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Original Article

Assessment of serum biochemical derangements and associated risk factors of chronic kidney disease

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الملخص

أهداف البحث: مرض الكلى المزمن و / أو الاضطراب في وظيفة الإخراج الكلوي قد يؤدي إلى تراكم النفايات النيتروجينية بالإضافة إلى اختلالات العديد من المواد البيوكيميائية في مصل الدم. لا توجد دراسة سابقة من باكستان تكشف عن اختلالات في كهارل مصل الدم لدى مرضى الكلى المزمن المؤكد والمواد البيوكيميائية الأخرى المرتبطة بأمراض الكلى المزمنة. تهدف هذه الدراسة إلى تقييم اختلالات المواد البيوكيميائية في مصل الدم والارتباط بين العديد من عوامل الخطر مع مرض الكلى المزمن.

طرق البحث: ضمت الدراسة 612 مريضا مؤكدا بمرض الكلى المزمن مع معدل ترشيح كبيبي أقل من 15 مل / دقيقة تم علاجهم كجزء من برنامج الرعاية المتكاملة في مستشفى مايو في لاهور (أحد أكبر المستشفيات في باكستان). تم تقدير المواد البيوكيميائية في المصل على 680 وحدة بتقنية القياس الطيفي.

النتائج: كان جميع مرضى الكلى المزمن يعانون من ارتفاع مستويات الكرياتينين واليوريا ولكن 63.4٪ فقط كانوا يعانون من فرط حمض يوريك الدم. كانت نسبة الإصابة بمرض السكري وسوء التغذية المقيّمة بألبومين المصل (نقص ألبومين الدم) 27.4٪ و 72٪ على التوالي. من بين اضطرابات الكهارل، وجد أن فرط فوسفات الدم (71.8٪) ونقص كالسيوم الدم (61.9٪) الأكثر انتشاراً. علاوة على ذلك، تم العثور على عوامل خطر ذات دلالة إحصائية للإصابة بمرض الكلى المزمن وهي جنس المريض وسوء التغذية، والسكري، وفرط حمض يوريك الدم، واختلالات الفوسفور والمغنيسيوم، بينما ارتبط سوء التغذية واضطراب المغنيسيوم بفرط حمض يوريك الدم.

الاستنتاجات: من الضروري تحسين النظام الغذائي للبروتين ومراقبة تركيز الكهارل في الدم لدى مرضى الخلل الكلوي لإبطاء تطوّر مرض الكلى المزمن إلى مرض الكلى بمراحله الأخيرة وغيرها من المضاعفات الخطيرة.

الكلمات المفتاحية: أمراض الكلى المزمنة؛ السكري؛ اضطرابات الكهارل؛ فرط حمض يوريك الدم؛ سوء التغذية

Abstract

Objective: Chronic kidney disease and/or disturbance in renal excretory function may lead to nitrogenous waste collection beyond the term as well as derangements of several serum biochemicals. There is no previous study from Pakistan that reveals serum electrolyte derangements in confirmed chronic kidney disease (CKD) patients and other biochemicals associated with CKD. This study aims to examine the derangements of serum biochemicals and the association of several risk factors with CKD.

Methods: The study enrolled 612 confirmed CKD patients with a glomerular filtration rate (GFR) < 15 ml/min that were treated as a part of the integrated care programme at Mayo Hospital Lahore (one of the largest hospitals in Pakistan). Serum biochemicals were

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estimated on AU 680 (Beckman Coulter) using the spectrophotometric technique.

Results: All the CKD patients had elevated creatinine and urea levels, but only 63.4% were suffering from hyperuricemia. The incidence of diabetes and malnutrition assessed by serum albumin (hypoalbuminemia) was 27.4% and 72%, respectively. Among electrolyte disorders, hyperphosphatemia (71.8%) and hypocalcaemia (61.9%) were found to be more prevalent. Furthermore, gender, malnutrition, diabetes, hyperuricemia, and phosphorus and magnesium derangements were found to be statistically significant risk factors for CKD, whereas malnutrition and magnesium derangement were associated with hyperuricemia.

