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Hyperhomocysteinemia in Chronic Kidney Disease Patients in a Teaching Hospital in Nigeria

Afeaje B. Olokor[1*], Ikechukwu L. Ojogwu[1] and Peter F. Ugbodaga[2]

[1]Nephrology Unit, Department of Internal Medicine, University of Benin, Benin City, Nigeria.
[2]Nephrology Unit, Department of Internal Medicine, Specialist Hospital, Benin City, Nigeria.

Authors' contributions

This work was carried out in collaboration between all authors. Authors ILO and PFU designed the study. Author ABO wrote the protocol, performed the statistical analysis and wrote the first draft of the manuscript. All authors managed the literature searches and analyses of the study. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Aim: To determine the prevalence of hyperhomocysteinemia amongst chronic kidney disease (CKD) patients at a Teaching Hospital in Nigeria and to determine its relationship with the severity of kidney disease.
Study Design: A comparative cross sectional study carried out in the department of Medicine in a Teaching Hospital in Nigeria between April 2012 and May 2013.
Methodology: A comparative cross sectional study among138 patients with CKD and 69 healthy consenting hospital staff individuals. Glomerular filtration rate was estimated for both patients and controls, using measured serum creatinine in the Cockcroft-Gault formula and the patients were grouped into the different stages of chronic kidney disease. All subjects had the homocysteine levels measurements using the enzyme- linked immunosorbent assay. Homocysteine levels were compared between healthy persons and CKD patients as well as within different stages of chronic kidney disease.
Results: Most of the CKD patients (47.8%) were stage 4, followed by (33.3%) stage 3 and stage 5

**Corresponding author: E-mail: sweetafe@yahoo.com;*

(14.5%). While stages 1 and 2 were the least (2.2% each). The mean age of the patients was 45.9 ± 16.5 years and 42.3 ± 14.7 years for control subjects. The prevalence of hyperhomocysteinemia was 57.9% amongst cases and 4.3% among control subjects with median homocysteine (Hcy) level being 19.1 µmol/l (IQR - 13.8) in cases and 8.3 µmol/l (IQR - 2.9) in controls, this was significant (*P*<.001), the chronic kidney disease patients having higher median homocysteine levels as the degree of kidney disease worsened.

Conclusion: The prevalence of hyperhomocysteinemia is high in CKD patients compared to controls and it increases as CKD progresses.

Keywords: Chronic kidney disease; homocysteine; hyperhomocysteinemia; cardiovascular disease.

ABBREVIATIONS

BMI : Body Mass Index
CHD : Coronary Heart Disease
CKD : Chronic Kidney Disease
CVD : Cardiovascular Disease
ESRD : End Stage Renal Disease
EIA : Enzyme Immuno Assay
FBS : Fasting Blood Sugar
GFR : Glomerular Filtration Rate
Hcy : Homocysteine
IQR : Inter Quartile Range
KDIGO : Kidney Disease Improving Global Outcomes
SD : Standard Deviation

1. INTRODUCTION

Chronic kidney disease (CKD) is a public health problem that is present worldwide with an incidence that's on the rise, unfavourable outcomes and very high cost [1].

Cardiovascular disease (CVD) is a major cause of morbidity and mortality in patients with CKD that is well documented [2]. Although patients with CKD are at risk of ultimately developing end-stage renal disease (ESRD), about 50% of CKD patients die of CVD before commencement of dialysis [3-6]. In patients requiring haemodialysis (usually stage 5 CKD patients) the morbidity and mortality from CVD is extremely high [7]. Based on data from the U.S. Renal Data System Coordinating Center Case-Mix Adequacy Study, clinical coronary heart disease (CHD) is seen in 40% of haemodialysis patients and CVD in them is 10 to 30 times higher than in the general population despite stratification by gender, age, race, and the presence of diabetes [7].

CKD patients usually develop accelerated atherosclerosis and the risk of premature death from CVD is higher. The predisposition of these patients to atherosclerosis is driven mainly by inflammation, dyslipidemia and oxidative stress, and these are features associated usually with CKD [2]. Chronic inflammation is prevalent in CKD patients and numerous studies have demonstrated that chronic inflammation may be a contributor to the morbidity and demise among end stage renal disease (ESRD) patients [8,9]. The increased cardiovascular morbidity and mortality among CKD patients may not be fully explained by conventional risk factors.

A number of abnormalities in the metabolism of protein and amino acid are seen in patients with CKD especially ESRD. An increase in the plasma concentration of homocysteine, a sulphur containing amino acid, is one of such abnormalities that may be seen [10].

