Cinacalcet Hydrochloride (Sensipar) in Hemodialysis Patients on Active Vitamin D Derivatives with Controlled PTH and Elevated Calcium × Phosphate

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Active vitamin D derivatives attenuate the severity of secondary hyperparathyroidism but often increase serum calcium (Ca) and phosphorus (P) as a result of enhanced intestinal absorption. The calcimimetic cinacalcet HCl lowers parathyroid hormone (PTH) and tends to decrease Ca × P. A 16-wk, open-label clinical trial was conducted in adult hemodialysis patients who had controlled PTH (biointact PTH [biPTH] 80 to 160 pg/ml) and elevated Ca × P (>55 mg^2/dl^2) and were receiving paricalcitol >6 μg/wk (or an equipotent dose of an alternative active vitamin D derivative). At the start of the study, active vitamin D derivatives were decreased to a mean equivalent dose of paricalcitol 6 μg/wk, and cinacalcet was titrated from 30 mg/d to a maximum possible dose of 180 mg/d. Of the 72 study patients, 53 (74%) completed 8 wk of dose titration with cinacalcet. In response to cinacalcet, the following mean percentage changes were observed: biPTH, −1.8%; Ca, −9.7% ($P < 0.0001$), phosphorus, −11.1% ($P < 0.0001$), and Ca × P, −20.1% ($P < 0.0001$). At the end of the study, approximate Kidney Disease Outcomes Quality Initiative targets for biPTH (≤160 pg/ml) were achieved in 85% (45 of 53) of patients and for Ca × P (≤55 mg^2/dl^2) in 72% (38 of 53) of patients. Concurrent achievement of both targets occurred in 47% (25 of 53) of patients. In this open-label clinical trial, hemodialysis patients who had controlled PTH but elevated Ca × P and were taking moderate- to high-dose active vitamin D derivatives achieved improved control of mineral metabolism with a combination of low-dose active vitamin D derivatives and cinacalcet. The long-term effects of this treatment regimen on clinical outcomes should be tested prospectively.

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Secondary hyperparathyroidism (SHPT) is a common complication of chronic kidney disease (CKD). Among patients who receive dialysis, SHPT often manifests as elevations in parathyroid hormone (PTH), serum calcium (Ca), and phosphorus (P). Elevations in these parameters of mineral metabolism have been associated with increased morbidity and mortality in multiple observational cohorts (1–3). Conventional management of SHPT includes the provision of active vitamin D derivatives and phosphate binders (Ca and non–Ca-based). Although active vitamin D derivatives are effective in reducing PTH levels, their use may exacerbate hypercalcemia and hyperphosphatemia as a result of enhanced intestinal Ca and P absorption (4). Therefore, despite the use of phosphate binders and active vitamin D derivatives, the majority of hemodialysis patients fail to achieve all four targets (PTH, Ca, P, and the Ca-P product [Ca × P]) recommended by the National Kidney Foundation Kidney Disease Outcomes Quality Initiative (K/DOQI) clinical practice guidelines (5,6).

Calcimimetics bind to the Ca-sensing receptor, a G protein–coupled receptor that is present on the parathyroid gland (7). The calcimimetics, such as cinacalcet HCl, allosterically modulate the Ca-sensing receptor, increasing its sensitivity to extracellular Ca and thereby decreasing PTH synthesis and secretion from the parathyroid gland (8,9). Cinacalcet reduces PTH with simultaneous decreases in both serum concentrations of Ca and P (10,11). Cinacalcet in combination with low-dose active vitamin D derivatives enabled simultaneous achievement of the K/DOQI treatment goals in dialysis patients with elevated PTH and Ca × P levels (12). Because active vitamin D derivatives can increase Ca × P levels, the objective of this 16-wk study was to evaluate whether a treatment approach that included cinacalcet with low-dose active vitamin D derivatives enhanced the combined achievement of K/DOQI PTH and Ca × P targets in patients with controlled PTH and elevated Ca × P.

