

Adherence to K/DOQI Practice Guidelines for Bone Metabolism and Disease

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Objective: To determine adherence to Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines for frequency of testing and control of parathyroid hormone (PTH), calcium, and phosphorus levels among patients with chronic kidney disease (CKD).

Study Design: Retrospective cohort.

Methods: The analysis was performed with administrative claims data from large US managed care plans. Patients with CKD were identified based on claims and laboratory data. Patients were excluded if they were <18 years or ≥65 years old, had fewer than 18 months of continuous eligibility, or had renal cancer.

Results: A total of 793 patients were identified with CKD stages 3, 4, or 5 (n = 424, n = 212, and n = 157, respectively). Serum calcium testing was conducted according to guidelines (once a year) in a high percentage of patients with stage 3 CKD (91%); however, the percentage dropped among patients with stage 4 CKD (64%), for whom the guidelines recommend testing 4 times a year. Plasma PTH and serum phosphorus levels were tested infrequently. Among those tested, a high percentage of both stage 3 and 4 CKD patients were in K/DOQI target ranges for calcium and phosphorus. However, fewer than half of the patients tested had PTH values within the target ranges.

Conclusion: There remains substantial opportunity to improve the quality of care with respect to bone and mineral metabolism in patients with CKD.

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Patients with chronic kidney disease (CKD) who require treatment with dialysis have a much shorter life expectancy and consume much larger amounts of healthcare-related resources than persons in the general population. Annual mortality rates among patients receiving dialysis are approximately 21%, and more than half of the deaths are due to cardiovascular (CV) diseases.¹ Hospitalization rates among dialysis recipients average between 1.8 and 2.4 admissions per year.¹ As many as one third of these hospitalizations are from CV causes.¹

Annual mortality rates also are higher among patients with stage 3 or 4 CKD compared with the general population. Mortality rates average 15.5% per year, or nearly three quarters as high as the mortality rate for patients undergoing dialysis.² Cardiovascular disease not only is the leading cause of death among these patients but also accounts for a substantial proportion of their hospital admissions, as it does for patients undergoing dialysis.^{3,4} The adjusted risk of hospitalization increases progressively as renal function declines, ranging from a 14% greater risk in patients with stage 3 CKD and an estimated glomerular filtration rate (eGFR) between 45 and 59 mL/min to a 315% greater risk in patients with stage 5 CKD and an eGFR below 15 mL/min.⁵

Several important CV risk factors are present in patients with CKD, including hypertension, extracellular fluid volume overload, diabetes, glucose intolerance, dyslipidemia, and alterations in homocysteine metabolism.⁶⁻¹¹ Unfortunately, these factors collectively fail to account fully for the very high morbidity and mortality rates from CV causes even when considered together with other established CV risks such as advanced age, male sex, obesity, and tobacco use.^{7,12,13} In this regard, disturbances in mineral metabolism have received considerable attention in recent years as potentially important nontraditional risk factors for CV disease among patients with CKD.¹⁴⁻¹⁸

Abnormalities in calcium and phosphorus metabolism are common among patients treated with dialysis regularly, and observational studies suggest that elevated serum calcium and phosphorus levels are associated with increases in all-cause and CV mortality. In some reports, elevated plasma parathyroid hormone (PTH) levels also have been linked to adverse clinical outcomes.¹⁹⁻²³ Although less is known about the risks associated with these biochemical abnormalities among patients with stage 3 or 4 CKD, plasma PTH levels often are elevated,

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whereas serum calcium and phosphorus levels typically remain within the normal range until the GFR is less than 15-20 mL/min. Nevertheless, patients who underwent any assessment of mineral metabolism or secondary hyperparathyroidism (SHPT) before beginning dialysis had a 38% lower risk of death than those who did not undergo this assessment in multivariate adjusted models (odds ratio = 0.62; 95% confidence interval = 0.49, 0.80).²⁴ Such findings suggest that patients with stage 3 and stage 4 CKD are a good target population for therapeutic interventions aimed at reducing CV morbidity and mortality among patients with end-stage renal disease.

