IS CAROTID INTIMA-MEDIA THICKNESS USEFUL IN PREDICTING IMPAIRMENT IN RENAL FUNCTION IN ASYMPTOMATIC HYPERTENSIVE PATIENTS ATTENDING A TERTIARY HOSPITAL IN NIGERIA?

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ABSTRACT

Background: *Intima-media thickness of the carotid artery walls (CIMT) is a strong predictor of cardiovascular disease (CVD). The aim of this study was to investigate the association between CIMT and renal function as determined by the estimated glomerular filtration rate (eGFR), as well as determine the ability of CIMT to predict the presence of covert renal insufficiency in hypertensive Nigerian adults.*

Method: *Two hundred and sixteen participants took part in the study, comprising of 72 hypertensive patients already taking anti-hypertensive medication (treated), 72 newly-diagnosed (untreated) patients, and 72 apparently healthy, normotensive subjects. Anthropometric indices, serum lipid profiles, and serum creatinine levels were determined. The eGFR was determined by the Cockcroft-Gault formula, while the CIMT was determined by carotid ultrasonography.*

Result: *The age range of the participants was between 24 and 86 years. There was no significant difference in the mean age of the study population (p=0.073). The prevalence of chronic kidney disease (CKD) and increased CIMT in the study population was 8.8% and 13.5% respectively. CKD was found more in patients with increased CIMT (33.5%), than in those with normal CIMT (6.5%) (x^2=12.170, p<0.0001). CKD was also most prevalent in the untreated hypertensive patients than in any of the other groups (x^2=15.022, p=0.011).*

Patients with increased CIMT suffered from a lower glomerular filtration rate (p<0.0001). The decline in eGFR with increasing CIMT had significant inverse correlation in the untreated group (r=-0.391, p=0.013). The predictability of renal insufficiency by CIMT determined using the Receiver Operating Characteristics (ROC) curve, showed an area under the curve (AUC) of 0.807 (95% CI: 0.708-0.907) (p<0.0001).

Conclusion: *CIMT is a strong and independent predictor of covert renal insufficiency in the untreated hypertensive adult Nigerian patients, and should be considered a valuable tool for cardiovascular risk stratification in this population group.*

Key words: *Carotid, Intima-media, asymptomatic hypertensive patients.*

INTRODUCTION

Background

Chronic kidney disease (CKD), which is defined according to current guidelines as kidney damage or glomerular filtration rate (GFR) less than 60ml/min/1.73m^2 for 3

months or more, regardless of cause. Kidney damage is defined by structural or functional abnormalities of the kidney, with or without decreased GFR that can lead to decreased GFR, manifest by either pathologic abnormalities; or the presence of the markers kidney damage including abnormalities in the urine or blood composition, or abnormalities in imaging tests[1]. CKD is a recognized cause of increased cardiovascular morbidity and mortality[2, 3], and a major cause of increased health care expenditure. Kidney disease severity is classified into five stages according to the level of GFR[1].

It is established that cardiovascular disease (CVD) mortality is approximately 15 times higher in patients on maintenance hemodialysis than in the general population[4], and the attendant major adverse cardiovascular events (MACE) associated with CKD seems to occur across the spectrum of CKD stages[5, 6]. Even mild renal insufficiency is an independent predictor of CVD or death in high-risk patients (with pre-existing CVD or multiple risk factors for CVD), in general or elderly populations, as well as in patients with essential hypertension[7-10].

Atherosclerosis is a chronic inflammatory injury of the arterial wall, which is often preceded by endothelial dysfunction, and ultimately culminates in cardiovascular, cerebrovascular, and renovascular pathologies. Atherosclerosis is a multi-factorial disease that usually takes many years before any clinical symptoms are manifest; and the measurement of carotid intima-media thickness (CIMT) has been suggested to be an important surrogate marker of atherosclerotic vascular disease (ASVD), and is predictive of cardiovascular events in the future independent of age, gender, and other risk factors for CVD[11].

