

## Serum Biochemical Evaluation of Patients with Chronic Renal Failure on Hemodialysis

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### Abstract

**Introduction:** Chronic renal failure (CRF) is associated with aberrations in the metabolism of minerals, such as calcium, phosphates, sodium, and potassium and other biochemical parameters. Various studies have identified parathyroid hormone (PTH) as the main regulator of minerals and biochemical parameters homeostasis. This study was conducted to evaluate the biochemical profile in CRF patients on hemodialysis in Aden.

**Methods:** This study is a descriptive, cross sectional study, conducted in Aden Hemodialysis Center for the period Jan.1st to June 30th, 2022. Included 82 patients with CRF on HD. The data collected included demographic with clinical data, and blood samples taken for complete blood count and serum creatinine; urea; sodium; potassium; total calcium, ionized calcium; phosphate; alkaline phosphatase, and parathyroid hormone.

**Results:** More male were found than female patients with CRF (67.1% vs. 32.9% respectively), with a mean age of  $48.8 \pm 12.6$  years. The mean body mass index was  $(23.3 \pm 4.7 \text{ kg/m}^2)$  and the mean duration of CRF was  $(4.8 \pm 2.9)$  years. For renal function, the mean serum creatinine, urea, and estimated creatinine clearance were (9.9 mg/dl, 128.6 mg/dl, and 7.1 mL/min per 1.73 m<sup>2</sup> respectively). For minerals, the mean serum sodium, potassium, chloride, phosphorus, calcium and ionized calcium were (134.4 mmol/L, 5.04 mmol/L, 104.1 mmol/L, 4.37 mg/dl, 9.4 mg/dl, and 1.12 mmol/L, respectively). The mean Calcium x Phosphorus product was in the recommended range ( $40.7 \text{ mg}^2/\text{dl}^2$ ). The mean alkaline phosphatase was (286.2 U/L), and the mean parathyroid hormone was (322.7 pg/ml). Secondary hyperparathyroidism (PTH level of  $\geq 130$  pg/ml) was detected in (58.5%) of them. Parathormone concentration showed significant positive correlation to alkaline phosphatase ( $r: 0.640, p:0.001$ ) in patients with CRF on hemodialysis.

**Conclusion:** This study concluded that in patients with CRF on HD, there is an increase level of alkaline phosphatase which is considered as an adjunct marker of high-turnover bone disease associated with disturbed level of calcium and phosphorus that increase serum PTH level.

**Keywords:** Chronic renal failure, Biochemical, Parathyroid hormone, Alkaline phosphatase, Correlation, Aden

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## تقييم المعايير الكيميائية الحيوية في الدم لمرضى الفشل الكلوي المزمن والخاضعين للغسيل الكلوي

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### ملخص الدراسة

**المقدمة:** يرتبط داء الفشل الكلوي المزمن بمراحله الأخيرة مع انحرافات في استقلاب المعادن، مثل الكالسيوم والفوسفات والصوديوم والبوتاسيوم وغيرها من العوامل البيوكيميائية. ويعتبر هرمون الغدة جار الكلوية هو المنظم الرئيسي للمعادن والمعايير الكيميائية الحيوية لديهم. أجريت هذه الدراسة لتقييم المعايير الكيميائية الحيوية في مرضى الفشل الكلوي المزمن الخاضعون للغسيل الكلوي في عدن.

**طرق البحث:** هذه الدراسة عبارة عن دراسة وصفية قطعية أجريت في مركز غسيل الكلى في عدن للفترة من يناير إلى يونيو 2022م. شملت 82 مريضاً بالفشل الكلوي المزمن بمراحله الأخيرة يخضعون للغسيل الكلوي. تضمنت البيانات التي تم جمعها البيانات الديموغرافية والسرييرية، وعينات الدم المأخوذة لتعداد الدم الكامل والكرياتينين في الدم، اليوريا، الصوديوم، البوتاسيوم، إجمالي الكالسيوم والكالسيوم المتأين، الفوسفات، الفوسفاتيز القلوي وهرمون الغدة جار الدرقية.