Materials and Methods

Study Design

This open-label clinical trial consisted of a 30-d screening phase, an 8-wk dose-titration phase, and an 8-wk assessment phase. Study visits

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occurred at weekly intervals. Adults who were ≥18 yr of age and on maintenance hemodialysis thrice weekly for at least 3 mo were included in the study when two serum samples from the screening phase yielded a mean biointact PTH (biPTH) between 80 and 160 pg/ml (approximately equivalent to intact PTH between 150 and 300 pg/ml), a mean Ca × P >55 mg^2/dl^2, and a mean albumin-corrected serum Ca concentration ≥8.4 mg/dl. All patients were required to have received intravenous active vitamin D derivatives (doses of paricalcitol >6 μg, doxercalciferol >3 μg, or calcitriol >1.5 μg/wk) during the 30 d before study treatment. Exclusion criteria were pregnancy or nursing, use of inhibitors of cytochrome P450 (CYP)3A4 (*e.g.*, ketoconazole, itraconazole, erythromycin) or inducers of CYP3A4 (*e.g.*, rifampin, St. John's Wort) within 21 d of study start, use of medications that are metabolized predominantly by CYP2D6 (*e.g.*, flecainide, vinblastine, thioridazine, most tricyclic antidepressants) within 21 d of study start, myocardial infarction or parathyroidectomy within 3 mo, or any unstable medical condition. The study was conducted in accordance with the principles originating in the Declaration of Helsinki. The protocol and informed consent form were approved by the appropriate Independent Ethics Committee/Institutional Review Board, and written informed consent was obtained from all patients.

Intervention (Drug Titrations)

On day 1 of the dose-titration phase, the active vitamin D derivative dose was decreased to low doses that are considered to be approximately physiologic (equivalent to paricalcitol 2 μg, doxercalciferol 1 μg, or calcitriol 0.5 μg per dialysis session), and oral cinacalcet was initiated at 30 mg/d. The dose of cinacalcet could be increased every 2 wk sequentially to 60, 90, 120, and 180 mg/d when the biPTH was >160 pg/ml or between 80 and 160 pg/ml with Ca × P >55 mg^2/dl^2. The dose of cinacalcet was not titrated further when the maximum dose had been reached, the serum Ca was <8.4 mg/dl, or an adverse event precluded a dose increase. The active vitamin D derivative dose could be increased when the patient had a serum Ca level <8.4 mg/dl or exhibited symptoms of hypocalcemia. The active vitamin D derivative dose could also be increased when biPTH was >270 pg/ml and Ca × P was <70 mg^2/dl^2 and cinacalcet could not be titrated further. The active vitamin D derivative dose could be decreased when two consecutive biPTH concentrations were <80 pg/ml. The doses of Ca-based and other phosphate binders could be adjusted throughout the study and could be increased when the serum Ca was <8.4 mg/dl or the patient had symptoms of hypocalcemia. The dose of cinacalcet could be decreased when the biPTH level was <80 pg/ml and active vitamin D derivative therapy had already been discontinued. When the biPTH dropped below 80 pg/ml on cinacalcet 30 mg/d, the dose could be reduced to 30 mg on alternate days.

Efficacy and Safety Measures

Laboratory biochemical values (biPTH, serum Ca and serum P, Ca × P) were determined from blood samples that were collected before dialysis and the daily dose of cinacalcet at study visits at weeks 1, 3, 5, 7, 9, 11, 13, 15, and 16. The Nichols Advantage Bio-Intact $PTH_{(1-84)}$ immunometric assay (Nichols Institute Diagnostics, San Clemente, CA) was used by the central laboratory to measure biPTH. A strong correlation between the results of intact PTH and biPTH assays has been demonstrated (13), suggesting that the biPTH assay can be used to examine the attainment of K/DOQI or other clinical practice guideline targets.

The doses of active vitamin D derivatives and phosphate binders were recorded at each visit. Adverse events were collected from spontaneous reports and in response to nondirected questioning at each study visit.

Statistical Analyses

The safety population included all patients who received at least one dose of cinacalcet. The efficacy population consisted of patients with at least one efficacy measurement during the assessment phase. The primary efficacy end points were mean proportion of patients with biPTH ≤160 pg/ml (approximately equal to iPTH ≤300 pg/ml) and mean Ca × P ≤55 mg^2/dl^2 during the assessment phase and the absolute values and percentage changes from baseline for biPTH, serum Ca (corrected), serum P, and Ca × P. Differences in biochemical parameter values at baseline and during the assessment phase were analyzed using paired *t* test. Secondary efficacy end points included combined achievement of the K/DOQI goals for biPTH and Ca × P; mean doses and changes in dose from baseline for active vitamin D derivatives and phosphate binders; and safety assessments, including all adverse events and the incidence of serum Ca concentrations <8.4 or <7.5 mg/dl.