Hypertension and atherosclerosis are two distinct but linked entities; with increases in blood pressure being associated with a progression of preclinical atherosclerosis[12]. The mechanisms by which hypertension predisposes to atherosclerosis include endothelial dysfunction, hemodynamic stress, increased oxidative stress, and multiple metabolic alterations[13].

Atherosclerosis is typically an asymptomatic condition that can begin as early as childhood, whereas symptomatic organ-specific clinical manifestations often do not appear until 40 years of age or older[14]. In this regard, the measurement of the CIMT becomes particularly important since its increase represents a stage of preclinical atherosclerosis[15], and tends to occur early in the course of CKD[16,17].

Limited information is available in our environment on whether or not a decline in renal function may be preceded by an increase in CIMT among our hypertensive patients. In this study, we investigated whether or not there is an association between CIMT and renal insufficiency (determined by eGFR). Secondly, we investigated whether or not CIMT was able to predict the occurrence of renal insufficiency in the hypertensive participants.

METHODS

Study Population

A descriptive study conducted from January to August 2016 in the general out-patients, medical out-patients clinics, and the medical

wards of the University of Port Harcourt Teaching Hospital.

Data was obtained from subjects who were not diabetic, not currently taking statins, not cigarette smokers, not in congestive cardiac failure, without overt features of CKD, 18 years and above, and gave informed consent. These subjects were serially recruited from the above named units of the hospital. One hundred and forty-four subjects were classified as cases. These were stratified into two groups with one group (72 persons) consisting of hypertensive patients already taking anti-hypertensive drugs (treated) while the other group (72 persons) were newly-diagnosed, treatment-naïve hypertensive patients who presented to the general out-patient clinics for minor illnesses, and were incidentally found to be hypertensive. Seventy-two age- and sex-matched apparently healthy adults without hypertension and diabetes were recruited from the community and served as the control. All the patient population studied were blacks from Nigeria.

Ethical approval was obtained from the University of Port Harcourt Teaching Hospital Ethical Review Committee before the commencement of the study.

Demographic and clinical characteristics

Demographic and clinical characteristics such as age, gender, duration of hypertension and current anti-hypertension therapy were obtained by a structured questionnaire. Blood pressure was measured with a standard mercury sphygmomanometer using standard protocols[18]. Height, weight, waist circumference, hip circumference were measured manually. Height and body weight were measured with subjects wearing light clothing and no shoes. Body mass index (BMI) was calculated as weight (kilograms) divided by height (meters) squared. Waist circumference (WC) was measured midway between the inferior border of the last rib and the crest of the ilium in a horizontal plane. Hip circumference was measured around the pelvis at the point of the maximal protrusion of the buttocks.

Laboratory examination

Fasting venous blood were collected and analyzed in the chemical pathology laboratory of the University of Port Harcourt Teaching Hospital for serum electrolytes, urea, creatinine, blood glucose, and lipidprofile. CKD defined as abnormalities of kidney structure or function, present for > 3 months, with health implications[1], was staged after glomerular filtration rate [GFR] for all patients were calculated using the Cockcroft – Gault Equation[19] having been validated in Africans[20].

The Kidney Disease Improving Global Outcomes (KDIGO) guideline was used to stage participants for GFR categories of CKD[1]. Carotid intima-media thickness was assessed using the Aloka Prosound SSD 4000 ultrasound machine equipped with a 7.5MHz imaging transducer. With the subject supine, neck slightly hyper-extended, and head turned 45^0 away from the side being scanned, the common carotid artery (CCA), carotid bulb and bifurcation were identified. The intima-media thickness (IMT) was taken at the far wall of the CCA about 1 cm proximal to the carotid bulb, and the mean of two measurements taken (Fig. 1). The CIMT for the far wall was evaluated as the distance between the lumen-intima interface and the

media-adventitia interface according to the methods of Salonen *et al*[21]. For the purpose of this study, CIMT was considered increased if its thickness was greater than 0.91mm[22].