Conclusion: It is imperative to improve dietary protein and monitor serum electrolyte concentration in renal dysfunction patients to slow the progression of CKD to end-stage renal disease (ESRD) and other serious complications.

Keywords: Chronic kidney disease; Diabetes; Electrolyte derangements; Hyperuricemia; Malnutrition

Introduction

Chronic kidney disease (CKD) is considered a silent killer as symptoms do not appear at an early stage. CKD is now a global epidemic, with substantially high morbidity and mortality; it places a huge economic burden on both developing and developed countries.[1,2] CKD's estimated prevalence is 8%−16%, and it is the ninth leading cause of mortality, with 9−10 million annual deaths globally.[3−5] CKD's incidence in Pakistan is very difficult to estimate due to the country's lack of a central renal registry programme, but independent studies report 15%−20%.[6,7]

CKD is characterized by gradual loss of the kidneys' excretory and regulatory functions attributed to functional or structural anomalies with a decreased glomerular filtration rate (GFR) of < 15 ml/min per 1.73 m^2 for a minimum of 3 months.[8−10] Creatinine and urea are the most important biomarkers to check GFR function.[11] CKD is usually diagnosed by measuring the GFR level, evaluating biomarkers, or both.[12] Serum albumin and uric acid levels are other less commonly used prognostic factors.[13,14] There are multiple CKD aetiologies including diabetes, obesity, hypertension, an unhealthy lifestyle, old age, cardiovascular problems, lung disorders, malnutrition, anaemia, and hypercholesterolemia.[15−17]

Electrolytes or ions are essential components that perform a variety of key functions in the body.[18] Sodium, potassium, calcium, magnesium, chloride, and phosphorus are included among the macro or major electrolytes and are involved in various metabolic and homeostatic functions including enzymatic reactions, bone mineralisation, nerve impulse conduction, muscle contraction, and the regulation of osmotic balance.[19] Their normal concentrations are vital for smooth body functioning.

Moreover, electrolyte disturbances are measurable serum biochemical parameters that can be evaluated for renal physiology.[17] These severe biochemical derangements in CKD patients can be corrected by regular dialysis and renal transplantation.[20] Furthermore, some dietary supplementation therapies can be designed to prevent CKD patients from experiencing electrolyte derangement complications. The number of CKD patients in Pakistan is increasing daily.[21] Adequate treatment and diagnosis will minimise complications and can potentially be lifesaving. The current investigation evaluates the derangement of serum biochemicals including serum electrolytes, glucose, albumin, and renal function biomarkers in CKD patients. Risk factors associated with hyperuricemia are also evaluated.

Materials and Methods

Study design and population

This was a cross-sectional study that enrolled CKD patients treated as a part of the integrated care programme at Mayo Hospital Lahore (one of the largest hospitals in Pakistan). Patients with a background of acute renal failure, a GFR that decreased by more than 50% within 3 months, and those who had intermittent renal replacement therapy (RRT) previous to their first appointment were excluded. Confirmed CKD patients with a GFR <15 ml/min, irrespective of age and gender, were included in the study after obtaining written consent for participation. Demographic features and GFR values were obtained from their case history. All procedures performed in this study involving human participants were in accordance with the ethical standards of the research committee at the institution where the study was conducted.

Sample size

A total of 612 CKD patients were included in the study. The following equation[22] was used for sample size calculation:

$$n = \frac{(Z\alpha/2)^2\, p^{*}q}{d^2}$$

where n is the number of samples, Z is the confidence level (99%), i.e. 2.576, p is the prevalence of CKD, which is reported as 64% in Pakistan,[7] q is 1-p, and d is the degree of freedom (0.05).

