The aim of the present study was to compare parameters of dietary intake, nutritional status, dialysis adequacy, and laboratory data between continuous ambulatory peritoneal dialysis (CAPD) patients having a normal body mass index (BMI) and those having an increased BMI. Two groups were selected: BMI = 20 – 25 (group I, n = 29) and BMI = 25 – 30 (group II, n = 19). No difference in age or peritoneal dialysis duration were observed between the study groups.

Among parameters of dietary intake, only vitamin C ingestion was higher in group II than in group I. As compared with the patients in group I, the patients in group II showed significantly higher total body mass, lean body mass, fat body mass, and total body water. The Kt/V was lower in group II than in group I. In group II, values of serum iron concentration and transferrin saturation were both lower than those seen in group I. No differences were observed between the study groups for the other examined parameters. Those results show that overweight CAPD patients have higher anthropometric parameters and a lower Kt/V owing to a higher urea distribution volume. Disorders in iron parameters are more frequent in overweight patients. The observed differences do not influence duration of peritoneal dialysis treatment.

Key words
Body mass index, nutrition, adequacy
laboratory data had been repeatedly measured for each patient at 3-month intervals (at least). Dietary records were obtained and analyzed as previously described (5). In addition to BMI, anthropometric indices included total body mass, total fat mass, lean body mass (LBM), and total body water calculated using the Watson formula (6).

Measures of CAPD adequacy included urea parameters (Kt/V, protein nitrogen appearance) and creatinine parameters (total weekly creatinine clearance, efficacy number). These laboratory blood data were also analyzed: total protein, albumin, total globulin, iron, total iron binding capacity, transferrin saturation, ferritin, total cholesterol, urea, creatinine, uric acid, glucose, and peripheral blood morphology. Total protein and albumin losses in daily collections of dialysate and urine were also estimated. Laboratory indices were determined as previously described (7).

For every patient, an arithmetic mean was calculated for all examined parameters as representative for the patient’s CAPD course. The respective means were then used to calculate a mean and standard deviation for the two study groups. Results obtained for the groups were compared using Mann–Whitney test. A $p$ value less than 0.05 was accepted as significant.

**Results**

No differences were observed in age [44.1 ± 12.3 years (group I) vs. 48.6 ± 10.0 years (group II)] and CAPD duration [20.2 ± 12.5 months (group I) vs. 23.0 ± 11.1 months (group II)] between the study groups. Among parameters of dietary intake, only vitamin C intake was higher in group II than in group I (47.3 ± 13.2 mg/day vs. 37.3 ± 22.1 mg/day, $p = 0.010$, Figure 1). As compared with patients in group I, patients in group II showed significantly higher total body mass (79.5 ± 10.0 kg vs. 65.0 ± 6.6 kg, $p < 0.001$) and fat body mass (18.6 ± 5.2 kg vs. 13.6 ± 4.8 kg, $p = 0.001$, Figure 2). Lean body mass calculated from creatinine kinetics (52.4 ± 12.6 kg vs. 44.2 ± 10.4 kg, $p = 0.042$), LBM calculated using anthropometric parameters (60.7 ± 10.0 kg vs. 51.0 ± 8.8 kg, $p = 0.001$, Figure 3), and total body water (41.6 ± 6.2 kg vs. 36.0 ± 5.3 kg, $p = 0.001$, Figure 4) were also higher in group II than in group I. The Kt/V was lower in group II than in group I ($1.87 ± 0.37$ vs. $2.06 ± 0.36$, $p = 0.021$, Figure 5). In group II, serum iron concentration (85.8 ± 23.3 µg/dL vs. 97.7 ± 24.6 µg/dL, $p = 0.046$) and transferrin saturation (27.2% ± 7.9% vs. 32.1% ± 8.8%, $p = 0.022$) were both lower than in group I (Figure 6). No differences were observed between the study groups for the other examined parameters.

**Discussion**

Our results show that, except for a higher vitamin C ingestion in overweight patients, there were no significant differences in dietary intake between the examined groups. This slightly surprising finding should turn our attention to the lifestyle of dialyzed patients. We did not examine that particular problem, but the available evidence suggests that trends in the rate of obesity are related more to a reduction in energy expenditure than to an increase in caloric intake (1).

