Adherence to Mineral and Bone Disorder Clinical Practice Guidelines in Chronic Kidney Disease

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Background: *Mineral and bone disorders (MBD) in patients with chronic kidney disease (CKD) are cardiovascular risk factors. Clinical practice guidelines were developed to prevent MBD and to decrease cardiovascular events in CKD patients.*
Objective: *To determine adherence to mineral and bone disorder clinical practice guidelines (MBD-CPG) in chronic kidney disease patients.*
Material and Method: *A retrospective, observational study was performed on 206 patients with CKD stage 3, 4, and 5 that were followed-up at pre-dialysis and dialysis clinic, Nephrology Unit, Srinagarind Hospital between July and September 2007.*
Results: *The mean percentages of adherence in each patient were 89.5% for calcium monitoring, 88.6% for phosphate monitoring and 17.1% for PTH monitoring. The mean percentage of adherence to using of phosphate binder in each patient was 84.6%. The mean percentage of adherence to using of vitamin D_3 was 72.2% in patients who had all three clinical parameters monitoring. The K/DOQI 2003 target recommendation achievements at the end of study were 73.7% for serum calcium, 76.1% for serum phosphate, 94.6% for calculated CaxP product, and 23.7% for serum PTH. The mean percentage of K/DOQI 2003 target recommendation achievement, in each patient during 12 months of postindex period, were: 79.3% for serum calcium, 78.1% for serum phosphate, 95.8% for serum CaxP product and 26.3% for serum PTH. The 100% achievement of target recommendations for serum calcium, serum phosphate and serum CaxP product were statistically, significant different, when compared between the group of 100% and 75.0-99.9% adherence to using phosphate binder, with the odd ratio 5.43 (95% CI 2.43-12.11) for serum calcium achievement, 11.33 (95% CI 4.63-27.72) for serum phosphate achievement and 11.75 (95% CI 2.92-47.24) for CaxP product achievement.*
Conclusion: *The use of vitaminD_3, monitoring of serum PTH and achieving of PTH target level, are still far from recommendations. Therapeutic end point for cardiovascular and bone diseases should be investigated in long-term studies.*

Keywords: *Chronic kidney disease-mineral and bone disorder (CKD-MBD), Adherence, Mineral metabolism abnormality, Clinical practice guideline achievement*

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Chronic kidney disease-mineral and bone disorder (CKD-MBD) is a systemic disorder of mineral and bone metabolism that demonstrates either one, or a combination of, mineral metabolism abnormality, alteration of bone or extraskeletal calcification, occurring in patients with CKD[1]. CKD-MBD is caused by the initiation of mineral metabolism abnormality such as serum calcium, phosphate, vitamin D_3 (calcitriol) or parathyroid hormone (PTH)[2]. Mineral metabolism abnormalities occur in early stage of CKD and increase of severity in advanced stage[3,4]. In the United States, from 40,538 hemodialysis patients, statistics showed mineral metabolism abnormalities (17.5%), more than anemia (11.3%) and inefficient dialysis (5.1%)[5]. Mortality risk increased to 10 to 61% in pre-dialysis and dialysis patients who had mineral metabolism abnormalities[5-9].

The Kidney Disease Outcomes Quality Initiative (K/DOQI) clinical practice guidelines, for bone metabolism and disease 2003, were published to improve the clinical management of the patient with CKD[10]. The study, in 22,937 hemodialysis patients, indicated that patients who could not control all three clinical parameters (calcium, phosphate, and PTH level) had a 51% significant increase of mortality risk compared to patients who could control all of three clinical parameters[11]. Furthermore, the previous

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study showed that the parameters in patients with CKD were monitored 12.1 to 90.8% for serum calcium, 5.7 to 26.7% for serum phosphate, and 0.5 to 7.3% for serum PTH[12]. Twenty nine percent of patients with CKD did not follow K/DOQI clinical practice guideline for bone metabolism and disease 2003, for the use of phosphate binder[13]. The serum calcium, serum phosphate, serum Calcium x phosphate (CaxP) product and serum PTH achieved K/DOQI 2003 target recommendations in 40 to 90%, 50 to 90%, 70 to 99% and 10 to 49%, respectively[3,14-19].