**النتائج:** كان المرضى الذكور أكثر من الإناث (67.1% مقابل 32.9% على التوالي)، بمتوسط عمر 48.8 ± 12.6 سنة. كان متوسط مؤشر كتلة الجسم (23.3 ± 4.7 كجم/م<sup>2</sup>) وكان متوسط مدة المرض (4.8 ± 2.9 سنة). بالنسبة لوظائف الكلى، كان متوسط الكرياتينين واليوريا وتنقية الدم من الكرياتينين (9.9 مجم/ديسيلتر، 128.6 مجم/ديسيلتر، و7.1 مل/دقيقة لكل 1.73م<sup>2</sup> على التوالي). بالنسبة للمعادن، كان متوسط الصوديوم والبوتاسيوم والكلوريد والفوسفور والكالسيوم والكالسيوم المتأين (134.4 مليمول/لتر، 5.04 مليمول/لتر، 104.1 مليمول/لتر، 4.37 مجم/ديسيلتر، 9.4 مجم/لتر، و1.12 مليمول/لتر على التوالي). كان متوسط منتج الكالسيوم × الفوسفور في النطاق الموصى به (40.7 ملجم/2ديسيلتر). وكان متوسط الفوسفاتيز القلوي (286.2 وحدة/لتر)، وكان متوسط هرمون الغدة الدرقية (322.7 بيكوغرام/مل). تم الكشف عن فرط نشاط جار الدرقية الثانوي (مستوى هرمون الغدة الدرقية ≤ 130 بيكوغرام / مل) في (58.5%) منهم. أظهر تركيز هرمون الغدة جار الدرقية ارتباطاً معنوياً إيجابياً بالفوسفاتيز القلوي (معامل ارتباط: 0.640، قيمة الأرجحية: 0.001) في المرضى الذين يعانون من الفشل الكلوي ويخضعون للغسيل الكلوي.

**الاستنتاج:** خلصت هذه الدراسة إلى أن مرضى الفشل الكلوي المزمن والذين يخضعون لغسيل الكلى لديهم زيادة في مستوى الفوسفاتيز القلوي والذي يعتبر علامة مساعدة لمرض العظام المرتفع المرتبط باضطراب مستوى الكالسيوم والفوسفور والمتسبب بزيادة مستوى هرمون الغدة جار الدرقية في الدم.

**الكلمات المفتاحية:** فشل كلوي مزمن، الكيميائية الحيوية، هرمون الغدة جار الدرقية، الفوسفاتيز القلوي، علاقة الارتباط، عدن.

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## Introduction

**C**hronic renal failure (CRF) is a disease manifested by a gradual decline in renal function over time.

It is a worldwide public health problem, ranking as the ninth leading cause of disease mortality.

A trend towards increased incidence and prevalence of CRF is being reported worldwide with epidemic proportions in many countries [1].

Patients with CRF on [hemodialysis](#) (HD) are characterized by altered patterns of mineral metabolism as disorders of calcium and phosphorus metabolism, and variety of bone disorders associated with high parathyroid hormone (PTH) levels, and altered patterns of alkaline phosphatase (ALP) [2].

Studies reported that in HD patients, elevated levels of serum ALP are associated with [secondary hyperparathyroidism](#) (SHPT) [3,4], renal osteodystrophy [5,6], and cardiovascular diseases [7,8].

In Aden Hemodialysis Center, there is marked increase in the number of patients with CRF, being referred for hemodialysis, which has provided active renal care services for Aden and the nearby governorates.

This will help to assess the correlation between parathyroid hormone and alkaline phosphatase in these patients. In spite of the clear benefit of early detection of the biochemical complications of CRF, most studies for CRF patients conducted in Aden were clinical studies, with a marked paucity of biochemical data for CRF patients in Aden [9,10].

To cover this gap, it was decided to conduct this study to evaluate the biochemical profile in CRF patients

on hemodialysis in Aden Hemodialysis Center as a baseline data for future researches.

## Objectives

To evaluate the biochemical profile in CRF patients on hemodialysis in Aden.