Sample collection and processing

A total of 612 blood samples taken from confirmed CKD patients with a GFR <15 ml/min were collected for chemical analysis under aseptic conditions from patients visiting Mayo Hospital Lahore using sterile syringes. Samples were placed in bottles with yellow caps and transported at room

temperature in a leak-proof box to the central diagnostic laboratory in the Department of Pathology, Mayo Hospital Lahore as soon as possible for further processing. After the laboratory received the blood samples, the samples were centrifuged at 4,000 rotations per minute (rpm) for 5–10 min, and all the biochemical tests, including renal function biomarkers (urea, uric acid, creatinine, glucose, and albumin) and serum electrolytes namely calcium (Ca^{+2}), sodium (Na^{+}), potassium (K^{+}), phosphorus and chloride (Cl^{-}), were performed on AU680 (Beckman Coulter). The reference ranges for these chemical parameters are given in Table S1.

Statistical analysis

Data were analysed using SPSS v.25.0. Frequency and percentages were calculated for categorical variables. A Chi-square (χ^2) test was employed to calculate the association between various parameters in CKD patients. Multinomial logistic regression analysis was performed by including the variables that were significant at P-value < 0.05. Adjusted odds ratios (AOR) with their corresponding 95% confidence intervals (CIs) were calculated to reveal the association of various predictors (age, gender, serum electrolytes, diabetes, malnutrition, and uric acid) with CKD. A P-value <0.05 was considered statistically significant.

Results

Study participants' demographic features

A total of 612 patients with CKD were selected for this study. The patients' mean age was 48.6 ± 16.27 years (Table 1). CKD was found to be more prevalent in males ($n = 352$, 57.5%) than in females ($n = 260$, 42.5%).

The CKD incidence rate was the highest in male patients aged 41–60 years ($n = 171$, 50%) followed by 25.3% ($n = 89$) aged 21–40 years and 17.9% ($n = 63$) aged 61–80 years. In patients aged less than 20 years and more than 80 years, CKD prevalence was 3.8% ($n = 14$) and 4.3% ($n = 15$), respectively. A similar CKD prevalence pattern was observed in various age groups of female patients; it was the highest in females aged 41–60 years ($n = 129$, 49.6%), followed by those 21–40 years ($n = 83$, 32%), 61–80 years ($n = 29$, 11.2%), 1–20 years ($n = 15$, 5.7%), and 81–100 years ($n = 4$, 1.5%).

Evaluation of renal function biomarkers

Renal function biomarkers, including serum urea, uric acid, and creatinine, were evaluated in CKD patients, and their association with patients' age and gender was also assessed.

All male and female CKD patients in all age groups were evaluated as having high levels of serum urea and creatinine in the range of 52–562 mg/dL and 2–27.8 mg/dL, respectively. More male CKD patients ($n = 352$, 57.5%) were suffering from uraemia than female patients ($n = 260$, 42.5%). This difference was found to be statistically significant, with a P-value of 0.03 (Table S2). Moreover, the highest number of CKD patients with uraemia ($n = 300$, 49%) was observed in the 41–60 age group, while the least number of patients with uraemia ($n = 23$, 3.7%) and elevated creatinine ($n = 16$, 2.6%) was found in the 81–100 age group (Table S3), with no statistically significant association between age and uraemia (P-value 0.79), although the association between age and creatinine level (P-value 0.03) was statistically significant.

Table 1: Study participants' demographic and clinical characteristics.

	$N = 612$
Mean age (years)	48.6 ± 16.27
Gender (n, %)	
Male	352 (57.5)
Female	260 (42.5)
Age groups (years) (n, %)	
1–20	16 (3.6)
21–40	111 (25.6)
41–60	218 (50.3)
61–80	76 (17.5)
81–100	12 (2.7)
Diabetes	
Diabetics	266 (43.5)
Non-diabetics	346 (56.5)
Blood tests	
Urea (mg/dL)	180.5 ± 8.3
Creatinine (mg/dL)	7.6 ± 3.6
Glucose (mg/dL)	149.2 ± 8.8
Uric acid (mg/dL)	8.8 ± 3.4
Albumin (g/dL)	2.9 ± 0.75
Calcium (mg/dL)	7.9 ± 1.3
Phosphorus (mg/dL)	6.7 ± 2.8
Magnesium (mg/dL)	2.6 ± 0.62
Sodium (mEq/L)	135.8 ± 7.2
Potassium (mEq/L)	5.1 ± 1.2
Chloride (mEq/L)	101.4 ± 8.4

Note. Values are presented as n (%) and mean ± SD.