Homocysteine is associated with inflammation and is been considered as an inflammatory marker [11,12]. It acts as an atherogenic and thrombophilic agent which potentiates hypertension and smoking as well as other risk factors that predispose to peripheral arterial disease [10]. All of which increase morbidity as well as mortality in CKD patients. Hence homocysteine is attracting a lot of attention among renal patients.

Hyperhomocysteinemia in itself has also been shown to be an independent cardiovascular risk factor in patients with chronic kidney disease [10,13] however, the mechanism is not clear. Elevated levels of homocysteine and cardiovascular disease are common in patients with decreased renal function. An increase in Homocysteine represents a potent risk factor for coronary, cerebrovascular and peripheral arterial disease as well as for deep vein thrombosis [14]. Hyperhomocysteinemia is seen in the early stages of CKD at levels of glomerular filtration rate (GFR) of about 60 ml/min and its prevalence increases to about 85-100% in ESRD [15]. In the general population moderate hyperhomocysteinemia is seen in approximately 5 – 7% [16].

The burden of CKD in terms of morbidity and mortality is huge, worse in developing countries where access to, and affordability of care is not readily available. A major factor contributing to this burden is CVD. To reduce this burden, cardiovascular risk factors in CKD patients must be sought and addressed. The paucity of data on hyperhomocysteinemia in chronic kidney disease in a developing country like Nigeria necessitated this study.

2. MATERIALS AND METHODS

This was a hospital-based comparative cross-sectional study carried out in the Nephrology unit, in a tertiary hospital in Nigeria. Patients presenting at the Nephrology clinic/ Dialysis/ Accident and Emergency units who met the inclusion criteria -adults above 18 years of age in CKD stages 1 – 5, on conservative or renal replacement therapy and who gave their consent, were consecutively recruited. Exclusion criteria were patients below 18 years of age, non-consenting patients, patients on methotrexate, phenytoin or theophylline therapy, menstruating women, patients with acute kidney injury, hypothyroidism, acute lymphoblastic leukemia and cancers of the breast, ovaries and pancreas. Controls were recruited from amongst hospital staff (doctors and nurses) who were apparently healthy and not on medication for any acute or chronic ailments who gave their consent. Approval for the study was obtained from the Ethics and Research Committee of the hospital. All participants gave written informed consent.

2.1 Sample Size

Studies on the prevalence of hyperhomocysteinemia revealed a range of 56% - 90% [7,10,16-19]. The sample size was extrapolated from the formula for sample size determination in an infinite population [20] using a prevalence of 90% and a degree of precision of 0.05. A sample size of 138 was arrived at. A total of 138 chronic kidney disease patients and 69 controls in a ratio 2:1 were recruited for this study.

Upon recruitment, a researcher administered questionnaire was completed. Data on physical characteristics such as weight, height, hip and waist circumference and blood pressure were recorded. Weight was measured in kilograms using hospital health scale ZT-120 with patients putting on light clothing without foot wears. The height was measured in meters using the same scale. The body mass index BMI defined as weight in kilogram divided by the square of patient's height in meters was calculated. The waist circumference in centimetres was measured in the horizontal plane at the level of the natural waist line taken to be at the umbilicus using a non-stretchable tape. All patients and controls were instructed to be on overnight fast for 8-10 hours before blood sample collection on the next day. About 10 ml of venous blood was collected, 5 ml into a lithium heparin sample bottle for serum creatinine estimation using the Jaffe's reaction and 5 ml into an EDTA bottle and centrifuged for 15 minutes within 30 minutes of collection and plasma stored at < 20℃ for homocysteine level assay using the Axis® Homocysteine FHCY100 Enzyme Immunoassay (EIA) [21].

The results were categorized as follows: moderate hyperhomocysteinemia - 15-30 µmol/L, intermediate hyperhomocysteinemia - >30-100 µmol/L, and severe hyperhomocysteinemia - >100 µmol/L [16].

Fasting blood sugar (FBS) was measured using an Accucheck glucometer and strips.

Glomerular filtration rate was calculated using the Cockcroft-Gault formula to estimate creatinine clearance (CCr): CCr = (140 - age) × (weight)/72 × SCr x (0.85 if female), where SCr is in mg/ dL, weight in kg and age in years and results were stratified according to the KDIGO guidelines [22] into CKD stages 1-5.

2.2 Data Analysis

Data entry, storage, and management were performed on the SPSS version 17.