Recent articles show that anthropometric parameters indicating overweight are associated with better survival and reduced hospitalization in dialysis patients (3,8,9). It was also established that a large BMI does not predict short-term survival in PD patients (4). In our study, no difference was observed in CAPD duration between our two groups with similar age but different BMI [20 – 25 (median: 23.0); 25 – 30 (median: 27.0)]. Aslam et al. (4) analyzed groups of similar age, sex, race, diabetes status, Charlson comorbidity index, initial albumin, and dialysate-to-plasma ratio of creatinine and found that large-BMI (>27) and control-BMI (20 – 27) groups did not differ in 2-year patient and technique survival.

Although anthropometric measures of nutrition were significantly higher in the overweight group of patients, serum iron concentration and transferrin saturation were lower in those patients. That finding may
indicate that other trace elements are also lower in the overweight group. We conclude that overweight CAPD patients have to be carefully evaluated with respect to undernutrition just as normal-weight patients do.

Adequacy of CAPD, measured using Kt/V, was lower in the overweight group. Our patients typically perform standard CAPD using 8 L of dialysis solution daily. (They are not usually willing to accept a fifth exchange when they feel well and are working.) The larger patients had higher total body water (urea distribution volume), which influenced calculations of Kt/V.

**Conclusions**

In our CAPD patients, we observed no differences in serum total cholesterol, or in total protein or albumin losses that might be related to BMI. In undialyzed
patients with kidney disease, such relationships are more clearly demonstrated (10).

Our results show that overweight CAPD patients have higher anthropometric parameters and a lower Kt/V owing to a higher urea distribution volume. Disorders in iron parameters are more frequent in overweight patients. The observed differences do not influence duration of peritoneal dialysis treatment.

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Secondary hyperparathyroidism is a major complication in uremic patients undergoing dialysis. Various active metabolites of vitamin D are used as oral treatment; however, in some patients, parathyroid hormone (PTH) is not ideally suppressed. Intravenous injection of an active form of vitamin D inhibits PTH more effectively than does oral administration. However, intravenous administration is often restricted by the complication of hypercalcemia.

In the calcitriol analog 22-oxacalcitriol (OCT), the 22nd carbon atom is replaced by oxygen. The OCT analog has been reported to have a lesser hypercalcemic effect than does calcitriol.

The present study was planned to determine whether intraperitoneal administration of OCT would be a more effective treatment of secondary hyperparathyroidism than intravenous administration in CAPD patients who manage themselves at home. The results showed that OCT is stable in dialysis solution and that its intraperitoneal administration was effective for suppressing PTH in patients with secondary hyperparathyroidism.

Key words
22-Oxacalcitriol, continuous ambulatory peritoneal dialysis, intraperitoneal administration

Introduction
The skeletal effects of hypersecretion of parathyroid hormone (PTH) in dialysis patients worsens patient prognosis and quality of life. Management of serum phosphorus and calcium and replacement of vitamin D are essential therapies. Various oral vitamin D analogs are widely used; however, for suppressing PTH, oral administration is less effective than parenteral administration is. Intravenous injection of calcitriol is reported to be sufficiently effective (1). However, intravenous administration often has hypercalcemia as an adverse effect. Intravenous administration of the calcitriol analog 22-oxacalcitriol (OCT) inhibits PTH effectively and has less of a calcemic effect than does administration of calcitriol (2,3).

Because continuous ambulatory peritoneal dialysis (CAPD) is theoretically a home-based therapy, patients visit hospital only occasionally—for example, once per month. Intravenous injection of calcitriol is therefore is difficult and impractical for CAPD patients. Intrapерitoneal injection of antibiotics has been used for treatment of bacterial peritonitis in CAPD patients. Intrapерitoneal route for vitamin D administration would be ideal for CAPD patients. Intrapерitoneal injection of calcitriol was reported to have a suppressive effect on PTH (4–7), but the results were not consistent, probably due to adsorption of calcitriol to dialysate bags (8).

The objective of the present study was to ascertain the efficacy of intraperitoneal OCT in CAPD patients with secondary hyperparathyroidism.