Results

Study Population

The study was conducted from September 30, 2003, to June 30, 2004. Of the 72 patients who were enrolled and received study drug, 53 (74%) entered the 8-wk efficacy assessment phase and 39 (54%) completed the 16-wk study. The mean age of patients who entered the study was 57 yr; 45 (63%) patients were male and 38 (53%) were black (Table 1). All patients were receiving active vitamin D derivatives at baseline, in accordance with the study design.

Four (6%) patients discontinued because of adverse events. Overall, the most common additional reasons for early discontinuation were ineligibility for study inclusion on the basis of screening laboratory values ($n = 11$; 15%), administrative decision ($n = 5$; 7%), and withdrawal of consent ($n = 4$; 6%). Baseline characteristics for patients who entered the assessment phase ($n = 53$) were similar to the overall study population ($n = 72$; Table 1).

Effects of Cinacalcet on Biochemical End Points

Among the 53 patients who entered the assessment phase, baseline mean ± SD concentration of biPTH was 117.3 ± 32 pg/ml (Table 1). Forty-eight (91%) patients had a biPTH concentration ≤160 pg/ml at baseline, and 45 (85%) patients maintained this control during cinacalcet therapy (Figure 1). Because eligibility was determined in the screening phase before baseline, not all patients had a baseline mean biPTH <160 pg/ml. Mean biPTH remained within the K/DOQI target range (80 to 160 pg/ml) throughout the study (Figure 2A). Only one patient had an active vitamin D derivative dose increase as a result of failure to control the biPTH with cinacalcet.

The mean ± SD serum Ca concentration at baseline was 9.7 ± 0.7 mg/dl (Table 1). Treatment with cinacalcet significantly reduced mean serum Ca (Figure 3) to 8.8 mg/dl during the assessment phase ($P < 0.0001$ *versus* baseline). The mean serum Ca was within the K/DOQI target range after 1 wk of cinacalcet treatment and remained within range throughout the study (Figure 2B).

Table 1. Baseline demographics and clinical characteristics[a]

Characteristic	Safety Population (n = 72)	Assessment Phase Population (n = 53)
Gender (n [%])		
male	45 (63)	33 (62)
female	27 (38)	20 (38)
Race (n [%])		
black	38 (53)	25 (47)
white	30 (42)	25 (47)
other	4 (6)	3 (6)
Age (yr [mean ± SD])	56.9 ± 11.8	57.8 ± 12.8
Active vitamin D derivative use (n [%])	72 (100)	53 (100)
Phosphate binder use (n [%])	71 (99)	53 (100)
biPTH (pg/ml [mean ± SD])	118.9 ± 32.5	117.3 ± 32.0
Ca × P (mg^2/dl^2 [mean ± SD])	59.6 ± 14.6	63.8 ± 10.8
Serum calcium (mg/dl [mean ± SD])	9.7 ± 0.7	9.7 ± 0.7
Serum phosphorus (mg/dl [mean ± SD])	6.2 ± 1.5	6.6 ± 1.2

[a]biPTH, biointact parathyroid hormone; Ca × P, calcium-phosphorus product. Dialysate calcium concentration 2.5 mEq/L was used.

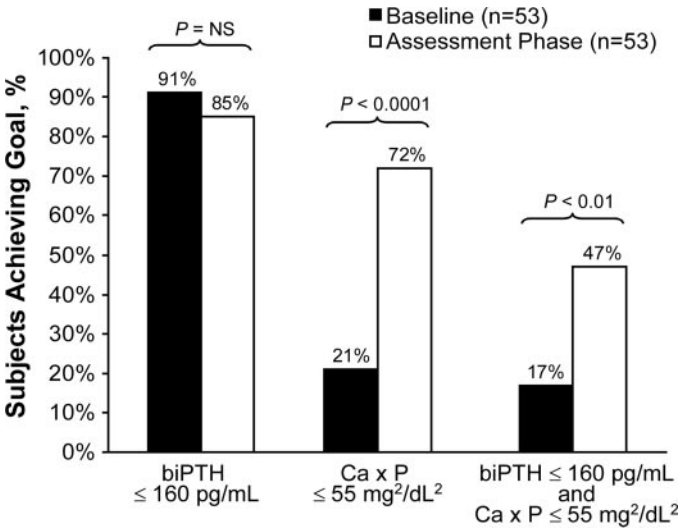

Figure 1. Achievement of Kidney Disease Outcomes Quality Initiative (KDOQI) goals for biointact parathyroid hormone (biPTH) and calcium-phosphorus product (Ca × P) among patients who reached the assessment phase (n = 53). The primary efficacy end points of the study were mean biPTH of ≤160 pg/ml and Ca × P of ≤55 mg^2/dl^2. A secondary efficacy end point was concurrent achievement of the goals for both biPTH and Ca × P.