No CKD patients were found to have low serum uric acid, 224 (36.6%) patients had a normal serum uric acid level (normourecemia), and 388 (63.4%) had a high level of serum uric acid (hyperuricemia). Serum uric acid showed a significant association with age (P-value = 0.025), but no association was found with gender (P-value = 0.28). More males ($n = 217$, 55.9%) were suffering from hyperuricemia than females ($n = 171$, 44.1%) (Table S2). All patients ($n = 15$, 100%) aged 81–100 were suffering from hyperuricemia. It was found that 19 (76%), 109 (64%), 186 (61%), and 59 (60%) CKD patients belonging to Age Groups I (0–20 years), II (21–40 years), III (41–60 years), and IV (61–80 years) were suffering from hyperuricemia, respectively (Table S3).

Estimation of serum glucose in CKD patients

Glucose metabolism was found to be disturbed in CKD patients. Patients with a fasting plasma glucose level ≥126 mg/dL (7.0 mmol/L) were considered to be diabetic. Only 43.5% ($n = 266$) of CKD patients were observed to be suffering from hyperglycaemia (Table 1). More males ($n = 147$, 55.2%) were diabetic than females ($n = 119$, 44.7%). No statistical association was found between CKD patients' gender and glycaemia (P-value = 0.375).

Moreover, the association between age groups and glycaemia was found to be statistically significant (*P*-value = 0.000). The highest number of diabetic CKD patients ($n = 158$, 59.3%) were aged 41−60 years, followed by 21−40 years ($n = 53$, 19.9%), and 61−80 years ($n = 48$, 18%). The age groups 1−20 years and 81−100 years included only four (1.5%) and three (0.1.1%) CKD patients with hyperglycaemia, respectively.

Estimation of serum albumin in CKD patients

Disturbance in the serum albumin level was evaluated in CKD patients. A low serum albumin level (hypoalbuminemia) was found in 72% ($n = 439$). A significant association was found between serum albumin and gender (*P*-value = 0.049) as well as with age (*P*-value = 0.017). Hypoalbuminemia was more prevalent in males ($n = 242$, 55%) than in females ($n = 197$, 45%). A linear increase in hypoalbuminemia was observed with increased age, up to the age of 60. The incidence of hypoalbuminemia was 3.6% ($n = 16$), 25.5% ($n = 112$), 50.1% ($n = 220$), 17.9% ($n = 79$), and 2.7% ($n = 12$) in the age groups 0−20, 21−40, 41−60, 61−80, and 81−100 years, respectively (Table 2).

Distribution of serum electrolytes in CKD patients

Disturbances in serum electrolytes, namely calcium, phosphorus, magnesium, sodium, potassium, and chloride, were assessed in CKD patients (Table S4). Serum electrolyte perturbances were observed in all patients. The majority (74.2%) were assessed as having disturbed phosphorus (2.2% hypophosphatemia and 71.8% hyperphosphatemia), followed by calcium (62.7%; 61.9% hypocalcaemia and 0.8% hypercalcemia), magnesium (60.13%; 7.5% hypomagnesaemia and 52.6% hypomagnesaemia), chloride (48.8%; 30.2% hypochloraemia and 18.6% hyperchloremia), sodium (40.8%; 38.5% hyponatremia and 2.2% hypernatremia), and potassium (39.5%; 6.2% hypokalaemia and 33.3% hyperkalaemia).

Moreover, more male than female patients were suffering from disturbed electrolytemia. Male patients were found to have altered levels of calcium (56.5%; $n = 217$), phosphorus (57.2%; $n = 260$), magnesium (60.5%; $n = 223$), sodium (50.8%; $n = 127$), potassium (59.9%; $n = 145$), and chloride (56.18%; $n = 168$) (Table S4). These gendered differences in electrolyte levels were not statistically significant for any of the electrolytes, except sodium (*P*-value = 0.014).