## Methods

This is a descriptive cross sectional, center based study, conducted in Aden Hemodialysis Center in Aden governorate, Yemen, for 6 months (from Jan.1st to June 30th, 2022). It included 82 patients with end stage CRF on regular hemodialysis.

### *Inclusion criteria:*

1. Age of 18 years and above.
2. Confirmed end stage CRF patients on regular HD.
3. Patients who agreed to participate in the study.

### *Exclusion criteria:*

1. Patients' age below 18 years.
2. Patient with acute renal failure.
3. Patient with primary hyperparathyroidism.
4. Patients who are pregnant.
5. Patients who declined consent.

Data were collected by direct interview with patients. The author took the thorough history and pre-dialysis blood samples taken for complete blood count (CBC), serum creatinine; urea; sodium; potassium; chloride; total calcium, ionized calcium; phosphorus; alkaline phosphatase; parathyroid hormone; and vitamin D.

All of them were tested in the laboratory of the hospital using cell counter for CBC and the spectrophotometer for other parameters. The estimated creatinine clearance (eCrCl) was calculated by the use of CKD-EPI formula [11].

**Sample size calculation:**

Sample size was calculated by the following formula for a known population, with the 95% confidence level and  $p=0.5$  [12].

$p$  is the population proportion = 0.5 (for unsure population proportion, it is advised to use 50%, which is conservative and gives the largest sample size).

$$n = N / [1 + N (e)^2 ]$$

**Where:**

- $n$  is the calculated sample size.
  - $N$  is the population size [number of patients with CRF on hemodialysis in Aden Hemodialysis Center] = 450 patients per 6 months.
  - $e$  is the level of precision or the margin of error = 10%.
- Final calculated sample size was 82 patients with CRF.

$$n = 450 / [1 + 450 (0.10)^2 ] = 81.8 = 82$$

**Statistical analysis:**

Data analysis was performed by the Statistical Package for Social Science (SPSS v.24).

Qualitative variables were presented as absolute and relative frequencies. Quantitative variables were tested for normality distributions by the Kolmogorov-Smirnov test, which revealed parametric distribution. Accordingly they were presented as means with standard deviations. Correlation tests between quantitative variables were conducted by the Pearson correlation coefficient ( $r$ ) for parametric data.

Significance test results were quoted as two-tailed probabilities and judged at the 5% level [with the 95% confidence interval], so that  $p$ -values of  $\leq 0.05$  were considered statistically significant.

**Ethical Apprpval**

This study was approved by the committee of postgraduate studies of the Faculty of Education, Aden University.

## Results

In this study, 82 patients with CRF on HD were investigated. They were male patients more than female (67.1% vs. 32.9%) with a male to female ratio of 2: 1. Their age ranges from 20 to 80 years and the mean age was  $48.8 \pm 12.6$  years. The mean BMI was  $(23.3 \pm 4.7 \text{ kg/m}^2)$ . The duration of CRF was ranging from 1 year to 12 years with a mean of  $(4.8 \pm 2.9 \text{ years})$  [Table 1].

**Table 1:** Characteristics of the Studied Patients

Item	(n = 82)	
	Mean $\pm$ SD [Min. - Max.]	
Male gender [No. (%)]	55	67.1
Patients' age (years)	48.8 $\pm$ 12.6 [20 - 80]	
Body Mass Index (kg/m <sup>2</sup> )	23.3 $\pm$ 4.7 [16 - 42.5]	
Duration of CRF (years)	4.8 $\pm$ 2.9 [1 - 12]	

CRF: chronic renal failure

The mean hemoglobin concentration was (11.9  $\pm$  1.8g/dl), the mean total WBCs count was (5.7  $\pm$  2.1x 10<sup>9</sup>/L),

and the mean platelets count was (255.2  $\pm$  83.9x 10<sup>9</sup>/L) [Table 2].