The mean ± SD serum P concentration at baseline was 6.6 ± 1.2 mg/dl (Table 1). Treatment with cinacalcet significantly reduced mean serum P to 5.7 mg/dl ($P < 0.0001$ *versus* baseline; Figure 3). Mean serum P concentrations were reduced to within the K/DOQI target range (3.5 to 5.5 mg/dl) by week 13 of the assessment phase (Figure 2C).

The mean ± SD Ca × P at baseline was 63.8 ± 10.8 mg^2/dl^2 (Table 1). Cinacalcet treatment significantly reduced mean Ca × P to 50.0 mg^2/dl^2 ($P < 0.0001$ *versus* baseline; Figure 3). Improvement in mean Ca × P was rapid and sustained, occurring within the first week of cinacalcet treatment and lasting throughout the study (Figure 2D). In line with the sustained decrease in Ca × P, treatment with cinacalcet increased the percentage of patients who achieved the K/DOQI Ca × P goal of ≤55 mg^2/dl^2 from baseline to the assessment phase (21 *versus* 72%; $P < 0.0001$; Figure 1). As was observed with biPTH, eligibility was determined in the screening phase before baseline, and accordingly, 11 patients had a baseline mean Ca × P <55 mg^2/dl^2.

Finally, a key aspect of this study was to determine whether administration of cinacalcet in combination with low-dose active vitamin D derivatives could maintain control of biPTH and provide improved Ca × P control compared with conventional moderate- to high-dose active vitamin D derivative therapy. Indeed, 47% (n = 25) of patients jointly achieved the target levels for both biPTH and Ca × P (Figure 1).

Medication Use

All patients were receiving active vitamin D derivatives at baseline. The mean ± SD equivalent paricalcitol dose at baseline for the 53 patients who subsequently reached the assessment phase was 14.1 ± 7.8 μg/wk (Table 2). By the assessment phase, 21% of patients had stopped taking active vitamin D derivatives completely. For the remainder, the mean dose was decreased by approximately 49% to 6.9 μg/wk (Table 2). All patients who reached the assessment phase were receiving phosphate binders at the start of the study. The proportion of patients who were receiving sevelamer was similar at baseline and during the assessment phase of the study (59 *versus* 57%). The mean sevelamer dose decreased nonsignificantly from 9036 to 8250 mg/d (Table 2). Use of Ca-based phosphate binders increased from baseline to the assessment phase, both in terms of the percentage of patients who were taking the binders (from

