routine use of ACE inhibitors and ARBs in the treatment of both CHF and ESRD (18,19). Previously, we reported that valsartan, an ARB, slowed the decline in residual renal function that is a major factor contributing to the mortality and morbidity of CAPD patients (10). In the present study, all patients were treated with either ACE inhibitors or ARBs, resulting in a favorable effect on cardiac function and preservation of renal residual function. Moreover, the disadvantages of these drugs in producing hyperkalemia in patients with the combination of CHF and ESRD might be overcome by the CAPD, which efficiently removes excess potassium, preserving normal serum levels of that element.

Conclusions
Treatment with CAPD may be effective for patients with the combination of heart and renal failure.

References
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