Normally distributed continuous variables were presented as means and standard deviation (SD) and skewed data as medians with inter-quartile ranges (IQR) or standard deviation while discrete variables were presented as percentages. The student t-test was employed for comparing the means of data with normal distribution while Wilcoxon Signed Ranks was used for skewed data in cases versus controls. Chi-square was used in testing for significant differences between proportions and frequencies of cases and controls that had hyperhomocysteinemia.

The confidence interval was set at 95% limit, with a level of significance, $P < 0.05$.

3. RESULTS

The ages of patients ranged from 18 to 80 years with the mean age of the study population being 45.9 years ± 16.4 for cases and 42.2 years ± 14.6 for control (*P* =0.119). The cases consisted of 89 males (64.5%) and 49 females (35.5%) while controls were made up of 42 males (60.9%) and 27 females (39.1%), P = 0.610.

There was no statistically significant difference between mean ages, sex and marital status of cases and controls as shown in Table 1. The homocysteine and FBS levels were significantly higher in the patients (*P* = 0.0001), while the estimated GFR was significantly lower in cases.

Three (2.2%) of the patients with CKD were in stage 1, another three (2.2%) were in stage 2, 46 (33.3%) in stage 3, 66 (47.8%) in stage 4 and 20 (14.5%) in stage 5.

The frequency of hyperhomocysteinemia was 57.9% among CKD patients and 4.3% among the controls *P* <0.01, OR = 30.34 (95% CI = 9.09,-101.29). Forty-two percent of the CKD patients had normal levels of homocysteine, 30.4% moderate hyperhomocysteinemia and 27.5% intermediate hyperhomocysteinemia. None had severe hyperhomocysteinemia as depicted in Table 2.

The median values of Hcy increased from stage 1 to 5. There was a significant correlation between the stages of CKD and the degree of homocysteine levels (spearman's rho = 0.204, *P* = 0.016) as shown on Fig. 1.

4. DISCUSSION

Increased cardiovascular morbidity and mortality in CKD patients has been associated with elevated homocysteine levels which is a common finding in them [10,11]. This study shows that hyperhomocysteinemia is significantly higher among CKD patients. Using the classification by Kang et al. [16] 57.9% of the CKD patients had hyperhomocysteinemia. This is comparable with 56% reported by Menon et al. [19] in England in which baseline homocysteine was measured in 2 different populations; population A with estimated GFR 25 – 55 ml/min had a prevalence of hyperhomocysteinemia of 56%. It is, however, lower than that reported by Ajith et al. [23] in New York, in which 147 patients; 85 males and 62 females aged 58±15 years requiring hemodialysis had a prevalence of 82%. The difference in prevalence rate may be due to the fact that the index study assessed the prevalence in both dialyzing and non-dialyzing patients.

Cases with moderate and intermediate hyperhomocysteinemia were 30.4%, and 27.5% respectively, none had severe hyperhomocysteinemia, which is not surprising as cases of severe hyperhomocysteinemia usually due to homozygous defects in genes encoding for enzymes of homocysteine metabolism leading to accumulation of Hcy in blood and urine, are extremely rare. An example of this is a disorder caused by homozygousity for a defective gene which encodes for cystathionine beta-synthase. In this condition Hcy can be as high as 400 umol/L [24]. In the index study,

Table 1. Sociodemographic and clinical characteristics of study population

Socio demographic and clinical characteristic	CKD patients N= 138	Healthy individuals N=69	Test of significance	P value
Age(years) mean ± SD	45.9± 16.4	42.2±14.6	t=1.570	0.119
Sex n (%)				
Male	89 (64.5)	42 (60.9)	X^2=0.260	0.610
Female	49 (35.5)	27 (39.1)		
Marital status n (%)			X^2=0.214	0.644
Unmarried	34 (24.6)	15 (21.7)		
Married	104 (75.4)	54 (78.3)		
BMI (kg/m^2) mean ± SD	23.71 ± 4.94	26.7 ± 3.6	t= 0.303	0.762
Waist-Hip ratio mean ± SD	0.92 ± 0.07	0.90 ± 0.45	t= 0.562	0.575
Fasting Blood Sugar (mg/dl) mean ± SD	107.2 ± 34.0	92.6 ± 9.9	t=4.637	0.001
GFR (mg/dl) (Median IQR)	29.9(18.9)	96.7(16.7)	Wilcoxon=187	0.001
Homocysteine level (µmol/L) (Median IQR)	19.0 (13.8)	8.3 (2.9)	Wilcoxon=1820	0.001