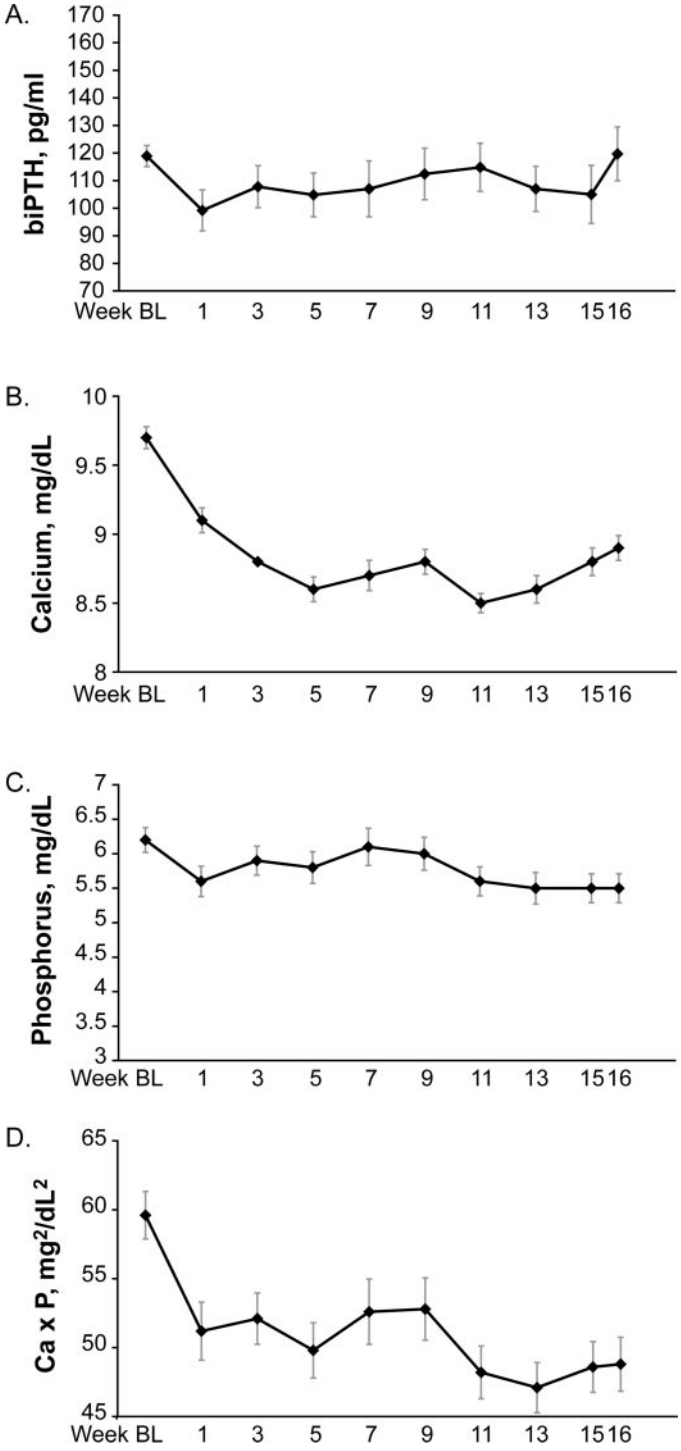

Figure 2. Mean ± SEM laboratory values by study week. biPTH (A), serum Ca (B), serum P (C), and Ca × P (D).

62 to 79%) and significantly with respect to the mean dose (from 1435 to 1847 mg/d of elemental Ca; Table 2). All patients started the study on 30 mg once daily of cinacalcet. The mean ± SD dose at week 16 (end of study) was 55 ± 29 mg/d.

Safety

During the course of the study, 74% (53 of 72) of enrolled patients reported adverse events, which were predominately

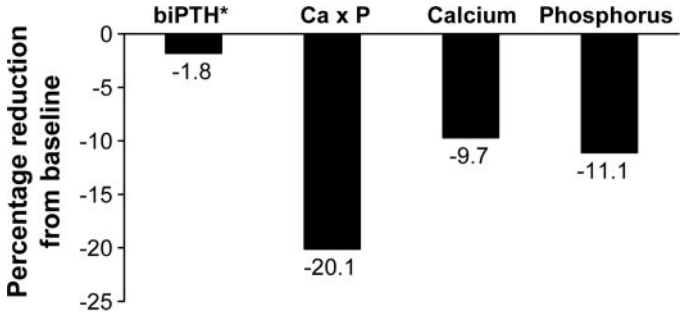

Figure 3. Mean percentage change in biochemical end points from baseline during cinacalcet therapy. *Objective was to stay in range at approximate baseline level.

mild to moderate in severity and similar to those previously reported (10,11). The most commonly reported adverse events included nausea ($n = 10$; 14%), vomiting ($n = 10$; 14%), and diarrhea ($n = 9$; 13%; Table 3). The level of biPTH fell below 80 pg/ml for 53 (74%) patients but returned to the target range in 42 of these patients. Of the 11 patients whose biPTH levels did not return to >80 pg/ml, six discontinued the study after the laboratory test had been obtained (and before a follow-up laboratory test), and one patient experienced the low biPTH value at the end of the study (week 15). Four patients had sustained low biPTH concentrations throughout the study. Overall, 17 (24%) patients had two consecutive serum Ca levels <8.4 mg/dl, and one (1%) patient had two consecutive values <7.5 mg/dl. No patient discontinued cinacalcet therapy as a result of hypocalcemia. One patient with a history of seizure disorder experienced generalized seizure approximately 2 mo after initiating cinacalcet therapy; the event was considered to be unrelated to cinacalcet treatment by the investigator. Four patients died during the study (angina pectoris, foot infection, respiratory arrest, and unexplained death); none of the deaths was considered to be related to cinacalcet.