Srinagarind Hospital is a 650-bed, public, tertiary-care, referral, medical center in the Northeast of Thailand. The Nephrology Unit at Srinagarind Hospital has many physicians and health care teams in pre-dialysis and dialysis clinic. The objective of the present study was to determine the monitoring clinical parameters, the use of phosphate binders, the use of vitamin D_3 and the achievement of serum calcium, serum phosphate, serum CaxP product, and serum PTH in the patients with CKD, in manner consistent with the clinical practice guidelines.

Material and Method

Study design

Retro-cohort observational study.

Study groups

The present study was performed in patients having CKD in pre-dialysis and dialysis clinics at the Nephrology Unit, Srinagarind Hospital. Patients over 18 years old, with CKD stage 3, 4 and 5, who visited the clinics between July 1, 2007 and September 30, 2007 (index date) and had 12 months complete data, before and after index date, were included into the present study. Patients with primary hyperparathyroidism or thyroid neoplasia, parathyroidectomy or kidney transplant were excluded. The present study was reviewed and approved by the Ethics Committee of Khon Kaen University.

Data collection and follow-up

The patient medical record and laboratory result's database were reviewed. Demographic data, current medications, and laboratory results such as serum creatinine, serum albumin, serum calcium, serum phosphate, and serum PTH were recorded.

Data analysis

The adherence to MBD-CPG for monitoring clinical parameters, the use of phosphate binder and the use of vitamin D_3 in each patient was determined at first visit after the index date and every visit during the 12 months of postindex period. At the end of study, the percentage of adherence (% Adherence) for monitoring clinical parameters; the use of phosphate binder and the use of vitamin D_3 was evaluated with the formula: {% Adherence = (No. of adherence to clinical parameters monitoring visits/Total visits) x 100}.

The achievement of clinical parameters according to K/DOQI 2003 target recommendations was determined at first visit after index date and every visit during the 12 months of postindex period if the laboratory tests were performed. At the end of study, the percentage of K/DOQI target recommendation achievement (% Achievement) was calculated as the formula: {% Achievement = (No. of the achievement of target recommendations visits/Total visits) x100}.

Statistical analysis

All the data was presented in percentages, mean (SD) for normal distribution data or median (IQR) for skewed data. The comparison of the percentage of achievement for target recommendation between the groups of the adherent and non-adherent patients, was made with Chi-square test or Fisher-exact test. Odds ratio with 95% confidence interval (CI) of overall 100% achievement of target recommendations between the group of 100% and 75 to 99% adherence to MBD-CPG were presented. Statistical analyses were performed using SPSS for Windows. The statistical significance was set at p-value less than 0.05.

Results

Demographic data

At index date, 305 patients were screened into the present study. Only 206 patients satisfied the inclusion criteria, 80 with stage 3, 62 with stage 4, and 64 with stage 5 CKD. The demographic data of patients are presented in Table 1. The average age was 60.6 year old and 59.7% were male. Eighty-nine percent hypertension, 41.7% diabetes, 35% dyslipidemia, and 13.6% cardiovascular disease were found in these patients. Forty (19.4%) and eleven patients (5.3%) were on continuous ambulatory peritoneal dialysis and hemodialysis.

Adherence to mineral and bone disorder clinical practice guidelines

Adherence to clinical parameters monitoring to MBD-CPG are shown in Table 2. The overall mean percentages of adherence to clinical parameters

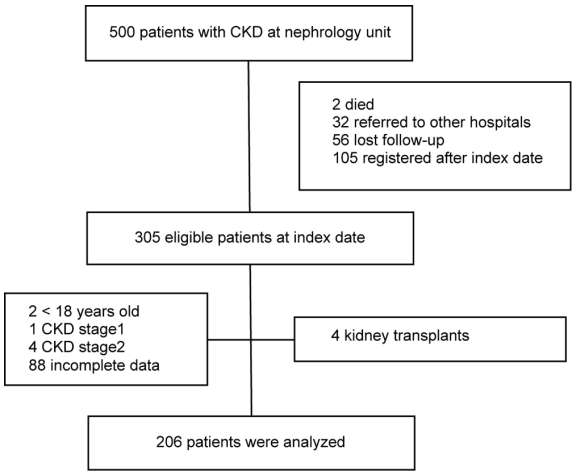

Fig. 1 Inclusion of CKD patients into the present study

monitoring in each patient are 89.5% for serum calcium monitoring, 88.6% for serum phosphate monitoring, and 17.1% for serum PTH monitoring in all 12 months of postindex period.