Patients and methods
Stability of OCT
To study the stability of OCT, we injected 30 µg OCT into 4 bags of peritoneal dialysate [Dianeal PD-2
(1.5%, 2 L): Baxter Healthcare Corporation, McGaw Park, IL, U.S.A.). The bags were kept at room temperature (approximately 20°C – 25°C), and 5-mL samples were drawn at 0 hours, 1 hour, 3 hours, 6 hours, 1 day, 2 days, 3 days, 1 week, 2 weeks, 3 weeks, and 4 weeks after injection to measure OCT concentration. The OCT was measured by radioreceptor assay.

**Time course of OCT disappearance from peritoneal cavity and concentration of OCT in plasma**

Five CAPD patients received 2-L overnight dialysate exchanges containing 30 µg OCT (12 hours’ dwell time). Samples (5 mL) of dialysate were drawn at 0, 3, 6, 9, and 12 hours after instillation, and blood samples were taken at 0, 1, 3, 6, 9, 12, 15, 18, 21, and 24 hours after instillation to measure OCT concentration in plasma.

**PTH-suppressive effect of OCT in CAPD patients with secondary hyperparathyroidism**

With informed consent, we enrolled 7 CAPD patients (3 women, 4 men; age: 54.4 ± 8.4 years) with secondary hyperparathyroidism (intact PTH > 300 pg/mL) into the study. The duration of CAPD therapy was 64.7 ± 42.4 months. All patients were receiving oral calcitriol or α-calcidiol which was stopped before the intraperitoneal OCT was initiated. The nursing staff injected 30 µg OCT into 2-L peritoneal dialysate bags at the PD center. A bag was then delivered to each patient’s home once weekly by commercial delivery service. The patients used the OCT-containing dialysate for the nocturnal exchange on the day that the bag arrived.

Blood tests were monitored monthly. Treatment continued for 4 months.

**Results**

**Stability of OCT**

Figure 1 shows the concentration of OCT in the dialysate bags. Using the data from the sample that was drawn just after the OCT was injected, we calculated adsorption of OCT. Adsorption of OCT to the dialysate bag was estimated to be 26.7%.

The OCT was fairly well preserved in the dialysate, with 64.3% being retained at 1 week, 51.2% at 2 weeks, 39.1% at 3 weeks, and 31.3% at 4 weeks as compared with the amount at 0 hours.

**Time course of OCT disappearance from peritoneal cavity and concentration of OCT in plasma**

The intraperitoneal OCT concentration decreased rapidly to 32.3% in 3 hours and to 6.9% in 9 hours, as compared with the concentration immediately after instillation (Figure 2). In plasma, OCT reached its peak in 1 hour, and decreased slowly, being restored to basal level in 24 hours (Figure 3).
PTH-suppressive effect of OCT in CAPD patients with secondary hyperparathyroidism

Figure 4 shows the time course of intact PTH after the start of intraperitoneal administration of OCT. Intact PTH in serum decreased significantly within 1 month, with a continuous decline until 4 months (48.8% as compared with pre-treatment values). Table I shows biochemical data for the 7 patients.

Asymptomatic hypercalcemia (>11.5 mg/dL) was seen in 4 of 7 patients. The highest value of calcium in serum was 12.3 mg/dL. Phosphorus in serum was significantly elevated within 2 months of study commencement. The serum alkaline phosphatase did not change. No patient complained of subjective symptoms following intraperitoneal administration of OCT. No peritonitis was observed during the study period.

Discussion

Intraperitoneal administration of antibiotics to CAPD patients has been used to treat peritonitis. In the present study, the validity of OCT administration by the peritoneal route was examined in CAPD patients with secondary hyperparathyroidism.

Adsorption of OCT to the dialysate bag was calculated as 26.7%, which is lower than the 37% adsorption of calcitriol reported by Vieth et al. (8). The results obtained regarding the stability of OCT were unexpected. Injected OCT remained in considerable quantity after 4 weeks. On the other hand, only 20% of calcitriol was reported to be retained 20 hours after injection into dialysate bags.