Discussion

In this 16-wk, open-label clinical trial, we enrolled patients who were on hemodialysis and receiving active vitamin D derivatives and controlled biPTH and elevated Ca × P levels. We evaluated the effect of a treatment approach that incorporated cinacalcet plus low-dose active vitamin D derivatives on control of SHPT and attainment of K/DOQI targets. The introduction of cinacalcet maintained control of biPTH and, in addition, significantly improved control of Ca × P, resulting in an increase in the proportion of patients who simultaneously achieved the biPTH and Ca × P target levels (17 to 47% during the course of the study). During the study, 20% of patients discontinued active vitamin D derivatives completely, and the average dose for the remaining patients fell by 49%. In addition to demonstrated efficacy on biochemical outcomes, cinacalcet was well tolerated. As in earlier studies (10,11), gastrointestinal symptoms were the most commonly observed side effects but generally were mild in intensity. No patient experienced symptoms of hypocalcemia, and none was withdrawn as a result of hypocalcemia.

Table 2. Use of concomitant medications for SHPT at baseline and during the assessment phase in the efficacy population[a]

	Baseline (n = 53)	Assessment Phase (n = 53)
Active vitamin D derivative use		
received active vitamin D derivative (n [%])	53 (100)	42 (79)
paricalcitol dose equivalents[b] (μg/wk [mean ± SD])	14.1 ± 7.8	6.9 ± 4.6[c]
Phosphate binder use	53 (100)	52 (98)
Sevelamer use		
received sevelamer (n [%])	31 (59)	30 (57)
sevelamer dose (mg/d [mean ± SD])	9036 ± 5033	8250 ± 4980[d]
Ca-based phosphate binder use		
received a Ca-based phosphate binder (n [%])	33 (62)	42 (79)
total elemental Ca intake (mg/d [mean ± SD])	1435 ± 1030	1847 ± 1307[e]

[a]SHPT, secondary hyperparathyroidism.
[b]2 μg paricalcitol = 1 μg doxercalciferol = 0.5 μg calcitriol.
[c]$P < 0.0001$ among 42 patients on active vitamin D derivatives at baseline and in assessment phase.
[d]$P = 0.13$ among 28 patients who were on sevelamer at baseline and in assessment phase.
[e]$P = 0.0013$ among 32 patients on Ca-based phosphate binder at baseline and in assessment phase.

Table 3. Adverse events in >5% of patients

Event	n (%; N = 72)
Nausea	10 (14)
Vomiting	10 (14)
Diarrhea	9 (13)
Arthralgia	6 (8)
Graft thrombosis	6 (8)
Upper respiratory tract infection	5 (7)
Constipation	4 (6)
Hypotension	4 (6)
Rigors	4 (6)

SHPT generally is associated with abnormally high rates of bone resorption and is often accompanied by pain and fractures (14–16). Extraskeletal manifestations of the disease include vascular calcification, hypertension, anemia, pruritus, and sexual dysfunction (17–25). Analyses of data from large hemodialysis cohorts (1–3) have demonstrated significant relations among elevated PTH, Ca, and P and mortality and morbidity. Block *et al.* (3) showed that PTH concentrations >600 pg/ml were associated with an increase in the risk for death compared with PTH concentrations <600 pg/ml; higher PTH was also associated with higher risks for cardiovascular disease and fracture. In the same analysis, hyperphosphatemia was strongly associated with mortality, cardiovascular disease, and fracture; hypercalcemia was also associated with mortality (3). The K/DOQI treatment guidelines provide recommended target levels for PTH (150 to 300 pg/ml), serum Ca (8.4 to 9.5 mg/dl), P (3.5 to 5.5 mg/dl), and Ca × P (<55 mg^2/dl^2) (6). Observational studies have shown that being "in range" is associated with enhanced survival (3,5). Although treatment of SHPT is often aimed at the achievement of these goals, to date, no interventional studies have demonstrated that achievement of K/DOQI targets directly improves clinical outcomes. Randomized trials to compare alternative Ca or P targets have not been conducted.