Furthermore, CKD patients' age has been observed to influence serum electrolyte balance. The majority of the patients with disturbed calcium (30.8%; hypocalcaemia 98.9% and hypercalcemia 1.05%), phosphorus (35.1%; hypophosphatemia 3.2% and hyperphosphatemia 96.7%), magnesium (30%; hypomagnesaemia 11.4% and hypermagnesemia 88.5%), potassium (20.2%; hypokalaemia 16.1% and hyperkalaemia 83.8%), sodium (19.6%; hyponatremia 93.3% and hypernatremia 6.6%), and chloride (25.3%; hypochloraemia 61.9% and hyperchloraemia 38.06%) belonged to Age Group III (41−60 years). Age Group I (0−20 years) did not contain any patients with hypernatremia, whereas Age Groups IV (61−80 years) and V (81−100 years) were free from hypercalcemia patients (Table S5). There was no statistically significant association between any of the electrolytes and patients' age.

Table 2: Prevalence of hypoalbuminemia by CKD patients' age and gender.

Gender	Age Groups (Years)				
	1−20	21−40	41−60	61−80	81−100
Male (n)	6	49	122	52	10
Female (n)	10	62	96	24	2
Total (n)	16	111	218	76	12
Percentage (%)	3.6	25.6	50.3	17.5	2.7

Table 3: Multinomial regression analysis to assess the risk factors associated with CKD.

Variables	AOR (95% CI)	*P*-value
Age	0.980 (0.951−1.010)	0.200
Gender	0.275 (0.093−0.815)	0.012*
Diabetes	0.985 (0.974−0.997)	0.011*
Uric acid	1.263 (1.084−1.472)	0.003*
Malnutrition	6.521 (2.734−15.554)	0.000*
Calcium	1.025 (0.669−1.570)	0.910
Phosphorus	1.654 (1.372−1.994)	0.000*
Magnesium	0.314 (0.126−0.779)	0.013*
Sodium	1.000 (0.895−1.118)	0.999
Potassium	1.185 (0.782−1.796)	0.424
Chloride	0.955 (0.872−1.045)	0.316

*: statistically significant; AOR: adjusted odds ratio; CI: confidence interval.

Risk factors associated with CKD

Multinomial regression analysis was performed to identify the association between various risk factors, namely age, gender, diabetes, serum electrolyte disturbances, malnutrition, uraemia, and uric acid. Among them, malnutrition (low albumin), phosphorus imbalance, and old age were found to have a statistically significant association with CKD, with *P*-values 0.037, 0.003, and 0.012, respectively (Table 3).

Table 4: Multinomial regression analysis to assess the risk factors associated with hyperuricemia.

Variables	AOR (95% CI)	*P*-value
Age	1.010 (0.997−1.02)	0.134
Gender	0.859 (0.583−1.264)	0.440
Diabetes	1.000 (0.998−1.002)	0.996
Malnutrition	1.459 (1.081−1.970)	0.014*
Calcium	0.855 (0.719−1.017)	0.077
Phosphorus	0.950 (0.863−1.046)	0.296
Magnesium	1.606 (1.137−2.270)	0.007*
Sodium	0.993 (0.949−1.038)	0.754
Potassium	0.862 (0.725−1.024)	0.091
Chloride	0.984 (0.948−1.022)	0.409

*: statistically significant; AOR: adjusted odds ratio; CI: confidence interval.

Discussion

The current investigation reveals an insignificant association between CKD and old age but a significant association between CKD and gender. CKD prevalence is higher in younger patients in the age range 21−60 years (Table 1). Other studies have supported this insignificant association between older age and CKD.[23,24] This might be due to the prevalence of hypertension in young Pakistanis, as it is considered the major CKD risk factor. Moreover, lower CKD prevalence in female patients may be explained by the effect of gender-specific hormones on renal cells, structural glomerulus differences, and the hemodynamic condition.[25] This gender discrimination is also supported by Freethi et al., who found a higher prevalence of renal diseases in male patients (68.33%) compared to females.[26]