Intra-abdominal OCT seemed to enter rapidly into the blood circulation, as shown by the immediate disappearance of OCT from the intraperitoneal dialysate and the rise of OCT concentration in plasma to a peak 1 hour after instillation of the OCT-containing dialysate. Weekly intraperitoneal administration of OCT over a 4-month period effectively suppressed PTH in CAPD patients whose intact PTH was greater than 300 pg/mL.

Although OCT is known to have a less calcemic effect than calcitriol does(2), hypercalcemia was seen in 4 of 7 study patients. That hypercalcemia might be prevented by regulating the dose of OCT or the instillation duration. Because CAPD patients visit the hospital only occasionally, intravenous injection is not realistic as chronic treatment. Given the stability observed, OCT is superior to calcitriol for intraperitoneal treatment of secondary hyperparathyroidism. For instance, CAPD patients could potentially bring OCT-containing dialysate bags for 2 – 3 weeks home from the hospital.

Conclusion

Given the findings in the present study, intraperitoneal injection of OCT is an attractive therapy for CAPD patients with secondary hyperparathyroidism.
An adequate dose and the effect of OCT on the peritoneum have to be elucidated in future work.

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References


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Paricalcitol [Zemplar: Abbott Laboratories, Abbott Park, IL, U.S.A.] is efficient for treating secondary hyperparathyroidism in patients on maintenance hemodialysis (HD). Zemplar is thought to be more potent than calcitriol and has been reported to cause less hypercalcemia and hyperphosphatemia.

Here, we report a 1-year follow-up on patients from one inner-city dialysis unit. We reviewed the charts of 100 patients and collected data for 1 year. Patients were stratified into four groups depending upon their intact parathormone (iPTH) levels. Hemoglobin (Hb) and erythropoietin (EPO) doses were determined.

More than 50% of patients had iPTH levels greater than 300 pg/mL. Mean Ca and PO₄ levels were not significantly different, but Zemplar doses were significantly different in all groups. None of the patients had symptomatic bone disease. Seven patients were changed to low-Ca dialysate (1.0 mEq/L) secondary to hypercalcemia (Ca > 11.5 mg/dL) and severe secondary hyperparathyroidism. Interestingly, patients with low iPTH (<100 pg/µL) showed relative EPO resistance, and patients with high iPTH (>600 pg/µL) required smaller EPO doses. An inverse relationship was observed between Zemplar and EPO dose. The effect of Zemplar on EPO responsiveness needs to be confirmed in a larger study.

Our data suggest that severe secondary hyperparathyroidism is frequent despite aggressive paricalcitol therapy in our inner-city HD population. To control severe secondary hyperparathyroidism in these patients, dietary and medication compliance may need to be supplemented with more effective non-calcium phosphate binders or calcimimetic agents, or both.

**Key words**
Hyperparathyroidism, paricalcitol, anemia

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**Introduction**
Secondary hyperparathyroidism (HPT) is a significant complication of chronic renal failure (CRF) and occurs early in the course of that disease (1,2). Hyperphosphatemia and low levels of calcitriol are believed to be the principal factors in the generation of HPT (3). In the early stages of CRF, the chief factor contributing to HPT is reduced synthesis of calcitriol by the kidneys (4). As renal function deteriorates, hyperphosphatemia develops (3)—usually when the glomerular filtration rate (GFR) decreases to 20 mL/min. Hyperphosphatemia then becomes the predominant factor in worsening HPT (3). Thus, reduced kidney mass, PO₄ retention, and reduced calcitriol levels have major roles in the initiation and maintenance of a hyperparathyroid state.

An important consequence of HPT progression is the development of osteitis fibrosa cystica (2). In addition, substantial morbidity occurs from the generalized aches and pains that seem to accompany HPT. Additional complications of HPT include extraskeletal calcifications and (because the PTH receptor is widely distributed) possible adverse effects on other organs such as bone marrow, vasculature, heart, and immune system.

Clinical manifestations of HPT have changed over the last three decades, and today, most patients are asymptomatic because of effective treatment. That treatment includes efforts to control serum PO₄ levels by using dietary restriction, phosphate binders, effective dialysis, and supplementation with calcitriol.