Statistical analysis

Data was expressed as mean± standard deviations and frequencies as a percentage. Continuous variables were compared with the Students t-test as considered appropriate. Proportions or categorical variables were compared with the Chi-square test. Relations among continuous variables were assessed using Spearman's or Pearson correlation coefficient and linear regression analysis, as appropriate. Multiple logistic models were constructed to elucidate the independent associations between CIMT and renal function (determined by eGFR), with adjustments made for age, waist circumference (WC), systolic blood pressure (SBP), and low-density lipoprotein cholesterol (LDL-C) concentration. Comparisons between groups were calculated using One-way ANOVA. The odds ratio and 95% confidence intervals were calculated. To obtain summative statistical measures of the predictability of renal impairment by CIMT, renal function (determined by eGFR) was subjected to area under the curve (AUC) analysis of Receiver Operating Characteristics (ROC) curves. All analyses were performed by SPSS statistical software (version 19.0, SPSS Inc., Chicago, IL, USA). *P* values of <0.05 were considered statistically significant.

RESULTS

Clinical characteristics of the subjects

Two hundred and sixteen subjects participated in the study, comprising 72 hypertensive patients already taking antihypertensive medication (treated), 72 newly-diagnosed (drug-naïve) patients, and 72 apparently healthy, non-hypertensive subjects, who served as controls. The prevalence of CKD in the study population was 8.8% (Fig.2). The proportion of CKD patients with eGFR between 60-89ml/min/1.73m^2 (CKD stage 2), 45-59ml/min/1.73m^2 (CKD stage 3A), and 30-44ml/min/1.73m^2 (CKD 3B) was 39.4%, 7.1%, and 1.8% respectively (Fig.3).

Among the study participants, 8.5%, 22.5%, and 0% of the treated hypertensives, drug-naïve/untreated hypertensives, and control respectively had CKD (X^2=15.022, p=0.001). The age range of the subjects was between 24 and 86 years. As shown in Table 1, there was no difference in the mean ages across the three groups (p=0.073). The groups were equally well-matched for gender (Table 1).

Anthropometric parameter such as BMI (p=0.004) and WC (p<0.001), as well as the cardiovascular parameters of SBP (p<0.001) and DBP (p<0.001) was significantly higher in the hypertensive patients than in the control (Table 1). Biochemical parameters such as serum creatinine (p<0.001) and eGFR (p=0.036) were also significantly higher in the hypertensive participants than in the control group (Table 1). Post-hoc analysis showed that the statistical significance in the decline in eGFR persisted for the comparison between the treated hypertensive subjects and the control participants (p=0.004).

The prevalence of increased CIMT was 13.5% (Fig.2). None of the control subjects had an increased CIMT. There was increased CIMT in 31% of the treated hypertensives and 69% of the drug-naïve hypertensive participants

(X^2=23.729, p<0.0001).

The proportion of participants with CKD and increased CIMT was 33.3%, while those with CKD and normal CIMT (6.5%), (X^2=12.174, p<0.0001).

There was also a statistically significant difference in the mean CIMT across the groups (p<0.001) (Table 1).

Post-hoc analysis showed that the statistical significance across the groups for CIMT; (treated Vs untreated: p=0.004), (treated Vs control: p<0.001), and (untreated Vs control: p<0.001).

Table 2 shows the value of each cardiovascular risk factor categorized by eGFR in the study population. There was statistical significant differences in the age (p<0.001), WC (p=0.007), and BMI (p<0.001) across the groups. Post-hoc analysis showed inter-group differences in age, BMI, and WC. There was no statistically significant differences in SBP (p=0.038) or in DBP (p=0.809).

Table 2 also shows the statistically significant difference in the values of CIMT across the stages of CKD (p<0.001). This inter-group difference persisted on post-hoc analysis with the following trend: (CKD1 Vs CKD 3A; p<0.001), (CKD 1Vs CKD 3B; p<0.001), (CKD 2Vs CKD 3A; p=0,013), and (CKD2 Vs CKD 3B; p=0.002).