**Table 2:** Pre-dialysis Laboratory Parameters of the Studied Patients

Item	(n = 82)	
	Mean $\pm$ SD [Min. - Max.]	
Hemoglobin concentration (g/dl)	11.9 $\pm$ 1.8 [6.7 - 15.1]	
White Blood Cells count (x 10 <sup>9</sup> /L)	5.7 $\pm$ 2.1 [2.2 - 15.0]	
Platelets count $\pm$ SD [Min.-Max.] (x 10 <sup>9</sup> /L)	255.2 $\pm$ 83.9 [92-502]	
Serum creatinine (mg/dl)	9.9 $\pm$ 4.1 [4.0 - 87.0]	
Serum urea (mg/dl)	128.6 $\pm$ 50.4 [49-240]	
Estimated CrCl (mL/min per 1.73 m <sup>2</sup> )	7.1 $\pm$ 2.9 [3.0 - 15.0]	
Serum sodium (mmol/L)	134.4 $\pm$ 2.8 [127 - 143]	
Serum potassium (mmol/L)	5.04 $\pm$ 1.15 [2.6 - 8.2]	
Serum phosphorus (mg/dl)	4.37 $\pm$ 1.89 [1.1 - 11.3]	
Serum calcium (mg/dl)	9.40 $\pm$ 1.04 [6.4 - 12.2]	
Ionized calcium (mmol/L)	1.12 $\pm$ 0.16 [0.7 - 1.8]	
Ca x Pi product (mg <sup>2</sup> /dl <sup>2</sup> )	40.7 $\pm$ 16.5 [10.1 - 98.0]	
Serum chloride (mmol/L)	104.1 $\pm$ 8.16 [95 - 167]	
Alkaline phosphatase (U/L)	286.2 $\pm$ 167.8 [55 - 2427]	
Parathyroid hormone (pg/ml)	322.7 $\pm$ 205.0 [7.6 - 1384.0]	

CRF: chronic renal failure

Ca x Pi product: Calcium-phosphorus product

CrCl: Creatinine Clearance

For renal function, the mean serum creatinine, urea, and eCrCl were (9.9 mg/dl, 128.6 mg/dl, and 7.1 mL/min per 1.73 m<sup>2</sup> respectively). For minerals, the mean serum sodium, potassium, chloride, phosphorus,

calcium and ionized calcium were (134.4 mmol/L, 5.04 mmol/L, 104.1 mmol/L, 4.37 mg/dl, 9.4 mg/dl, and 1.12 mmol/L, respectively). The mean Calcium x Phosphorus product was (40.7 mg<sup>2</sup>/dl<sup>2</sup>), the mean alkaline

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Alkaline phosphatase (U/L)	286.2 $\pm$ 167.8 [55 - 2427]
Parathyroid hormone (pg/ml)	322.7 $\pm$ 205.0 [7.6 - 1384.0]

CRF: chronic renal failure

Ca x Pi product: Calcium-phosphorus product

CrCl: Creatinine Clearance

About 34(41.5%) of CRF patients depicted a PTH level of less than 130 pg/ml and 48(58.5%) depicted higher level of  $\geq$ 130 pg/ml which is considered secondary hyperparathyroidism (SHPT) [Figure 1].



**Figure 1:** Parathyroid hormone level in patients with chronic renal failure.

The Pearson correlation test did not show significant statistical correlation between the parathyroid hormone concentration and the studied biochemical parameters in patients with CRF on HD, except for alkaline phosphatase. Alkaline phosphatase showed significant positive correlation to parathyroid hormone concentration ( $r$ : 0.640,  $p$ : 0.001) in patients with CRF on HD. Among the other biochemical parameters; the eCrCl, serum calcium, and serum chloride showed negative correlation to parathyroid hormone concentration without statistical significance ( $p > 0.05$ ). Other biochemical parameters as serum creatinine, urea,

sodium, potassium, ionized calcium, phosphorus, and Ca x Pi product showed positive correlation to parathyroid hormone concentration

without statistical significance ( $p>0.05$ ) [Table 3 and Figure 2].