Active vitamin D derivatives are commonly used for the treatment of SHPT (26). In addition to their effects on the parathyroid gland, potential benefits on muscle and immune function have been suggested (27–33). Treating SHPT with active vitamin D derivatives necessitates balancing its effect on PTH reduction with its effects on Ca and P absorption (leading to hypercalcemia and hyperphosphatemia). Hence, achievement of all K/DOQI bone metabolism and disease targets simultaneously is challenging (5). Our study has addressed a common clinical dilemma: Determining optimal management of mineral metabolism when PTH concentrations can be controlled with active vitamin D derivatives. The study has demonstrated the feasibility and the efficacy of combination therapy with cinacalcet and low-dose active vitamin D derivatives. Dual control of PTH and Ca × P, according to K/DOQI recommendations, can be achieved in 47% of patients with this strategy. Because these patients were previously being treated with vitamin D and phosphate binders, these data suggest that use of cinacalcet may lead to a greater percentage of patients' achieving K/DOQI targets. It is interesting that 20% of patients in the study discontinued active vitamin D derivatives, yet the overall population remained well managed with cinacalcet and phosphate binders alone.

Clinical trials using active vitamin D derivatives have included primarily small placebo-controlled or active vitamin D derivative comparison studies that evaluated effects on biochemical end points (34–38) or bone histomorphology and other surrogate markers (39–42). In an observational study that included >30,000 hemodialysis patients, Teng *et al.* (43) showed a 20% reduction in mortality among patients who were treated with active vitamin D derivatives compared with those who were not treated; subgroup analyses showed a benefit of active

vitamin D derivatives even among patients with high serum P and low PTH concentrations. Although these data suggest a benefit of active vitamin D derivatives on mortality, the results could be explained by residual confounding. In a similar retrospective analysis, Young *et al.* (2) did not observe a relation between activated vitamin D derivative use and mortality. Henley *et al.* (44) recently demonstrated progressive aortic calcification in rats that had SHPT and were treated with calcitriol, whereas vehicle- and cinacalcet-treated rats had no significant calcification, although extremely high doses of calcitriol were used (100 ng, corresponding to 0.25 to 0.28 μg/kg body wt). In humans, broad clinical experience has demonstrated increased Ca and P levels with vitamin D therapy (34,45–47). In a pooled *post hoc* analysis of prospective, randomized studies, a significant reduction in hospitalization for cardiovascular disease and fracture and an improvement in self-reported physical function were observed among patients who were randomly assigned to cinacalcet *versus* placebo when added to conventional therapy (48). It will be important to evaluate whether a combination of cinacalcet and low-dose active vitamin D derivatives might provide greater clinical benefit. For addressing this question definitively, prospective, long-term clinical trials to evaluate the effects of active vitamin D derivatives and cinacalcet on mortality, cardiovascular events, fracture, and other outcomes are required.

The dose of Ca-based phosphate binders that were prescribed after starting cinacalcet was increased. Oral Ca from phosphate binders has been associated with vascular calcification (20,21), and, compared with sevelamer, doses of oral Ca in the range provided here resulted in more rapid progression of vascular calcification (49,50) and a reduction in bone attenuation (51) in hemodialysis patients. Although the provision of Ca-based phosphate binders may normalize serum Ca after cinacalcet therapy, the net benefits of serum Ca correction *versus* the potential adverse effects of Ca loading are unknown. Although preclinical studies have shown that calcimimetics are not associated with vascular calcification (44), the effect of treatment with cinacalcet and Ca-based phosphate binders warrants further investigation.

Our study has some limitations. The sample size was small, and the study was open label. However, the study results were consistent with the biochemical effects seen in previous placebo-controlled, randomized trials (10,11). Different active vitamin D derivatives may exert varying effects on the absorption of Ca and P from the intestinal tract. Moreover, the use of Ca-containing phosphate binders may increase serum Ca. Because the protocol did not mandate specific active vitamin D derivatives or phosphate binders, differences in co-interventions may have confounded the results. However, the clinical dilemma addressed by this study is common, and the results can be used to inform clinical practice.

Conclusion

This study has demonstrated that combined therapy with cinacalcet and low-dose active vitamin D derivatives improves control of PTH and Ca $\times$ P in hemodialysis patients with SHPT and elevated Ca $\times$ P and increases the likelihood of achieving K/DOQI targets. The long-term effects of this therapeutic approach on clinical outcomes should be tested prospectively.

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See related editorial, "Calcium, Calcimimetics and Clinical Outcomes," on pages 170–171.

Clinical use of the calcimimetic cinacalcet in hemodialysis (Chertow *et al*.) and transplant patients (Srinivas *et al*.) with the corresponding editorial by Block are featured in this month's *CJASN*. A study in experimental animals on another congener by Lopez *et al*. in this month's *JASN* (pages 795–804) shows a decrease in extraosseous calcifications, even in calcitriol-treated animals.