Adherence to using phosphate binder for MBD – CPG is presented in Table 3. The overall mean percentage of adherence to using phosphate binder, with each patient, was 84.6%, in all 12 months of postindex period. With sub-group patients in CKD stage 3, 4, and 5, the mean percentage of adherence to using phosphate binder was 92.2%, 92.8%, and 68.6%, respectively.

Adherence to using vitamin D_3 to MBD – CPG is presented in Table 4. The overall mean percentage of adherence to using vitamin D_3 in each patient was: 72.2% in all 12 months of postindex period. With sub-group patients in CKD stage 3, 4, and 5, the mean percentage of adherence to using vitamin D_3 was 40.0%, 76.9%, and 74.2%, respectively.

Achievement of K/DOQI 2003 target recommendations

The achievements of K/DOQI 2003 target recommendations for clinical parameters at the end of study, and during 12 months of postindex period, were analyzed. At the end of study, the overall percentages of patients who achieved K/DOQI 2003 target recommendations were 73.7% for serum calcium, 76.1% for serum phosphate, 94.6% for calculated CaxP product, and 23.7% for serum PTH. During 12 months of postindex period, the overall mean percentages of K/DOQI 2003 target recommendation achievement in each patient were 79.3% for calcium level, 78.1% for phosphate level, 95.8% for serum CaxP product, and 26.3% for PTH level. Overall data is presented in Table 5.

Table 1. Demographic data of the patients with CKD in the present study

Characteristics	Total n = 206	CKD3 n = 80 (38.8%)	CKD4 n = 62 (30.1%)	CKD5 n = 64 (31.1%)
Male [n (%)]	123 (59.7)	54 (67.5)	35 (55.5)	34 (53.1)
Follow-up at nephrology unit > 1 year [n (%)]	180 (87.3)	72 (90.0)	54 (87.0)	54 (84.4)
Age [mean (SD)]	60.6 (12.6)	62.5 (18.8)	65.5 (17.3)	57.2 (12.2)
Pre-dialysis [n (%)]	155 (75.2)	80 (100)	62 (100)	13 (20.3)
Dialysis;				
CAPD [n (%)]	40 (19.4)	0	0	40 (62.5)
HD [n (%)]	11 (5.3)	0	0	11 (17.2)
Co-morbidity				
Diabetes mellitus [n (%)]	86 (41.7)	25 (31.3)	30 (48.3)	31 (48.4)
Hypertension [n (%)]	183 (88.8)	66 (82.5)	55 (88.7)	62 (96.9)
Dyslipidemia [n (%)]	72 (35.0)	32 (40.0)	21 (33.9)	19 (29.7)
Cardiovascular disease [n (%)]	28 (13.6)	5 (6.2)	10 (16.1)	13 (20.3)
Medications				
$CaCO_3$ [n (%)]	83 (40.3)	12 (15.0)	29 (46.8)	42 (65.6)
$Al(OH)_3$ [n (%)]	3 (1.5)	0	0	3 (4.7)
Vitamin D_3 therapy [n (%)]	5 (2.4)	0	1 (1.6)	4 (6.3)

$Al(OH)_3$ = aluminium hydroxide; $CaCO_3$ = calcium carbonate; CAPD = continuous ambulatory peritoneal dialysis; HD = hemodialysis

Table 2. Adherence of clinical parameters monitoring to MBD-CPG

Clinical parameters monitoring	All 12 months of post-index period			
	Total (n = 206)	CKD3 (n = 80)	CKD4 (n = 62)	CKD5 (n = 64)
Calcium				
Total follow-up visits (visit)	1,453	464	392	597
Laboratory test of calcium (visit)	1,038	203	271	564
Adherence to calcium monitoring (visit)	1,322	427	328	567
Overall adherence (%)	91.0	92.0	83.7	95.0
Mean percentage of adherence in each patient (SD)	89.5 (19.5)	90.8 (24.1)	82.8 (19.2)	94.4 (9.0)
Phosphate				
Total follow-up visits (visit)	1,453	464	392	597
Laboratory test of phosphate (visit)	1,011	194	259	558
Adherence to phosphate monitoring (visit)	1,310	426	321	563
Overall adherence (%)	90.2	91.8	81.9	94.3
Mean percentage of adherence in each patient (SD)	88.6 (20.7)	90.6 (24.2)	80.8 (22.1)	93.7 (9.7)
PTH				
Total follow-up visits (visit)	1,453	464	392	597
Laboratory test of PTH (visit)	104	8	15	81
Adherence to PTH monitoring (visit)	297	40	27	230
Overall adherence (%)	20.4	8.6	6.9	38.5
Mean percentage of adherence in each patient (SD)	17.1 (23.2)	9.1 (20.6)	6.8 (12.6)	36.9 (22.0)