The Kidney Disease Outcomes Quality Initiative (K/DOQI) Clinical Practice Guidelines for Bone Metabolism and Disease in Chronic Kidney Disease provide recommendations about the frequency of biochemical testing to determine plasma PTH levels and the serum levels of calcium (Ca) and phosphorus (P), including calculated values for the calcium-phosphorus ion product in serum ($\text{Ca} \times \text{P}$). Acceptable target ranges for these biochemical parameters also are delineated. The objectives of these guidelines are to improve the clinical management of patients with CKD, to minimize and/or prevent metabolic bone disease, and to reduce the risks of vascular calcification and CV disease.²⁵ The current research was done to assess the clinical surveillance of patients with stage 3, 4, or 5 CKD by obtaining data about their medical care and examining adherence to the K/DOQI guidelines from a naturalistic, managed care perspective.

METHODS

Administrative claims data from large managed care health plans within the United States were used for this study. The database included enrollment information, medical and prescription claims data, and laboratory test results.

The abbreviated version of the Modification of Diet in Renal Disease (MDRD) equation was used to estimate GFR. Race was not included in the computation as it was not available in the data.

Patients with CKD were identified from June 1, 2002, to May 31, 2004, by review of medical claims and electronic laboratory data. Patients were required to have, within 90 days of each other, both a claim categorization for CKD and an eGFR of <60 mL/min. The date of the first of these 2 events was used as the index date (Figure). The 90-day period following the index date was used to determine the stage of CKD, which was based either on the lowest eGFR during the period or receiving regular dialysis (Figure). The CKD stages were mutually exclusive as defined by the K/DOQI system of classification,

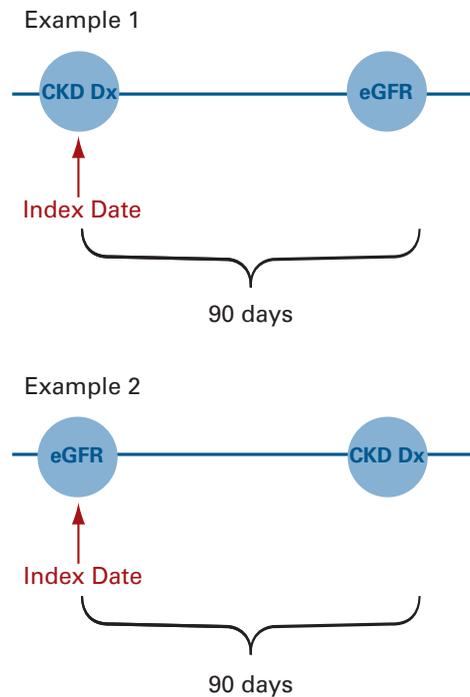
and the most advanced stage of CKD during the first 90 days after the index date was used to categorize patients:

- Stage 3: eGFR values ≥ 30 mL/min but <60 mL/min with no dialysis therapy.
- Stage 4: eGFR values ≥ 15 mL/min but <30 mL/min with no dialysis therapy.
- Stage 5: eGFR values <15 mL/min or regular dialysis therapy.

Current Procedural Terminology (CPT), UB-92, and *International Classification of Diseases, Ninth Revision* diagnosis and procedure codes were used to identify patients undergoing dialysis regularly.

Only patients with at least 6 months of data prior to the index date and at least 12 months of data after the index date were included in the analysis. The information available before the index date was used to determine comorbid conditions and medication utilization. The data available from the 12-month period after the index date were used to assess

■ **Figure.** Identification of Patients and Determination of Index Date



Example 1: The diagnosis of CKD determined the index date, and the eGFR value determined the stage of CKD. If there had been more than 1 eGFR measurement in the 90 days after the index date, then the lowest eGFR or the regular use of dialysis would have determined the CKD stage.

Example 2: The eGFR value determined the index date and the CKD stage. If there had been more than 1 eGFR measurement in the 90 days after the index date, then the lowest eGFR or the regular use of dialysis would have determined the CKD stage.

CKD indicates chronic kidney disease; Dx, diagnosis; eGFR, estimated glomerular filtration rate.

■ **Table 1.** Preindex Period Demographic and Clinical Characteristics

Characteristic	Total CKD Cohort (N = 793)	Stage 3 (n = 424)	Stage 4 (n = 212)	Stage 5 (n = 157)
Mean age, y (SD)	51.2 (10.0)	51.2 (9.8)	51.5 (10.1)	50.6 (10.3)
Female, %	39.1	34.4	43.4	45.9
Mean Deyo Charlson Comorbidity Index score	2.8	2.7	2.9	2.9
Diabetes mellitus, %	41.0	40.8	42.5	39.5
Hypertension, %	75.5	72.9	76.4	81.5
CV disease, %	33.3	30.4	37.7	35.0
Anemia, %	30.3	19.1	36.3	52.2
SHPT, %	6.8	2.1	3.8	23.6
Systemic infections, %	6.3	4.0	6.6	12.1
Prior renal transplant, %	8.6	8.3	9.0	8.9
Dialysis, %	5.6	0.9	1.4	23.6

CKD indicates chronic kidney disease; CV, cardiovascular; SHPT, secondary hyperparathyroidism.

of erythropoietin, vitamin D sterols, and phosphate-binding agents was substantially greater among patients with stage 5 CKD than among patients who had stage 3 or 4 CKD.