Table 3 showed that among the untreated hypertensives, there were significant changes in CIMT across the groups (p=0.011).

There was inter-group significance with post-hoc analysis of the data.

In the treated hypertensive participants, there was no significant difference in the blood pressure, DBP (p=0.123), SBP (p=0.289). There was significant difference in the serum creatinine levels of the participants (p<0.001).

Table 3 showed that among the treated hypertensives, there was no statistical significant difference in the values of CIMT (p=0.524).

Relationship between various risk factors including eGFR and CIMT

Table 3 shows the association between the various CVD risk factors, CIMT and eGFR**.** In the participants treated with anti-hypertensive medication, age (r=-0.417, p<0.0001), WC (r=0.278, p=0.019), and BMI (r=0.442, p<0.0001) were significantly correlated to eGFR.

In the newly-diagnosed hypertensive participants, age (r=-0.629, p<0.001), DBP (r=0.484, p=0.002), WC (r=0.384, p=0.015), and CIMT (r=-0.391, p=0.013) were significantly correlated to eGFR.

Logistic regression analysis for renal insufficiency as determined by eGFR

Binary logistic regression analysis using eGFR as the dependent variable, adjusted for age, WC, and CIMT as the independent variables, showed that in this model, the odds ratio (95% CI) of the covariates was as follows: age:1.167 (1.079-1.262), p<0.001; waist circumference: 1.035 (0.981-1.092), p=0.205; SBP: 0.959 (0.917-1.002), p=0.064; CIMT: 550 (4.15-7228), p=0.01.

Receiver Operating Characteristics Curve of the Predictability of Renal Impairment by CIMT

An ROC curve was constructed from the multivariate logistic regression model considering CIMT, age, WC , and SBP to demonstrate the ability of these variables to predict renal insufficiency, and it showed that increased CIMT was a good predictor of renal impairment with an AUC of 0.807 (95% CI: 0.708-0.907) (p<0.0001), (Fig.6).