**Table 3:** Correlation between Parathyroid Hormone and Biochemical Parameters in Patients with Chronic Renal Failure

Parameter	Pearson Correlation	
	<i>r</i>	<i>p</i>
Serum creatinine (mg/dl)	0.067	0.550
Serum urea (mg/dl)	0.170	0.127
Estimated Creatinine Clearance (mL/min per 1.73 m <sup>2</sup> )	-0.207	0.062
Serum sodium (mmol/L)	0.025	0.824
Serum potassium (mmol/L)	0.043	0.700
Serum calcium (mg/dl)	-0.059	0.598
Ionized calcium (mmol/L)	0.116	0.301
Serum phosphorus (mg/dl)	0.177	0.112
Ca x Pi product (mg <sup>2</sup> /dl <sup>2</sup> )	0.160	0.150
Serum chloride (mmol/L)	-0.071	0.528
Alkaline phosphatase (U/L)	0.640*	<b>0.001</b>

*r* : Pearson correlation coefficient

\* Significant statistical correlation

Ca x Pi product: Calcium-phosphorus product

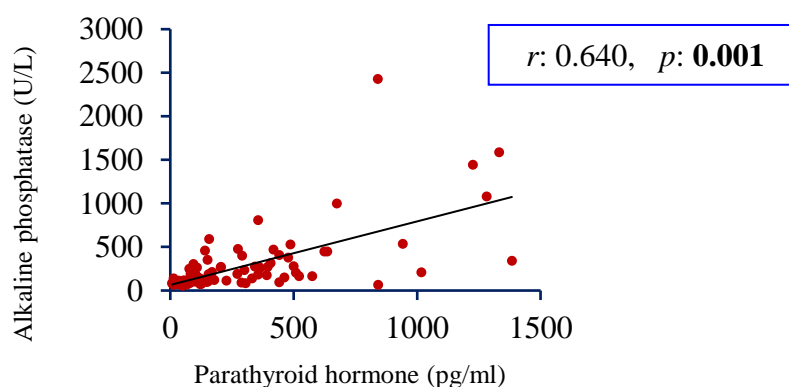


Figure 2: Positive Correlation between PTH and ALP in CRF Patients

## Discussion

The changes in biochemical parameters in the studied patients with CRF before HD were variable. Higher mean values of serum creatinine, urea, potassium, phosphorus and alkaline phosphatase were found in CRF patients. While lower values of serum mean sodium, calcium and ionized calcium were found in CRF patients. The increased mean creatinine and urea in the studied patients with CRF is directly proportional to the progression of the disease and may be attributed to a reduction in the number of functioning nephrons, which decreases the glomerular filtration rate (GFR) and hence a major reduction in excretion of water and solutes [13]. These findings are parallel to that reported by the study of Suhail N et al [14]. in KSA, with higher mean values for serum creatinine, urea, phosphorus and lower mean value for serum calcium. Similarly, other studies observed same findings as the study of Sarhat and Murtadha [15]. in Iraq, the study of Vhora R et al [16]. in India, the study of Saran R et al [17]. in USA, and the Hemodialysis (HEMO) Study conducted by Wald R et al [18]. in Canada. Sodium derangements are among the most frequently encountered electrolyte disorders in CRF patients on HD. They are predisposed to hyponatremia due to poor nutritional status and loss of residual kidney function [19]. In a recent study conducted by Fujisaki K et al [20]. pre-dialysis hyponatremia and changes in serum sodium concentration during a dialysis session were found significant predictors of mortality in patients undergoing hemodialysis.