The utilization of medications in each category increased during the postindex period compared with the preindex period (Table 2).

Rates of hospitalizations during the postindex period ranged from 24% for stage 3 CKD to 50% for stage 5 CKD (Table 3). The percentage of patients seen by a nephrologist also increased as kidney function declined, rising from 69% in stage 3 CKD to 98% in stage 5 CKD.

The frequency of biochemical testing for parameters of mineral metabolism differed substantially according to

changes in eGFR, changes in medication utilization, and adherence to K/DOQI guidelines for the frequency of assessment of biochemical markers of mineral metabolism.

Patients were excluded from the study if they were younger than 18 or older than 65 years of age, or had fewer than 18 months of continuous eligibility. Patients with a diagnosis of renal cancer also were excluded.

RESULTS

A total of 793 patients satisfied the inclusion criteria for CKD: 424 with stage 3, 212 with stage 4, and 157 with stage 5 CKD (Table 1). The mean age of the patients was 51 years (SD = 10.0 years) and 39% were female. The percentage of females increased according to the stage of CKD. Most patients had substantial comorbidities (Table 1). Hypertension was present in approximately 76% of the patients, diabetes in 41%, CV disease in 33%, and anemia in 30%. The prevalence of anemia increased from 19% in stage 3 CKD to more than 50% in stage 5 CKD.

During the preindex period, the use of antihypertensive medications was common. Approximately 41% of patients received diuretics, 39% received calcium channel blockers, 35% received angiotensin-converting enzyme inhibitors, 31% received beta blockers, and 12% received angiotensin II receptor blockers (Table 2). The use of oral hypoglycemic agents and insulin also was prevalent (10% received sulfonylureas and 8% received thiazolidinediones, the 2 most commonly prescribed oral agents, and 18% received insulin). Use

of the stage of CKD (Table 4). A progressively smaller proportion of patients with stage 3, 4, or 5 CKD had the recommended number of measurements of serum calcium and phosphorus concentrations and plasma PTH levels as set forth in the K/DOQI guidelines. Serum calcium concentrations were measured at the recommended frequency in most patients with stage 3 CKD, but the proportion of patients with stage 4 CKD who were monitored quarterly and the fraction with stage 5 CKD who were monitored monthly were substantially smaller. Serum phosphorus levels were measured in fewer patients than serum calcium levels, and plasma PTH levels were obtained in only a small proportion of patients at any stage of CKD, including those with stage 5 CKD in whom monthly testing is advised. Plasma PTH levels were within the recommended target range in a minority of patients regardless of the stage of CKD. In contrast, serum calcium and phosphorus levels were within the recommended range in a large proportion of patients with stage 3 or 4 CKD. Even among those with stage 5 CKD, serum calcium and phosphorus levels remained at acceptable levels in more than 80% and 70%, respectively.

DISCUSSION

In this naturalistic study, patients with CKD had substantial comorbidity and consumed considerable healthcare-related resources over the 1-year postindex period. Mineral metabolism was generally not monitored with the frequency recommended in the K/DOQI guidelines. Measurements of serum calcium concentrations were obtained most often in

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accordance with the K/DOQI guidelines among patients with stage 3 CKD, but the proportion of patients monitored adequately was substantially lower at more advanced stages of CKD. A very small proportion of patients had plasma PTH levels measured according to the frequency recommended in the K/DOQI guidelines at any stage of CKD. The results thus indicate that the prevalence and severity of SHPT are underestimated in this patient population.

A large proportion of patients with stage 3, 4, or 5 CKD had serum calcium and phosphorus levels that fell within the ranges considered acceptable according to the K/DOQI guidelines. That was not the case, however, for plasma PTH levels. Among those tested, fewer than 40% of patients with stage 3 CKD and fewer than a third of patients with stage 4 or 5 CKD were within the target range. Such findings indicate that the biochemical diagnosis of SHPT requires testing that is specific for PTH and that measurements of other biochemical parameters of mineral metabolism (including serum calcium and phosphorus concentrations) are grossly inadequate for identifying patients with this important clinical disorder.