Table 3. Adherence to the use of phosphate binder for MBD-CPG

Using of phosphate binder	All 12 months of postindex period			
	Total (n = 195)	CKD3 (n = 70)	CKD4 (n = 61)	CKD5 (n = 64)
Total visits of calcium and phosphate monitoring (visit)	1,006	194	258	554
Adherence to using phosphate binder (visit)	793	179	238	376
Overall adherence (%)	78.8	92.3	92.2	67.9
Mean percentage of adherence in each patient (SD)	84.6 (26.0)	92.2 (18.8)	92.8 (18.4)	68.6 (31.2)

Only the visits that had both calcium and phosphate monitoring were evaluated

Table 4. Adherence to the use of vitamin D_3 to MBD-CPG

Using of vitamin D_3	All 12 months of postindex period			
	Total (n = 68)	CKD3 (n = 5)	CKD4 (n = 13)	CKD5 (n = 50)
Total visits of calcium, phosphate and PTH monitoring (visit)	98	6	13	79
Adherence to using vitamin D_3 (visit)	67	3	10	54
Overall adherence (%)	68.4	50.0	76.9	68.4
Mean percentage of adherence in each patient (SD)	72.2 (42.8)	40.0 (54.8)	76.9 (43.9)	74.2 (40.9)

Only the visits that had all of calcium, phosphate and PTH monitoring were evaluated

Table 5. Achievement of K/DOQI 2003 target recommendations in patients with CKD during 12 months of postindex period

Achievement of K/DOQI target recommendations	All 12 months of postindex period			
	Total	CKD3	CKD4	CKD5
Calcium				
Total visits of calcium monitoring (visit)	1,038	203	271	564
Achievement of target recommendation (visit)	726	189	262	275
Overall (%)	69.9	93.1	96.7	48.8
Mean percentage of achievement in each patient (SD), n = 196 (%)	79.3 (31.3)	93.2 (20.1)	95.9 (10.6)	48.1 (31.9)
Phosphate				
Total visits of phosphate monitoring (visit)	1,011	194	259	558
Achievement of target recommendation (visit)	707	180	233	294
Overall (%)	69.9	92.8	90.0	52.7
Mean percentage of achievement in each patient (SD), n = 195 (%)	78.1 (31.0)	89.4 (25.6)	90.4 (20.0)	54.2 (31.4)
CaxP product				
Total visits of calcium and phosphate monitoring (visit)	1,010	194	258	558
Achievement of target recommendation (visit)	934	194	257	483
Overall (%)	92.5	100.0	99.6	86.6
Mean percentage of achievement in each patient (SD), n = 195 (%)	95.8 (15.5)	100.0	99.8 (1.4)	87.5 (25.2)
PTH				
Total visits of PTH monitoring (visit)	104	8	15	81
Achievement of target recommendation (visit)	25	1	3	21
Overall (%)	24.0	12.5	20.0	25.9
Mean percentage of achievement in each patient (SD), n = 72 (%)	26.3 (39.9)	14.3 (37.8)	17.9 (37.2)	30.2 (40.9)

Table 6. The odd ratio of the overall 100% achievement of target recommendations during 12 months of the study period between the group of 100% and 75-99% adherence to MBD-CPG

Adherence to clinical practice guidelines	Odds ratio (95% CI)			
	Serum calcium	Serum phosphate	CaxP product	Serum PTH
Calcium monitoring	1.36 (0.69-2.69)	1.52 (0.77-3.00)	0.34 (0.07-1.54)	0.59 (0.17-2.04)
Phosphate monitoring	1.26 (0.64-2.48)	1.26 (0.64-2.46)	0.31 (0.07-1.41)	0.66 (0.19-2.28)
PTH monitoring	NA	NA	NA	NA
Using of phosphate binder	5.43 (2.43-12.11)[a]	11.33 (4.63-27.72)[a]	11.75 (2.92-47.24)[a]	1.13 (0.26-4.84)
Using of vitamin D_3	NA	NA	NA	NA