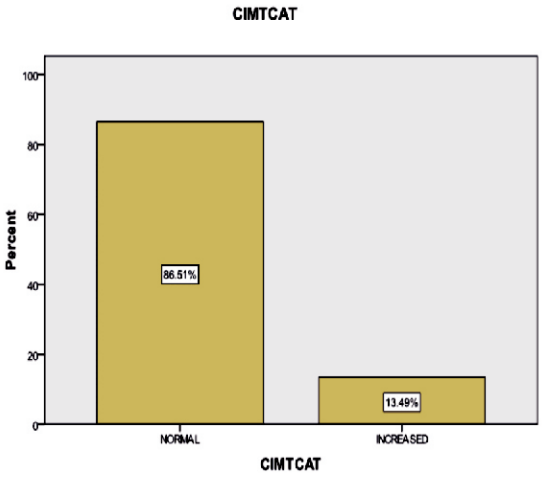

Figure 2: Prevalence of increased Carotid intima-media thickness

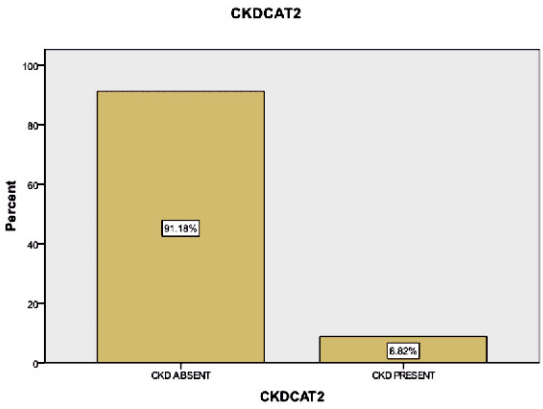

Figure 3: Prevalence of CKD in the study Population

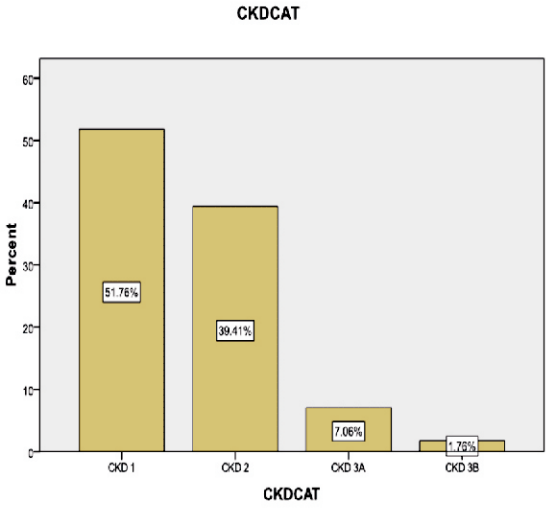

Figure 4: Proportion CKD stages in the Study Population

Table 1: Baseline demographic and clinical characteristics of the study population

Variables	TREATED (n=72) Mean±SD	UNTREATED (drug-naive) (n=72) Mean±SD	CONTROLS (n=72)	ANOVA p-value
AGE (Years)	49.21±11.19	52.65±12.67	48.22±12.45	0.073
FEMALES (%)	48.6	65.3	50.0	0.083
BMI (Kg/m²)	29.79±5.00	29.15±4.75	27.17±4.98	0.004*
WC (cm)	98.18±13.22	96.83±10.52	93.78±15.33	<0.0001*
LDL-C (mmol/l)	3.60±1.02	3.39±1.10	3.30±0.66	0.154
SBP (mmHg)	144.06±19.51	153.97±24.27	137.68±25.23	<0.0001*
DBP (mmHg)	91.74±13.82	94.17±13.40	70.61±9.12	<0.0001*
CIMT (mm)	0.75±0.14	0.83±0.22	0.62±0.08	<0.001
Cr (µmol/l)	98.04±21.20	87.92±18.35	91.10±18.66	<0.001*
Egfr (ml/min/1.73m²)	91.19±26.30	91.30±37.28	102.94±21.71	0.036*

BMI=Body mass index; WC=waist circumference; LDL-C=low-density lipoprotein cholesterol; SBP=systolic blood pressure; DBP=diastolic blood pressure; CIMT=carotid intima-media thickness; Cr=creatinine; eGFR=estimated glomerular filtration rate. *=Significant p value

Table 2: Baseline characteristics of the study participants categorized by estimated glomerular filtration rate

Variables ml/min/1.73m²	CKD 1 eGFR≥90	CKD 2 eGFR=60-89	CKD3A eGFR=45-59	CKD3B eGFR=30-44	ANOVA P value
AGE (years)	47.10±8.85	52.12±11.64	62.75±8.62	70.00±5.00	0.0001*
DBP (mmHg)	83.01±17.13	84.93±16.25	85.00±11.68	90.00±17.32	0.809
WC (cm)	98.86±14.07	97.13±11.36	102.83±11.46	87.67±5.77	0.007*
BMI (Kg/m²)	30.77±5.02	27.34±4.67	29.61±3.34	27.40±3.98	<0.0001*
SBP (mmHg)	130.76±23.16	139.79±23.90	145.0±25.76	148.33±20.20	0.038
LDL-C (mmol/l)	3.65±0.86	3.45±1.11	3.69±0.65	3.83±1.14	0.594
Cr(µmol/L)	82.61±14.17	101.79±18.58	109.33±11.94	108.00±10.39	<0.001*
CIMT (mm)	0.68±0.13	0.71±0.13	0.85±0.18	1.00±0.11	<0.001*
eGFR (ml/min/1.73m²)	117.70±18.56	75.87±9.23	53.75±4.40	39.37±6.64	<0.001*

WC=waist circumference; SBP=systolic blood pressure; DBP=diastolic blood pressure; Cr=creatinine; CIMT= carotid intima-media thickness; eGFR=estimated glomerular filtration rate. *=Significant p value