Patients undergoing maintenance HD have high risk of hyperkalemia, even when receiving adequate treatment with 3-times-weekly HD [21]. Hyperkalemia is a potentially life-threatening disorder that can cause arrhythmias and sudden cardiac arrest [22]. The mean serum calcium in the studied patients with CRF on hemodialysis was (9.40 mg/dl); this finding is consistent with that recommended by the Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guideline for Hemodialysis Adequacy during 2015 ( $< 9.5$  mg/dl) [23]. The mean serum phosphorus in the studied patients with CRF on hemodialysis was (4.37 mg/dl); this finding is consistent with that recommended by the KDOQI Clinical Practice Guideline for Hemodialysis Adequacy during 2015 (3.5 and 5.5 mg/dl)[23]. The study conducted by Kestenbaum B et al [24]. showed that the prevalence of hyperphosphatemia was high in dialysis patients and in 52% of patients, serum phosphorus levels were higher than normal. This is comparable to finding of serum phosphorus in the current study. The mean serum Ca x Pi product in the studied patients with CRF on hemodialysis was (40.7 mg<sup>2</sup>/dl<sup>2</sup>); this finding is consistent with that recommended by the KDOQI Clinical Practice Guideline for Hemodialysis Adequacy during 2015 ( $<55$  mg<sup>2</sup>/dl<sup>2</sup>) [23]. The obtained mean Ca x Pi product was coinciding with that reported by the study of Lim and Gun [25]. in Indonesia, who reported a mean of (47.5 mg<sup>2</sup>/dl<sup>2</sup>). These findings may be attributed to the effect of regular hemodialysis program in Aden center. Findings of



Ca, P, and the Ca×P product in the current study were comparable to that reported by the study of Kim G et al [26]. in Korea, where they reported mean serum levels of Ca, P, and the Ca×P product as (9.1±0.7 mg/dL), (5.3±1.4 mg/dL), and (48.0±13.6 mg<sup>2</sup>/dL<sup>2</sup>) respectively. ALP is considered a marker of high-turnover bone disease [27]. It can promote vascular calcification by hydrolyzing pyrophosphate in the arterial wall [28]. Studies found that elevated serum ALP was an independent risk factor for all-cause mortality among patients on hemodialysis [29,30]. The mean serum alkaline phosphatase in the studied patients was high (286.2 U/L). It is coinciding with that reported by the study of Valle E et al [31]. in Argentina (271.3 U/L). The obtained mean value is considered lower than that observed by the study of Rahman M et al [32]. in Bangladesh, among CRF patients (521.6 U/L), as well as that reported by the study of Douthat W et al [33]. in Argentina (378 U/L). The lower mean value for ALP in the current study when compared to previous studies may reflect better CRF management practices in Hemodialysis Center in Aden. The level of Parathormone (PTH) is a valid and clinically useful test for the diagnosis and monitoring of osteodystrophy in CKD, and the simultaneous measurement of alkaline phosphatase with PTH increases the predictive value of PTH [34]. The Kidney Disease Improving Global Outcomes (KDIGO) clinical practice guideline has broadened the range of target or goal PTH levels, in part to reduce the risk of treating patients with low turnover bone disease or to induce it, despite relatively high serum PTH levels [35]. The National Kidney

Foundation–Kidney Disease Outcomes Quality Initiative (NKF-KDOQI) recommended target ranges of PTH in CRF patients as (150-300 pg/mL), while the KDIGO recommended target ranges of PTH to be (2 or <9 times the upper limit of normal) [35]. PTH in the studied patients ranged from 7.6 to 1384.0 pg/ml. This very wide range was also reported by the study of Bansal B et al [36]. in India among 45 hemodialysis patients from 37 to 1066 pg/ml. As well as the study of Arici M et al [37]. in Turkey, among 39 hemodialysis patients (12–1233 pg/ml). The studied patients showed a mean PTH of (322.7 pg/ml), which is slightly higher than the recommended target by NKF-KDOQI, however; it is coinciding with the target recommended by KDIGO[35] between 2 and < 9 times the upper limit of normal (6.2 times the upper limit of normal). The mean PHT in the studied patients was not far from that reported by the study of Al-Mahdawi F et al [38]. in Iraq among 106 CRF patients (371.9 pg/ml). Other studies revealed comparable means as Abdolrahim et al [39]. in Iran, who reported that all their patients with CRF have over normal range of PTH and the mean was 219.2 ± 25.8 pg/ml. Vhora R et al.,[16] in India, reported a mean PTH of (124.6 pg/ml) in CRF patients under dialysis and among patients with high PTH level, the mean was (314.9 pg/ml), which is near to the mean value in this study. In the current study, 58.5% of patients depicted higher PTH level of ≥130 pg/ml. This percentage is higher than that reported by the study of Sankarasubbaiyan S et al [40]. in South India (30.0%). However, it is lower than that reported by Jinnan Li et al [41]. in USA (73.7%), the study of Douthat W et al [33]. in Argentina