[a] p-value < 0.05, thus the significant difference
CI = confidence interval; NA = not assessment by calculated statistics

Comparison of percentages of target recommendation achievement between the adherent and non-adherent patients

The results are shown in Table 6. The 100% achievement of serum calcium, phosphate and CaxP product target recommendations were statistically, significantly different, when compared between the group of 100% and 75.0 to 99.9% adherence to using phosphate binder with the odd ratio of 5.43 (95% CI 2.43-12.11) for serum calcium achievement, 11.33 (95% CI 4.63-27.72) for serum phosphate achievement and 11.75 (95% CI 2.92-47.24) for serum CaxP product

achievement. However, no statistically, significant difference was found in the analysis of monitoring clinical parameters. Analysis, in the group of adherence, of less than 75%, was not carried out due to a small sample sizes.

Discussion

The mean percentage of calcium monitoring was more than 90% for patients with CKD stage 3 and decreased to 80% for patients with CKD stage 4. These results corresponded to the previous study[12] that reported 91% for patients with CKD stage 3, decreasing to 64% for patients with CKD stage 4. The mean percentage of adherence to serum phosphate monitoring in the present study was more than 80% of patients with CKD stage 3 to 5. However, the results in patients with CKD stage 4 (80.8%) was lower than CKD stage 3 (90.6%). The current result for serum phosphate monitoring was higher than the results from the previous study[12], which reported only 26% in patients with CKD stage 3 and 15% in patients with CKD stage 4. The low, mean percentage of adherence to calcium and phosphate monitoring in patients with CKD stage 4 may be due to lack of awareness. In the present study, the mean percentage of adherence to serum calcium and serum phosphate monitoring in patients with CKD stage 5 was approximately 94%, which was higher than the previous study[12] that reported 6 to 12%. However, a small percentage of adherences to serum PTH monitoring were found in the present and previous study. The small percentage of adherence to serum PTH monitoring in the present study may be due to the inconvenience of the PTH laboratory tests. At Srinagarind Hospital, the PTH laboratory test is available only once a week and the results reported up to two weeks after the test is performed. The medical treatment decisions may be affected by the deferred PTH test results.

For the adherence to using phosphate binder, the mean percentage was more than 90% for patients with CKD stage 3 and 4 but decreased to lower than 70% for patients with CKD stage 5. Twenty nine percent of non-adherence to using calcium-base phosphate binder in 283 hemodialysis patients was reported in the previous study[13]. In addition to CaxP product, the difference in consideration for using of phosphate binder between patients with CKD stage 3 and 4 and CKD stage 5, is the serum calcium. Thus, the low percentage of adherence to using phosphate binder in patients with CKD stage 5 may due to unmeet standard criteria of serum calcium.

The percentage of adherence to using of vitamin D_3 was determined from three clinical parameters, serum calcium, serum phosphate, and serum PTH. Due to the low percentage of PTH monitoring in patients with CKD stage 3, 4 (lower than 10%) and 5 (lower than 40%), the percentage of adherence to using of vitamin D_3 could be evaluated in only 33% of all patients. The mean percentage of adherence to using vitamin D_3 in patients with CKD stage 3 and 4 was 40% and 76.9%, respectively. However, these results were determined from five and 13 patients, with CKD stage 3 and 4, respectively, whereas the mean percentage of adherence to using vitamin D_3 in patient with CKD stage 5 was 74.2%, being determined from a higher number of patients (50 patients).

At the end of study, the overall percentage of CaxP product achievement (95%) was higher than serum calcium (74%) and phosphate achievement (76%). The percentage of PTH achievement cannot be determined due to the small percentage of serum PTH monitoring. The results from the present study are similar in the previous studies[3,14-19]. During the postindex period, the percentage of patients gaining 100% achievement of serum calcium and phosphate are more than 50%. The previous study[14] reported that hemodialysis patients achieved 50% of the K/DOQI target recommendation. The results showed that less than 50% of hemodialysis patients achieved the criteria. In the present study, the percentage of patients with CKD stage 5 is more than 50%, if the 50% achievements of K/DOQI target recommendations are determined. Moreover, the percentage of patients with CKD stage 3 to 5 (more than 70%) met 100% achievement of serum CaxP product target recommendation.