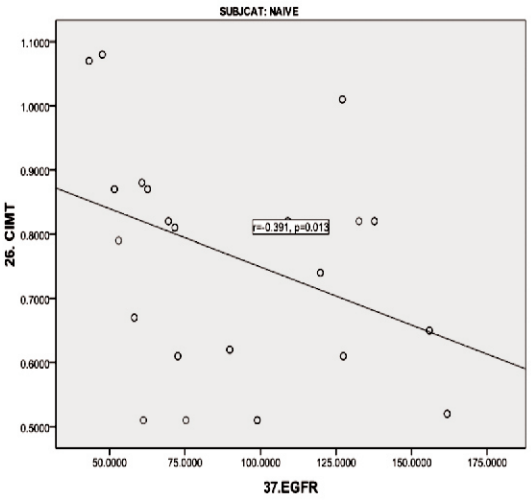

Figure 5: Relationship between GFR and carotid intima-media thickness in drug-naïve participants

Table 3: Characteristics of Various Cardiovascular Risk Factors of Subjects Categorized by Anti-hypertensive Intervention

Variable			Treated		P-Value			Drug-naive		P-value
	CKD1	CKD2	CKD 3A	CKD 3B		CKD1	CKD 2	CKD 3A	CKD 3B	
AGE Years	45.84±9.56	50.03±11.50	62.20±3.71	70.00±0.00	0.003*	45.06±8.03	55.71±13.90	69.14±16.27	75.00±0.00	<0.001*
WC (cm)	102.52±14.16	94.06±11.04	101.20±14.20	81.00±0.00	0.033*	104.7±7.05	90.29±13.11	104.0±10.13	91.00±0.00	0.001*
SBP (mmHg)	140.48±16.45	148.59±19.97	144±30.50	125.0±0.00	0.289	153.3±25.1	148.2±26.7	145.7±24.4	160.0±0.0	0.820
DBP (mmHg)	89.84±13.07	95.10±13.71	86.00±16.7	70.00±0.00	0.123	101.8±13.8	81.43±11.0	84.29±7.87	100.0±0.00	<0.001*
LDL-C (mmol/l)	3.83±1.03	3.47±1.03	3.09±0.57	2.52±0.00	0.276	4.12±0.75	3.50±1.70	4.05±0.36	4.49±0.00	0.419
Cr (µmol/l)	85.29±19.32	108.18±18.31	104.40±10.21	120.0±0.00	<0.001*	75.7±1.68	96.36±19.21	112.86±12.54	102.00±0.00	<0.001*
CIMT (mm)	0.74±0.13	0.75±0.14	0.82±0.21	0.87±0.00	0.524	0.76±0.16	0.73±0.14	0.86±0.17	1.07±0.00	0.011*

WC=waist circumference; LDL-C=low-density lipoprotein cholesterol; SBP=systolic blood pressure; DBP=diastolic blood pressure; CIMT=carotid intima-media thickness; Cr=creatinine; eGFR=estimated glomerular filtration rate. *=Significant p value.

Table 4: Relationship between Various Risk Factors Including CIMT and Estimated Glomerular Filtration Rate

VARIABLES	Pearson's correlation coefficient			
	Treated (72)		Untreated (72)	
	R	p-value	R	p-value
Age (years)	-0.417	<0.0001*	-0.629	<0.0001*
BMI (Kg/m²)	0.442	<0.0001*	0.475	0.002*
WC (cm)	0.278	0.019*	0.384	0.015*
SBP (mmHg)	-0.136	0.259	0.164	0.312
DBP (mmHg)	0.065	0.592	0.484	0.002*
LDL-C (mmol/l)	0.158	0.201	0.174	0.296
Cr (µmol/l)	-0.616	<0.0001*	-0.702	<0.0001*
CIMT (mm)	-0.194	0.104	-0.391	0.013*

WC=waist circumference; LDL-C=low-density lipoprotein cholesterol; SBP=systolic blood pressure; DBP=diastolic blood pressure; CIMT=carotid intima-media thickness; Cr=creatinine. *=Significant p value.