In the mid 1980s, intravenous (IV) calcitriol was introduced and was shown to be extremely effective at reducing serum PTH levels in patients with end-stage renal disease (ESRD) requiring dialysis (5). Parathyroid hyperplasia was less with bolus IV administration as compared with the same amount of calcitriol administered by continuous infusion (6).
In addition to suppressing PTH secretion, calcitriol also causes increased intestinal absorption of Ca and PO$_4^-$, thus increasing serum Ca and PO$_4^-$ levels (7). Those effects are the principal toxicities of calcitriol, and they can limit its use and efficacy. Increased serum Ca and PO$_4^-$ levels are important risk factors for extraskeletal calcification in soft tissues, periarticular areas, and the vasculature or heart valves (8). That risk led to the development of vitamin D analogs that have the ability to suppress PTH, combined with a lesser ability to elevate serum Ca and PO$_4^-$ levels. Two compounds commonly used in the United States are 19-nor-1,25-dihydroxyvitamin D$_2$ [paricalcitol (Zemplar: Abbott Laboratories, Abbott Park, IL, U.S.A.)] and 1-α-hydroxyvitamin D$_2$ [doxercalciferol (Hectorol: Bone Care International, Middleton, WI, U.S.A.)]. Paricalcitol (9–11) and doxercalciferol (12) both potently suppress PTH and cause less hypercalcemia and hyperphosphatemia.

**Patients and methods**

Charts of 100 patients from our inner-city outpatient hemodialysis (HD) unit were reviewed, and data were collected for 1 year. All patients were on stable, chronic HD for more than 3 months (range: 5 – 269 months). The age of the patients ranged from 20 years to 93 years. We excluded 26 patients because of active bleeding, active untreated infection, malignancy, or incomplete data (singly or in any combination). Of the remaining 74 patients, 47 (63.5%) were male. All but 2 were African-American. The causes of ESRD were diabetes ($n = 32$), hypertension ($n = 27$), chronic glomerulonephritis ($n = 6$), focal segmental glomerulosclerosis ($n = 3$), membranous glomerulonephritis ($n = 1$), adult polycystic kidney disease ($n = 2$), and obstructive uropathy ($n = 1$).

All patients underwent dialysis three times per week, using bicarbonate-based dialysate with Ca (2.5 mEq/L) and single-use high-flux polysulfone dialyzers. The length of the HD sessions ranged from 3.5 hours to 4.5 hours.

Urea reduction ratio (URR), intact parathyroid hormone (iPTH), serum Ca, phosphate, alkaline phosphatase (Alk), albumin (Alb), Ca×P product, hemoglobin, serum iron, ferritin, and Zemplar and erythropoietin (EPO) dosage were collected for 1 year. Serum Ca, PO$_4^-$, Alk, Alb, hemoglobin, iron, and URR were measured monthly; serum ferritin and iPTH were checked quarterly.

Patients were stratified into four groups depending on mean iPTH levels: group A, <100 pg/mL; group B, 101 – 300 pg/mL; group C, 301 – 600 pg/mL; and group D, >600 pg/mL.

**Statistical analysis**

All data are presented as the mean of all measurements. The statistical analysis was carried out using two samples, assuming equal variance test.

**Results**

Table I gives the demographic data for the 74 studied patients. Mean age in group A was 56.8 years (range: 46 – 68 years); in group B, 65.1 years (range: 37 – 93 years); in group C, 55.7 years (range: 20 – 78 years); and in group D, 52.5 years (range: 22 – 80 years). Patients in groups C and D had been on HD for a longer period than had the patients in groups A and B (57.4 months and 65.1 months vs. 34.8 months and 30.5 months respectively). Mean height and weight were similar in all groups.

Table II shows the biochemical data for the patients. Mean iPTH was significantly higher in groups B, C, and D as compared with group A ($p < 0.005$). All patients maintained adequate dialysis parameters during the year. Patients in group D had high serum Ca, PO$_4^-$, and Ca×P product, but the values were not statistically significant. None of the patients had symptomatic bone disease, although serum Alk was nonsignificantly high in group D. Because of persistently high serum Ca levels (>11.5 mg/dL), 7 patients were changed to low-Ca dialysate (1.0 mEq/L). All patients had good nutritional status, reflected by adequate serum albumin (range: 3.7 – 4.1 g/dL). Mean serum Alu levels were between 6.2 µg/dL and 7.2 µg/dL. Patients in group A (iPTH < 100 pg/mL) were not taking paricalcitol; the dose of paricalcitol was significantly different in all other groups ($p < 0.005$).