(75.6%), as well as by Waziri B et al [42]. in Johannesburg among 165 South African patients with CRF (82.4%). The increased PTH level in patients with CRF, is thought to be due to reduced glomerular filtration rate, acidosis, calcitriol resistance, increase level of serum phosphorous, decreased serum calcium due to reduction of the active form of vitamin D synthesis, and deficiency of 1-alpha hydroxylase [43]. Secondary hyperparathyroidism in CRF is defined by inappropriate secretion of parathyroid hormone, secondary to a phosphocalcic metabolic disorder [44]. Secondary hyperparathyroidism is one of the first disorders in minerals metabolism in CRF patients and over 50% of dialysis patients suffered this disorder [25]. In the Gulf Cooperation Council countries study, Pisoni R et al [45]. reported SHPT in up to 90% of those with CRF. In the current study, up to (58.5%) of CRF were found with secondary hyperparathyroidism (SHPT). This percentage was coinciding with that reported by the study of Lim and Gun [25]. in Indonesia, who reported (58%) of CRF patients with SHPT. As well as the recent study of Yu Y et al [46]. in China, who reported (55.8%) of CRF patients with SHPT. Increase of PTH levels in dialysis patients is considered as a toxin of uremia that can stimulate rapid bone absorption and reabsorption causing bone demineralization and renal osteodystrophy [47]. It can cause symptoms such as bone pain, joint problems, fracture, itch, or even soft-tissue calcification (lung, blood vessels, joints, and skin) that all affect duration of hospitalization, treatment costs as well as length and quality of life [43]. Studies have shown that patients with high levels of

parathyroid hormone experience high risk of cardiovascular diseases (due to calcium-phosphate deposition in the artery wall) and death [48,49]. In the current study, correlation test between PTH and other biochemical parameters showed negative correlation to eCrCl, serum calcium, and serum chloride, without statistical significance ( $p>0.05$ ). Similar to these findings were observed by the Indian study of Arora K et al [50]. who reported negative correlation between PTH and eGFR ( $r:-0.525$ ), as well as with serum calcium ( $r:-0.805$ ). As well the other study of Rahman M et al.,[32] in Bangladesh, who reported negative correlation between PTH and eCrCl ( $r:-0.564$ ), as well as with serum calcium ( $r:-0.507$ ). However, their negative correlations were statistically significant, while the negative correlations in the current study were not significant with these parameters. Alkaline phosphatase in the current study, showed significant positive correlation to PTH ( $r:0.640$ ,  $p:0.001$ ) in patients with CRF on hemodialysis. This is similar to that reported by the study of Rahman M et al [32]. in Bangladesh, who observed that serum PTH level was positively correlated with serum alkaline phosphatase ( $r: 0.469$ ,  $p<0.001$ ). Alkaline phosphatase is increased in high-turnover bone diseases such as in CRF. It is considered as an adjunct marker of high-turnover bone disease, as such, it is associated with disturbed level of calcium and phosphorus which increase serum PTH level [51]. In Aden Hemodialysis Center it is difficult to test for PTH for all patients serially to detect cases of SHPT. Testing for ALP is cheaper and easier than PTH in our circumstances. The linear direct relationship found between ALP and PTH may help in

using ALP as an alternative marker to PTH in the early diagnosis of SHPT.

### Conclusion

This study concluded that in patients with CRF on HD, there is an increase level of alkaline phosphatase which is considered as an adjunct marker of high-turnover bone disease associated with disturbed level of calcium and phosphorus that increase serum PTH level. Testing for ALP is cheaper and easier than PTH in our circumstances. It is recommended that measurement of ALP in patients with CRF on HD may be used as alternative marker to PTH in the diagnosis of secondary hyperparathyroidism.

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