In the present study, the results in Table 6 indicate that the patients that only monitor clinical parameters, according to MBD-CPG, cannot increase their target recommendations achievement. Whereas, the 100% achievement of target recommendations, in patient with CKD, is highly significant, in the group of 100% adherence to using phosphate binder, especially the achievement of target recommendation for serum phosphate (odd ratio 11.33) and CaxP product (odd ratio 11.75). An interesting finding, the adherence to using of phosphate binder, according to MBD-CPG, is a more important factor than the frequency of clinical parameter monitoring. However, the clinical parameters monitoring (a necessary aid) are needed in the selection of the phosphate binder.

Study limitations

The present study has several limitations. First, the reference guidelines in present study are the earlier guidelines, Kidney Disease Outcomes Quality Initiative (K/DOQI) clinical practice guidelines for bone metabolism and disease 2003[10]. Because the present study began before the publication of the new guidelines, Kidney Disease Improving Global Outcomes (KDIGO) clinical practice guidelines for the diagnosis, evaluation, prevention and treatment of chronic kidney disease-mineral and bone disorder (CKD-MBD) 2009[20]. The majority of the recommendations of those two guidelines are similar although the frequency of monitoring clinical parameters in the KDIGO 2009 guidelines is more flexible than the K/DOQI 2003 guidelines. Therefore, it follows, if the results of the adherence to monitoring clinical parameters in the present study are consistent with the K/DOQI 2003 guidelines, they will follow the KDIGO 2009 guidelines too. The recommendations for using phosphate binder and vitamin D_3 in KDIGO 2009 guidelines are similar to the K/DOQI 2003 guidelines. K/DOQI 2003 target recommendations specify definite clinical parameter values, in patients with CKD stage 3 to 5, but KDIGO 2009 target recommendations are modified to maintain the clinical parameters within normal rages, in each laboratory setting. The new recommendations are strictly for the both of serum calcium, and serum phosphate achievement, without the determination of CaxP product achievement. Second, the assessment of adherence, according to MBD-CPG, is based on the CKD stage at the index date, so the transition stages of CKD during the study period are not considered. Because a small number of transition stage of CKD (less than 15%) are found in the study, the percentage of adherence to MBD-CPG may be a slightly low, if the transition stage of CKD is determined at the end of study. Finally, the statistical analysis of 100% achievement of target recommendations, when compared between the group of 100% adherence and less than 100% adherence to MBD-CPG, cannot be determined, due to the small sample size. In further study, the new surrogate outcome that is recommended in KDIGO 2009 guidelines, such as alkaline phosphatase and calcidiol should be considered. Therapeutic end point for cardiovascular and bone diseases should be investigated in long-term study.

Conclusion

At the Nephrology Unit, Srinagarind Hospital, most practices, of mineral and bone disorder, follow MBD-CPG. The achievement of clinical parameters, target recommendations is managed by the use of phosphate binder, thus, this is an important factor. However, the use of vitamin D_3, PTH monitoring and achieving of PTH target level is still far from recommendations. An opportunity for improvement lies within the hospital for patients with CKD.

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Potential conflicts of interest

None.

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การปฏิบัติตามแนวทางการดูแลรักษาภาวะความผิดปกติของแร่ธาตุและกระดูกในผู้ป่วยโรคไตเรื้อรัง

วริศรา ปาณะวงษ์, อาภรณี ไชยาคำ, ชลธิป พงศ์สกุล

***ภูมิหลัง**: ภาวะความผิดปกติของแร่ธาตุและกระดูกในผู้ป่วยโรคไตเรื้อรังเป็นปัจจัยเสี่ยงอย่างหนึ่งที่ทำให้เกิดโรคหัวใจและหลอดเลือด ดังนั้นจึงได้มีการกำหนดและเผยแพร่แนวทางการดูแลรักษาภาวะความผิดปกติของแร่ธาตุและกระดูกเพื่อใช้ในการป้องกันภาวะความผิดปกติของกระดูกและเพื่อลดการเกิดโรคหัวใจและหลอดเลือด*