The current results are consistent with data reported elsewhere. Several previous studies have documented that the frequency of biochemical testing for disturbances in mineral metabolism is both inconsistent and infrequent. Results from 1 study indicated that only 50% of patients with CKD had at least 1 measurement of serum phosphorus and only 12% had 1 or more measurements of plasma PTH during the 2 years before beginning dialysis.²⁶ Others found that only 3.4% of 3014 patients had plasma PTH levels measured and only 0.3% had vitamin D levels measured during the year immediately prior to the start of dialysis.²⁷ Moreover, only 20% of patients

with stage 4 CKD who were followed by a nephrologist for 6 months or longer had plasma PTH levels that fell within the K/DOQI target range, whereas 91% of patients had acceptable serum calcium levels and 80% had acceptable serum phosphorus levels.²⁸ The potential importance of these findings is underscored by the fact that patients with CKD who were evaluated for SHPT before beginning dialysis had a 38% lower risk of death than those who were not.²⁴ The K/DOQI guidelines for bone metabolism and disease discussed in the current report were published initially in October 2003, which corresponds temporally with the latter portion of the observational period for this study. Additional work is needed to determine whether current practice differs substantially from

■ **Table 2.** Preindex Period and Postindex Period Medication Use*

Medications, %	Total CKD Cohort (N = 793)	Stage 3 (n = 424)	Stage 4 (n = 212)	Stage 5 (n = 157)
Preindex period				
ACE inhibitor	35.2	34.7	36.8	34.4
ARB	12.3	12.0	13.7	11.5
Diuretic	41.1	38.2	50.0	36.9
BB	30.9	27.1	33.5	37.6
CCB	38.6	33.5	41.0	49.0
Oral antidiabetic agents	23.8	31.6	16.5	12.7
Insulin	18.4	17.2	20.8	18.5
Iron supplement	2.0	0.9	1.9	5.1
Epoetin therapy	12.4	3.3	10.9	38.9
Vitamin D	2.4	0.7	1.9	7.6
Phosphate binders	6.4	0.9	3.8	24.8
Postindex period				
ACE inhibitor	41.4	45.1	38.2	35.7
ARB	24.2	25.0	26.9	18.5
Diuretic	49.6	46.9	59.4	43.3
BB	44.5	35.9	53.3	56.1
CCB	49.1	41.3	52.4	65.6
Oral antidiabetic agents	28.4	36.1	21.2	17.2
Insulin	23.8	21.7	28.3	23.6
Iron supplement	7.1	2.4	9.0	17.2
Epoetin therapy	27.2	7.8	30.2	75.8
Vitamin D	10.0	1.9	10.9	30.6
Phosphate binders	13.6	0.7	9.0	54.8

*The 6 months before the index date was the preindex period. The 12 months after the index date was the postindex period.
CKD indicates chronic kidney disease; ACE, angiotensin-converting enzyme; ARB, angiotensin II receptor blocker; BB, beta blocker; CCB, calcium channel blocker.

■ **Table 3.** Postindex Period Utilization and Laboratory Tests*

Resource Utilization and Laboratory Tests, %	Total CKD Cohort (N = 793)	Stage 3 (n = 424)	Stage 4 (n = 212)	Stage 5 (n = 157)
Inpatient hospitalization	33.8	24.3	40.6	50.3
Nephrologist visit	80.0	68.6	89.6	97.5
Dialysis	18.8	1.9	13.7	71.3
Serum creatinine	90.9	87.5	93.9	96.2
Albumin creatinine ratio	6.1	6.8	8.0	1.3
Kidney imaging	32.2	30.0	35.4	33.8
Hemoglobin	77.8	69.1	85.9	90.5
Hematocrit	77.6	68.6	85.4	91.1
A1C	34.8	33.5	40.1	31.2
Lipids	56.5	56.8	64.6	44.6

* The 12 months after the index date was the postindex period. CKD indicates chronic kidney disease; A1C, glycosylated hemoglobin.

other populations. Second, the use of diagnostic codes to identify individuals with CKD and other comorbid conditions is not as rigorous as formal diagnostic assessments for determining health status. Third, the use of medical claims data alone does not provide information about quality of life, the functional status of patients, or clinical outcomes. Finally, the requirement for data gathered over an 18-month interval, which was comprised of a 6-month preindex period and a 12-month postindex period, likely excluded some patients with more severe disease who may not have survived long enough to be included in the current analysis, but who

that described herein and whether biochemical surveillance for abnormalities in mineral metabolism and SHPT is now more widespread following the release and dissemination of this set of recommendations.