Table 5: Associations between renal function and CIMT in logistic regression model

VARIABLES	OR	P-VALUE	95% CI
CIMT	550	0.011*	4.152-7228
SBP	0.959	0.064	0.917-1.002
WC	1.035	0.205	0.981-1.092
AGE	1.167	<0.0001*	1.079-1.262

WC=waist circumference; SBP=systolic blood pressure; CIMT=carotid intima-media thickness. *=Significant p value

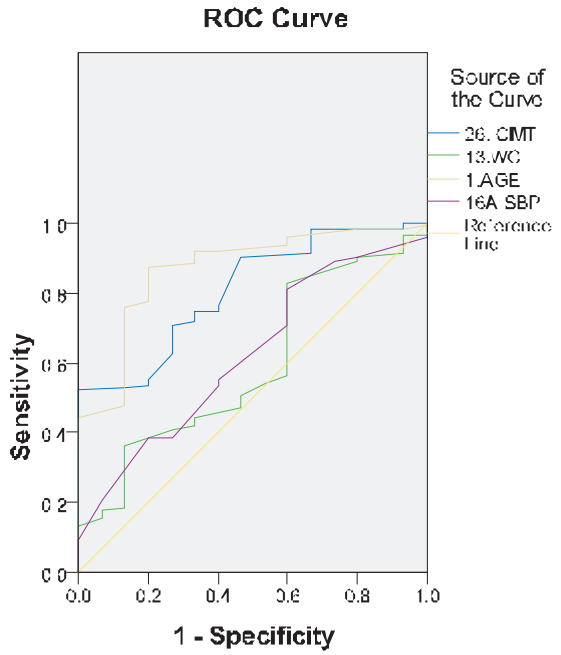

Fig 6: ROC Curve showing the predictability of renal impairment by CIMT

Table 6: Area Under the Curve for the ROC Curve showing the predictability of Renal Impairment by Cardiovascular Risk Factors

Variables	AUC	Std. Error	P-value	95% Confidence Interval	
				Lower Bound	Upper Bound
CIMT	0.807	0.051	0.000	0.708	0.907
WC	0.590	0.074	0.250	0.445	0.735
AGE	0.868	0.047	0.000	0.776	0.959
SBP	0.622	0.072	0.121	0.481	0.762

AUC=area under the curve

DISCUSSION

Heart disease accounts for approximately half of the deaths of patients with end-stage renal disease (ESRD)[23, 24]. In recent times, both coronary artery disease (CAD) and left ventricular hypertrophy (LVH) have been recognised as target organ damage consequent on ESRD. It is also clear that many patients with chronic kidney disease (CKD) and a GFR of <60 ml/min are at risk for heart disease; many of these patients succumb to heart disease before reaching dialysis[2,3]

To examine the ability of increased CIMT to predict renal insufficiency, we studied the relationship between CIMT and eGFR. This study showed that renal insufficiency (as determined by eGFR) was independently related to CIMT. Increased CIMT occurred in parallel with the decline in renal function, especially in the untreated hypertensive participants (see Fig. 5). This compares with findings by Kawamoto et al in Japan, who reported a similar decline in renal function with increasing CIMT[25]. The prevalence of CKD was higher in the participants with increased CIMT compared to those with normal CIMT. This suggests that renal impairment was found predominantly in patients with carotid atherosclerosis.

The prevalence of carotid atherosclerosis was significantly higher in the newly-diagnosed, untreated hypertensive participants compared to the treated hypertensive participants. The mean CIMT were equally significantly different (Table 1), and this inter-group difference persisted, even between the treated and untreated hypertensives (p=0.004).