Table III gives the patients’ hematologic data. All patients maintained their hemoglobin levels in the target range (11.5 mg/dL – 12.5 mg/dL). The dose of EPO was adjusted according to a preset protocol to keep hemoglobin within target range for each patient. Serum iron and ferritin were not statistically different in any of the groups. Requirement for EPO was significantly higher in group A as compared with group D, which is traditionally thought to be an EPO-resistant group ($p < 0.005$).
Table IV shows the relationship between iPTH, Zemplar dose, hemoglobin, and EPO dose in the various groups. Patients in group A showed relative EPO resistance and required significantly larger doses of EPO as compared with group D (255.8 U/kg per session vs. 74.35 U/kg per session). An inverse relationship between Zemplar and EPO dose was observed. The relationship seemed to be independent of iPTH, because group D patients continued to have high iPTH levels. The EPO index [EPO (U) / Hb (g)] was significantly higher in group A as compared with group D (1,642.3 vs. 496.5).

**Table I** Patient demographic data

<table>
<thead>
<tr>
<th></th>
<th>Group A (n = 6)</th>
<th>Group B (n = 22)</th>
<th>Group C (n = 29)</th>
<th>Group D (n = 17)</th>
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<tbody>
<tr>
<td>Mean iPTH (pg/mL)</td>
<td>&lt;100</td>
<td>101–300</td>
<td>301–600</td>
<td>&gt;600</td>
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<tr>
<td>Age (years)</td>
<td>56.8 (46–68)</td>
<td>65.1 (37–93)</td>
<td>55.7 (20–78)</td>
<td>52.5 (22–80)</td>
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<tr>
<td>Duration of HD (months)</td>
<td>34.8 (10–94)</td>
<td>30.5 (6–98)</td>
<td>37.4 (5–269)</td>
<td>65.1 (6–168)</td>
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<td>Height (cm)</td>
<td>168.8 (150–175)</td>
<td>169.8 (139–188)</td>
<td>170.7 (149–187)</td>
<td>170.8 (157–187)</td>
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<td>Weight (kg)</td>
<td>75.1 (63.1–98)</td>
<td>77 (48.5–109)</td>
<td>78.8 (45–138)</td>
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iPTH = intact parathyroid hormone; HD = hemodialysis.

**Table II** Patient biochemical data

<table>
<thead>
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<th>Group D (n = 17)</th>
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<td>iPTH (pg/mL)</td>
<td>56.8</td>
<td>197</td>
<td>422.8</td>
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<td>URR (%)</td>
<td>70.2</td>
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<td>68</td>
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<td>Ca (mg/dL)</td>
<td>9.7</td>
<td>9.02</td>
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<td>PO₄ (mg/dL)</td>
<td>5.3</td>
<td>5.5</td>
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<td>7.1</td>
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<td>CaP</td>
<td>51.4</td>
<td>49.6</td>
<td>53.5</td>
<td>69.5</td>
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<td>Alk (IU/L)</td>
<td>163.4</td>
<td>127.1</td>
<td>118.9</td>
<td>246.9</td>
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<td>Alb (g/dL)</td>
<td>3.88</td>
<td>3.68</td>
<td>3.91</td>
<td>4.1</td>
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<tr>
<td>Alu (µg/L)</td>
<td>7.2</td>
<td>6.5</td>
<td>6.5</td>
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<tr>
<td>Zemplar (µg per session)</td>
<td>0</td>
<td>2.48</td>
<td>4.54</td>
<td>12.5</td>
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iPTH = intact parathyroid hormone; URR = urea reduction ratio; Alk = alkaline phosphatase; Alb = albumin; Alu = aluminum.