The current study has several limitations. First, it was undertaken using an administrative claims database that only included patients with medical and prescription benefit coverage. As such, the results may not apply more generally to

nonetheless consumed considerable healthcare resources. Despite these limitations, the results can be considered reliable because information from this database was validated adequately.

In conclusion, there is substantial opportunity to improve adherence to the K/DOQI guidelines for bone disease and metabolism among a high-risk group of patients with CKD who have high rates of healthcare resource utilization.

■ **Table 4.** Adherence to Guidelines for Calcium, Phosphorus, and PTH Testing

Parameter	Calcium			Phosphorus			PTH		
	CKD Stage 3	CKD Stage 4	CKD Stage 5	CKD Stage 3	CKD Stage 4	CKD Stage 5	CKD Stage 3	CKD Stage 4	CKD Stage 5
Recommended number of laboratory tests per year	1	4	12	1	4	12	1	4	4
Patients receiving K/DOQI recommended number of laboratory tests per year, %	90.8	64.2	12.1	26.7	15.1	5.7	7.3	0.5	3.2
Patients receiving at least 1 laboratory test per year, %	90.8	94.8	93.0	26.7	53.3	67.5	7.3	17.5	38.2
Patients with at least 1 laboratory test falling within the K/DOQI target range, %	98.7	96.5	80.1	87.6	88.5	72.6	38.7	21.6	25.0

PTH indicates parathyroid hormone; CKD, chronic kidney disease; K/DOQI, Kidney Disease Outcomes Quality Initiative.