BMI – Body Mass Index, GFR – Glomerular filtration rate

however, a majority of the patients with hyperhomocysteinemia had moderate hyperhomocysteinemia which may be due to deficiencies in vitamins that play major roles in Hcy metabolism, depending on the arm of the 2 metabolic pathways that is defective, that is vitamin B12 and folate deficiency in the remethylation pathway. These vitamins may be lacking in CKD patients as renal disease results in a catabolic state, a syndrome of malnutrition, inflammation and atherosclerosis with reduced intake and minimal absorption usually prevalent in patients especially those in end-stage [25].

Table 2. Comparism of prevalence of homocysteinemia (Cases versus controls)

	Cases	Control
Elevated	80(57.97%)	3(4.35%)
Normal	58(42.03%)	66(95.65%)
Total	138(100%)	69(100%)

df = 2, P- value <0.01,
OR = 30.34 (95% CI = 9.09,- 101.29)

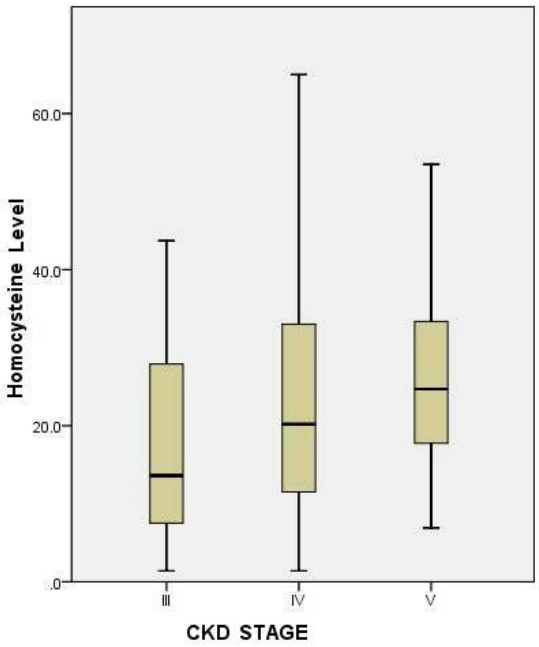

Fig. 1. Boxplot showing correlation between CKD stage and median homocysteine levels

The significant difference in homocysteine levels between cases and control in this study is also in keeping with the findings by Muhammad et al. [26] in Pakistan [26]. The mean tHcy value of the controls 8.3 ± 2.85 is also comparable to that reported by Okubadejo et al. [27] amongst their control subjects – 10.1 ± 7.7 and also with that reported by Osunkalu amongst otherwise healthy subjects with a mean tHcy of 9.5±2.4 [28]. This is expected as the kidneys help in clearing homocysteine, and with kidney disease the renal clearance of homocysteine is impaired.

This study also revealed an association between the severity of kidney disease and the level of hyperhomocysteinemia as it shows a steady rise in the prevalence rate of total hyperhomocysteinemia from CKD stage 1 through to 5. This association was significant; and is in concordance with findings from other studies [10,29-31]. Shankar et al. [32] found that higher plasma homocysteine levels were seen in patients with CKD, independent of BMI, smoking, diabetes mellitus, hypertension, cholesterol levels, and other confounders. Pooled data from 41 trials and 27,000 patients show that homocysteine levels are significantly inversely correlated with estimates of GFR, with higher levels of homocysteine seen in patients with reduced GFR indicating higher homocysteine levels as CKD worsens. This inverse correlation is even more robust when using clearance methods in measuring GFR [32].

There is good evidence that normal kidneys play a major role in amino acid and Hcy clearance and metabolism however it may be difficult to identify the source of clearance defect of Hcy owing to the lack of data on Hcy extraction and metabolism by diseased kidneys. The existence of Hcy-metabolizing enzymes and uptake systems in renal tubular cells has been confirmed, and Hcy extraction studies in animal kidneys documented significant Hcy uptake [33, 34]. Logically the loss of metabolically active kidney tissue normally involved in Hcy handling should decrease Hcy clearance and increase plasma levels. The inverse relationship between Hcy levels and GFR, which is consistent throughout the different stages of CKD, supports the fact that it is reduced renal function, not the accumulation of uremic toxins that causes Hcy levels to increase.

5. CONCLUSION

This study has shown that hyperhomocystienemia is prevalent in CKD patients and worsens as renal function declines.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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