**Table III** Patient hematologic data

<table>
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<tr>
<th></th>
<th>Group A (n = 6)</th>
<th>Group B (n = 22)</th>
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<td>Hemoglobin (g/dL)</td>
<td>11.7</td>
<td>12.1</td>
<td>11.8</td>
<td>12</td>
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<td>Serum iron (µg/dL)</td>
<td>78.8</td>
<td>69</td>
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<td>Ferritin (ng/mL)</td>
<td>457.6</td>
<td>667.3</td>
<td>486.6</td>
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<td>EPO (U)</td>
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<td>10,164</td>
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<td>EPO (U/kg per session)</td>
<td>255.8</td>
<td>137.5</td>
<td>128.8</td>
<td>74.35</td>
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<td>EPO index</td>
<td>1,642.3</td>
<td>875.7</td>
<td>861.3</td>
<td>496.5</td>
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EPO = erythropoietin.

Discussion

Patients with CRF often develop hyperparathyroidism secondary to phosphate retention and reduced serum calcitriol levels. Elevated PTH levels can lead to high-turnover bone disease and osteitis fibrosa. Treatment includes control of serum PO₄ and replacement therapy with calcitriol. However, the use of Ca-based phosphate binders combined with calcitriol poses a significant risk of hypercalcemia. The use of calcitriol is also associated with hyperphosphatemia. That side effect led to development of vitamin D analogs—paricalcitol and doxercalciferol—that effec-
tively suppress PTH, but that cause less-severe hypercalcemia and hyperphosphatemia.

The present retrospective study shows that severe HPT is frequent despite aggressive paricalcitol therapy. Possible causes include dietary and medication non-compliance and inability of the patients to afford sevelamer owing to poor socioeconomic conditions.

As in many other studies (13), Zemplar therapy was associated with many side effects: (A) rise in serum Ca level, (B) substantial increase in serum PO₄ level, (C) induction of adynamic bone disease, and (D) increase in Ca×P product. In our study, 7 patients were changed to low-Ca dialysate (1.0 mEq/L) owing to persistent hypercalcemia (Ca > 11.5 mg/dL). To control severe HPT in those patients, dietary and medication compliance may need to be supplemented with more effective non-calcium phosphate binders or calcimimetic agents, or both.

Conclusions
Interestingly, this study showed a positive impact of paricalcitol on anemia in HD patients with good iron status and adequate dialysis parameters. Patients in group A with low iPTH (<100 pg/dL) showed relative EPO resistance. Patients in group D (iPTH > 600 pg/dL, traditionally thought to be EPO-resistant patients) required smaller EPO doses. An inverse relationship was observed between Zemplar and EPO dose. The effect seemed to be independent of iPTH, because group D patients continued to have high iPTH levels. Large prospective trials are needed to replicate our findings and to elucidate the mechanism of action.

References
1 Llach F. Secondary hyperparathyroidism in renal failure: the trade-off hypothesis revisited. Am J

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### Table IV

<table>
<thead>
<tr>
<th>Group</th>
<th>iPTH (pg/mL)</th>
<th>Ca (mg/dL)</th>
<th>PO₄ (mg/dL)</th>
<th>Zemplar (µg per session)</th>
<th>Hb (g/dL)</th>
<th>EPO U/kg per session</th>
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<tbody>
<tr>
<td>A (n=6)</td>
<td>56.8ᵃ</td>
<td>9.7</td>
<td>5.3</td>
<td>0</td>
<td>11.7</td>
<td>255.8ᵇ</td>
</tr>
<tr>
<td>B (n=22)</td>
<td>197</td>
<td>9.02</td>
<td>5.5</td>
<td>2.48ᶜ</td>
<td>12.1</td>
<td>137.5</td>
</tr>
<tr>
<td>C (n=29)</td>
<td>422.8</td>
<td>9.4</td>
<td>5.7</td>
<td>4.54</td>
<td>11.8</td>
<td>128.8</td>
</tr>
<tr>
<td>D (n=17)</td>
<td>1,253.4</td>
<td>9.8</td>
<td>7.1</td>
<td>12.5</td>
<td>12</td>
<td>74.35</td>
</tr>
</tbody>
</table>

ᵃ p < 0.005 versus iPTH in groups B, C, and D.
ᵇ p < 0.005 versus EPO in group D.
ᶜ p < 0.005 versus Zemplar in groups C and D.


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