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REFERENCES

- 1. US Renal Data System.** *USRDS 2005 Annual Data Report: Atlas of Chronic Kidney Disease and End-Stage Renal Disease in the United States.* Bethesda, Md: National Institute of Diabetes and Digestive and Kidney Diseases; 2005.
- 2. Collins A, Li S, Gilbertson D, et al.** Chronic kidney disease and cardiovascular disease in the Medicare population. *Kidney Int.* 2003; 64(suppl 87):S24-S31.
- 3. Weiner D, Tabatabai S, Tighiouart H, et al.** Cardiovascular outcomes and all-cause mortality: exploring the interaction between CKD and cardiovascular disease. *Am J Kidney Dis.* 2006;48:392-401.
- 4. Khan S, Kazmi W, Abichandani R, Tighiouart H, Pereira BJ, Kausz AT.** Health care utilization among patients with chronic kidney disease. *Kidney Int.* 2002;62:229-236.
- 5. Go A, Chertow G, Fan D, et al.** Chronic kidney disease and the risks of death, cardiovascular events, and hospitalization. *N Engl J Med.* 2004;351:1296-1305.
- 6. Kobus G, Malyszko J, Mysliwiec M.** Cardiovascular risk factors in dialyzed patients [in Polish]. *Pol Arch Med Wewn.* 2004;112:1425-1431.
- 7. Locatelli F, Pozzoni P, Tentori F, del Vecchio L.** Epidemiology of cardiovascular risk in patients with chronic kidney disease. *Nephrol Dial Transplant.* 2003;18(suppl 7):vii2-9.
- 8. Buccianti G, Baragetti I, Bamonti F, Furiani S, Doriget V, Patrosso C.** Plasma homocysteine levels and cardiovascular mortality in patients with end-stage renal disease. *J Nephrol.* 2004;17:405-410.
- 9. Fabbian F, Benussi P, Cacic G, et al.** Relationship between diabetes mellitus and degree of coronary artery disease in uraemic patients investigated with coronary angiography. *Int J Artif Organs.* 2003;26:196-199.
- 10. Qunibi WY.** Dyslipidemia and progression of cardiovascular calcification (CVC) in patients with end-stage renal disease (ESRD). *Kidney Int Suppl.* June 2005;(95):S43-S50.
- 11. Suliman ME, Qureshi AR, Barany P, et al.** Hyperhomocysteinemia, nutritional status, and cardiovascular disease in hemodialysis patients. *Kidney Int.* 2000;57:1727-1735.
- 12. Cases A, Vera M, Lopez Gomez JM.** Cardiovascular risk in patients with chronic renal failure. Patients in renal replacement therapy [in Spanish]. *Nefrologia.* 2002;22(suppl 1):68-74.
- 13. Zoccali C.** Cardiovascular risk in uraemic patients—is it fully explained by classical risk factors? *Nephrol Dial Transplant.* 2000;15:454-457.
- 14. Martinez I, Saracho R, Montenegro J, Llach F.** The importance of dietary calcium and phosphorus in the secondary hyperparathyroidism of patients with early renal failure. *Am J Kidney Dis.* 1997;29:496-502.
- 15. De Boer I, Gorodetskaya I, Young B, et al.** The severity of secondary hyperparathyroidism in chronic renal insufficiency is GFR-dependent, race-dependent, and associated with cardiovascular disease. *J Am Soc Nephrol.* 2002;13:2762-2769.
- 16. Fajtova VT, Sayegh MH, Hickey N, et al.** Intact parathyroid hormone levels in renal insufficiency. *Calcified Tissue Int.* 1995;57:329-335.
- 17. Reichel H, Deibert B, Schmidt-Gayk H, et al.** Calcium metabolism in early chronic renal failure: implications for the pathogenesis of hyperparathyroidism. *Nephrol Dial Transplant.* 1991;6:162-169.
- 18. St John A, Thomas MB, Davies CP, et al.** Determinants of intact parathyroid hormone and free 1,25-dihydroxyvitamin D levels in mild and moderate renal failure. *Nephron.* 1992;61:422-427.
- 19. Slinin Y, Foley RN, Collins AJ.** Calcium, phosphorus, parathyroid hormone, and cardiovascular disease in hemodialysis patients: the USRDS waves 1, 3, and 4 study. *J Am Soc Nephrol.* 2005;16:1788-1793.
- 20. Ganesh SK, Stack AG, Levin NW, Hulbert-Shearon T, Port FK.** Association of elevated serum PO(4), Ca × PO(4) product, and parathyroid hormone with cardiac mortality risk in chronic hemodialysis patients. *J Am Soc Nephrol.* 2001;12:2131-2138.
- 21. Block GA, Klassen PS, Lazarus JM, Ofsthun N, Lowrie EG, Chertow GM.** Mineral metabolism, mortality, and morbidity in maintenance hemodialysis. *J Am Soc Nephrol.* 2004;15:2208-2218.
- 22. Marco MP, Craver L, Betriu A, Belart M, Fibla J, Fernández E.** Higher impact of mineral metabolism on cardiovascular mortality in a European hemodialysis population. *Kidney Int Suppl.* June 2003;(85): S111-S114.
- 23. Rubel JR, Milford EL.** The relationship between serum calcium and phosphate levels and cardiac valvular procedures in the hemodialysis population. *Am J Kidney Dis.* 2003;41:411-421.
- 24. Hsu CY, Cummings SR, McCulloch CE, et al.** Bone mineral density is not diminished by mild to moderate chronic renal insufficiency. *Kidney Int.* 2002;61:1814-1820.
- 25. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification.** *Am J Kidney Dis.* 2002;39: S1-S266.
- 26. Kausz AT, Guo H, Pereira BJ, et al.** General medical care among patients with chronic kidney disease: opportunities for improving outcomes. *J Am Soc Nephrol.* 2005;16:3092-3101.
- 27. Winkelmayer WC, Levin R, Avorn J, et al.** The nephrologist's role in the management of calcium-phosphorus metabolism in patients with chronic kidney disease. *Kidney Int.* 2003;63:1836-1842.
- 28. Lenz O, Mekala DP, Patel DV, Fornoni A, Metz D, Roth D.** Barriers to successful care for chronic kidney disease. *BMC Nephrol.* 2005; 6:11. ■

Take-away Points

Levels of parathyroid hormone, calcium, and phosphorus progressively worsen with advancing kidney failure and result in a substantial proportion of patients having severe complications long before they begin renal replacement therapy.

- Assessment of the frequency of testing and control of parathyroid hormone, calcium, and phosphorus levels found generally low adherence to the Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines for bone metabolism and disease.
- Given the significant resource utilization among patients with chronic kidney disease and the lack of adherence to the K/DOQI guidelines, management of these patients can be substantially improved.