***วัตถุประสงค์**: เพื่อประเมินการปฏิบัติตามแนวทางการดูแลรักษาภาวะความผิดปกติของแร่ธาตุและกระดูกในผู้ป่วยโรคไตเรื้อรัง*

***วัสดุและวิธีการ**: การศึกษาแบบย้อนหลัง ติดตามผู้ป่วยโรคไตเรื้อรังระยะที่ 3, 4 และ 5 จำนวน 206 ราย ที่มารับการรักษาแบบผู้ป่วยนอก ณ คลินิกโรคไต โรงพยาบาลศรีนครินทร์ ในระหว่างเดือนกรกฎาคม จนถึงเดือนกันยายน พ.ศ. 2550*

***ผลการศึกษา**: ค่าเฉลี่ยของการปฏิบัติตามแนวทางการดูแลรักษาภาวะความผิดปกติของแร่ธาตุและกระดูกที่ผู้ป่วยแต่ละรายได้รับ ได้แก่ การตรวจระดับแคลเซียมคิดเป็นร้อยละ 89.5 การตรวจระดับฟอสเฟตคิดเป็นร้อยละ 88.6 การตรวจระดับพาราไทรอยด์ฮอร์โมนคิดเป็นร้อยละ 17.1 การได้รับยาจับฟอสเฟตคิดเป็นร้อยละ 84.6 และการได้รับไวตามินดีคิดเป็นร้อยละ 72.2 ของผู้ป่วยที่ได้รับการติดตามพารามิเตอร์ทั้ง 3 เมื่อสิ้นสุดการศึกษาพบว่าจำนวนผู้ป่วยมีระดับแคลเซียม ฟอสเฟต แคลเซียมฟอสเฟต และพาราไทรอยด์ฮอร์โมนเป็นไปตามเป้าหมายของแนวทางการดูแลรักษาคิดเป็นร้อยละ 73.7 76.1 94.6 และ 23.7 ตามลำดับ ตลอดการศึกษาพบว่าค่าเฉลี่ยของระดับแคลเซียม ฟอสเฟต แคลเซียมฟอสเฟต และพาราไทรอยด์ฮอร์โมนที่เป็นไปตามเป้าหมายของแนวทางการดูแลรักษาในผู้ป่วยแต่ละราย คิดเป็นร้อยละ 79.3 78.1 95.8 และ 26.3 ตามลำดับ เมื่อเปรียบเทียบกลุ่มผู้ป่วยที่ได้รับยาจับฟอสเฟตตามแนวทางการดูแลรักษาร้อยละ 100 กับร้อยละ 75.0-99.9 พบว่าค่าระดับแคลเซียม ระดับฟอสเฟต และระดับแคลเซียมฟอสเฟตเป็นไปตามเป้าหมายของแนวทางการดูแลรักษาตลอดการศึกษาคิดเป็น ร้อยละ 100 ในกลุ่มผู้ป่วยที่ได้รับยาจับฟอสเฟตตามแนวทางการดูแลรักษาร้อยละ 100 แตกต่างกันอย่างมีนัยสำคัญทางสถิติ เมื่อเปรียบเทียบกับกลุ่มผู้ป่วยที่ได้รับยาจับฟอสเฟตตามแนวทางการดูแลรักษาร้อยละ 75.0-99.9 มีค่า odd ratio เป็น 5.43 (95% CI 2.43-12.11) 11.33 (95% CI 4.63-27.72) และ 11.75 (95% CI 2.92-47.24) เท่าตามลำดับ*

***สรุป**: จากผลการศึกษาทั้งหมด ผู้ป่วยโรคไตเรื้อรังได้รับการตรวจระดับพาราไทรอยด์ฮอร์โมนได้รับยาไวตามินดีและระดับพาราไทรอยฮอร์โมน ยังไม่เป็นไปตามเกณฑ์และเป้าหมายตามที่แนวทางการดูแลรักษาภาวะความผิดปกติของแร่ธาตุและกระดูกกำหนด อย่างไรก็ตามควรมีการศึกษาถึงผลแทรกซ้อนในระยะยาวของการเกิดโรคหัวใจและหลอดเลือด และความผิดปกติของกระดูกต่อไป*