The co-existence of diabetes and CKD has been reported in some patients and is considered the leading cause of diabetic nephropathy. Renal gluconeogenesis is impaired due to a progressive reduction in renal function, leading to insulin resistance and electrolyte impairment. Contrary to other studies, no significant association between hyperglycaemia and gender or age has been found in CKD patients. The prevalence of diabetes in female CKD patients was higher than that in males, and the majority of the patients belonged to the 41−60 age group. The association between gender and diabetic kidney disease is highly debatable. Yu et al. revealed a high incidence of CKD in diabetic females, which may be attributed to imbalanced sex hormones in females due to diabetes, as the protection female sex hormones offer the kidneys is lost in CKD.[27]

Malnutrition, specifically related to protein, is considered an important risk factor for kidney diseases. Serum albumin is widely used as a reliable quality care and nutritional marker to gauge malnutrition in CKD patients.[28] Hypoalbuminemia is a frequently-used independent CKD risk factor. In the present study, we have investigated the association between serum albumin and CKD. No statistically significant association between hypoalbuminemia and CKD was found (P-value = 0.037). The majority of CKD patients have been observed as suffering from low serum albumin levels (Table 2). Filipa et al. observed similar results, demonstrating a higher risk of CKD in patients with lower serum albumin.[29]

Mineral homeostasis is the vital kidney function. Derangements in serum electrolytes, including sodium, potassium, calcium, magnesium, phosphorus, and chloride, are attributed to disturbed kidney function, leading to some serious complications in CKD patients.[30] In the current investigation, more CKD patients were found to be suffering from hypoelectrolytemia for calcium (hypocalcaemia), hyperelectrolytemia for magnesium (hypomagnesaemia) and phosphorus (hyperphosphatemia), and normoelectrolytemia for sodium (normonatremia), potassium (normokalemia), and chloride (normochloremia) (Tables S3−S4). Hyperphosphatemia is the most prevalent electrolyte disorder, followed by hypocalcaemia. It was previously reported that a decreased GFR leads to increased phosphorus levels, which, in turn, decreases the calcium level, following the law of mass action; our results are in strong agreement with this finding.[31] Potassium is another important micro-element present intracellularly in a higher amount (98%) than outside of the cell. Kidneys maintain K^+ homeostasis by monitoring its uptake and removal. High concentrations (90%−95%) are filtered by the glomerulus but reabsorbed in the proximal convoluted tubule and/or the loop of Henle.[32,33] CKD patients exhibit disturbed K^+ homeostasis, leading to cardiovascular events.[34]

In the current study, the majority of CKD patients (60.4%) were found to have normal K^+ levels, with only 6.2% and 33.3% noted to be suffering from hypokalaemia and hyperkalaemia, respectively. These results are in accordance with Balci et al., who reported normokalemia in a majority of patients; only 18% and 8% were suffering from hypokalaemia and hyperkalaemia, respectively.[17]

The sodium level is usually elevated due to malfunctioning kidneys, but it may appear normal or hyponatremic due to dilution caused by fluid retention.[35] To the best of our knowledge, very few studies have explored the association between serum dysnatremias and CKD. The present study has revealed that the majority of CKD patients had normal sodium levels (normonatremia), and only 38.5% and 2.2% had hyponatremia and hypernatremia, respectively. Both hyponatremia and hypernatremia are fatal conditions with a high mortality rate in CKD patients.[36] These results are in line with Mulla et al., who reported that 96% of kidney patients had normal sodium levels, while only 2.4% were suffering from hypernatremia.[37]

Chloride is the most abundant anion present in extracellular body fluids and has an established key role in tubuglomerular feedback and reabsorption in the renal interstitium.[38] Dietary salt is the principal dietary source of Cl^{-}[39]; therefore, the prevalence of hypochloraemia is quite low. However, its high concentration due to excessive salt intake is injurious to the kidneys, as it is involved in vasoconstriction in renal vessels. In the present investigation, disturbed Cl^- was observed in 48.8% of CKD patients, which is in accordance with Molla et al., who reported a 5.8% prevalence of disturbed chloremia in CKD patients.[37] The high incidence of altered Cl^- is due to the fact that all the participants in the current study were suffering from CKD. Moreover, it has been reported in the literature that the mechanisms that regulate serum Na^{+1} concentration are involved in maintaining the serum Cl^- level[40]; our finding strengthens this fact, as the Na^+ and Cl^- prevalence patterns are comparable (Table 3).