The risk of renal impairment was significantly increased with increasing carotid atherosclerosis, with the subjects in the most advanced CKD stage (eGFR 30-40ml/min/1.73m^2) having the highest CIMT value (See Table 2). The inter-group differences between mean CIMT existed between the early and latter stages of CKD possibly emphasizing that miniscule differences in CIMT may portend severe changes in eGFR. The observed differences in the mean CIMT values across the CKD stages is of clinical importance because it has been established that atherosclerotic cardiovascular disease (ASCVD) (myocardial infarction, strokes, peripheral artery disease) occurs as a continuum across the CKD stages[26]. Zhang *et al* in China[27] reported a similar finding, with CIMT been significantly higher in subjects with early-stage CKD (eGFR 30-89 ml/min/1.73m^2).

Cardiovascular disease risk factors like age, and WC, were found to be significantly correlated to eGFR in the treated hypertensive population, while age, WC, and increased CIMT was found to correlate with eGFR in the untreated hypertensive population group (Table 3). This compares favourably with the findings by Lawal et al [28] in Nigeria, who found patients with CKD had significantly higher CIMT than age-matched controls.

The relationship between CIMT and eGFR was sustained in the untreated hypertensive participants, highlighting the beneficial effect of anti-hypertensive therapy in the prevention of CKD and its attendant CVD morbidity and mortality, even in the absence of overt renal insufficiency.

Table 4 revealed an interesting trend with respect to CIMT values, with no significant difference in the mean CIMT for the CKD patients receiving anti-hypertensive medication (p=0.524). The drug-naïve hypertensive participants with CKD however had higher mean CIMT values with statistical significance (p=0.011). This may suggest that in spite of the presence in CKD in both groups of hypertensives, the use of anti-hypertensive may retard the progression of atherosclerosis in CKD patients; thereby reducing the rate of occurrence of adverse cardiovascular events associated with atherosclerosis in the long-term[29].

Age is an important risk factor for atherosclerotic CVD. In our study, age had a strong correlation with eGFR in both the treated (r=-0.417, p<0.0001) and untreated hypertensive (r=-0.629, p<0.0001) participants, and was one of the most consistent markers of reduced renal function. The binary logistic regression model constructed and adjusted for CIMT, age, and other cardiovascular risk factors, to elucidate the relationships between eGFR and these variables further revealed that only age [1.167 (1.07-1.26)] and CIMT [550(4.14-7228)]were significantly predictive of renal function. Kuswardhani et al in Indonesia also observed an independent increase in CIMT in patients with CKD[30]. Increasing CIMT seems to reflect a natural aging process of the arterial wall, which becomes accentuated by the pro-inflammatory profile of CKD because levels of C-reactive protein (CRP), usually found to be higher in CKD patients compared to healthy controls[31].

The predictive accuracy of the CIMT in determining renal function in spite of the

possible confounding effect of aging was assessed by ROC curve, and showed an AUC of 0.807(95% CI: 0.708-0.907). This reflects the usefulness of CIMT in prognosticating renal function in hypertensive patients, since a major problem with the issue of coronary disease in many CKD patients, is the high burden of coronary disease despite these patients been asymptomatic. In a study by deFilippi *et al.*[32], 44% of a large cohort of asymptomatic CKD patients had significant coronary disease. This was confirmed by Ohtake *et al.*[33], who showed that coronary disease (defined as 50% stenosis in the coronary artery) was present in as many as 53% of a cohort of asymptomatic CKD patients. So any investigative non-invasive tool that could identify this insidious cardiovascular event threat would be quite beneficial.

CONCLUSION

In conclusion, the present study showed that CIMT measured by non-invasive carotid ultrasonography, is strongly associated with renal insufficiency and could be used to predict the presence of covert impaired renal function, especially in the newly-diagnosed hypertensive patient. Further prospective population-based studies are needed to investigate this association.

Limitations

1. This was a cross-sectional study and thus could not prove causation, only correlation.
2. The estimation of renal function was based on a single serum creatinine measurement.
3. Renal function was evaluated by the Cockroft-Gault equation which may underestimate GFR in the very old and overestimates GFR in the overweight patient.

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