Magnesium is a vital ion, as it is a cofactor for many enzymes and a component of nucleotides and membranes.[41] Its normal serum concentration is dependent on its intestinal absorbance, which was reported as disturbed in many CKD patients.[42] The present study reveals a 52.6% and 7.5% prevalence of hypomagnesaemia and hypomagnesaemia in CKD patients, respectively. These results are in good agreement with various studies that have reported a high incidence of hypomagnesaemia in CKD patients.[43]

All the serum electrolytes, including sodium, potassium, calcium, magnesium, phosphorus, and chloride, have been found to be significantly associated with CKD in several studies,[44,45] but in the present study, only phosphorus showed a statistically significant association with CKD. Moreover, the majority of CRF patients with electrolyte

derangements are in the age range 21–60 years, but there is a statistically significant association between age and any electrolyte derangement.

Along with the serum electrolyte panel, serum urea, uric acid, and creatinine are routinely used to gauge renal function. Creatinine and urea were elevated in all the CKD patients included in the study. However, only 63.4% were suffering from elevated uric acid levels (hyperuricemia) (Tables S2–S3). Several studies have revealed that serum uric acid is an independent CKD risk factor in clinical settings.[45] Despite these findings, it is still debatable whether serum uric acid is a key factor for CKD progression or whether it is simply a marker for measuring renal function. The present investigation ponders this topic and has revealed that hyperuricemia is not consistent with CKD, as only 63.4% of CKD patients were found to be suffering from it, although a statistically significant association was established between serum uric acid and CKD (P-value = 0.003). However, serum uric acid can undeniably lead to CKD, and its concentration should be monitored in CKD patients to avoid progression to renal failure.[46] Moreover, it is also important to evaluate several hyperuricemia risk factors to avoid renal dysfunction. The present study clarifies that malnutrition and magnesium derangement are associated with hyperuricemia prevalence (Table 4). The investigation's main significance is that it is the first study from this part of the world that describes the derangement of the serum electrolyte panel and renal function biomarkers in CKD patients. Moreover, it can estimate various risk factors associated with CKD, including age, gender, diabetes, and protein-deficient malnutrition. The findings are helpful for improving the dietary intake and thus treatment of CKD patients and for inhibiting/slowing the progression of CKD to ESRD.

Limitations

One of this study's limitations is that it is restricted to CKD patients that were treated as a part of the integrated care programme at the Mayo Hospital Lahore, which might affect the generalizability of these findings to all CKD patients in the country.

Conclusion

In conclusion, the present study has revealed severe derangements of all the serum biochemicals in CKD patients. Among serum electrolyte disorders, hyperphosphatemia and hypocalcaemia were more prevalent. Hyperuricemia, protein-calorie deficient malnutrition, hyperglycaemia, and mineral derangements, especially phosphorus and magnesium, have been identified as statistically significant risk factors for CKD. Moreover, hyperuricemia itself is associated with malnutrition and magnesium derangement.

Recommendation

It is imperative to improve dietary protein and monitor the concentration of serum electrolytes in renal dysfunction patients in order to slow the progression of CKD to ESRD and other serious complications.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of interest

The authors have no conflict of interest to declare.

Ethical approval

The study was approved by the Institutional Review Board (IRB) of the University of Lahore on 16-12-2019 under the approval number IRB-UG-19691.

Consent

All the patients included in the study were informed that their identity will not be disclosed and that their data will be used for research purposes only.

Authors contributions

ZK conceived and designed the work and provided logistic support, HRM acquired data and conducted the lab work, HMSJ analysed and interpreted the data, HRM and SMHA were involved in writing the final draft, and AE and AH critically reviewed the manuscript for intellectual content and statistical analysis. All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtumed.2021.09.009.

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