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Research Article

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Evaluation of Carotid Intima-Media Thickness in Maintenance Hemodialysis Patients in Dakar (West Africa)

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Abstract

Objective: *To evaluate carotid intima-media thickness (CIMT) and its association with cardiovascular risk factors (CVRFs) in chronic hemodialysis patients.*

Patients and methods: *This cross-sectional study was conducted over a period of six months at the hemodialysis unit of University Hospital Aristide Le Dante in Dakar, Senegal. CIMT was measured using a B mode ultrasonography.*

Results: *Fifty-seven patients, with a mean age of 48.36±14.93 years, 42.1% male, were included. The sex ratio was 0.72%. The mean CIMT was 0.835±0.21 mm. Increased CIMT was associated with older age (p=0.004), history of smoking (p=0.034), peripheral artery disease (p=0.02), and elevated pre- and post-dialysis systolic blood pressure and pulse pressure (p<0.05 for all). No association was found with dyslipidemia, C-reactive protein (CRP), phosphate, or intact parathyroid hormone (it) levels.*

Conclusion: *CIMT is a marker of subclinical atherosclerosis in hemodialysis patient. It may help in cardiovascular risk stratification, particularly in older patients, smokers and those with a history of PAD, or elevated blood pressure.*

Keywords: Carotid Intima-Media Thickness, Atherosclerosis, Hemodialysis, Senegal

1. Introduction

Atherosclerosis is the leading cause of cardiovascular disease (CVD) worldwide [1]. In its early stages, atherosclerosis is often asymptomatic and characterised by a progressive increase in arterial intima-media thickness [2]. In its advanced stages, complications such as coronary artery disease, stroke and peripheral artery disease (PAD) can occur due to the formation of atherosclerotic plaques and occlusive lesions within the arterial wall [3,4]. In patients with end-stage renal disease (ESRD), accelerated atherosclerosis is caused by both traditional cardiovascular risk factors (CVRFs) and non-traditional risk factors (oxydative stress, inflammation, uremic toxin, mineral bone metabolism disorders…) [3-5]. Mineral and bone disorders, (e.g. hyperphosphatemia, secondary hyperparathyroidism) play an important role among these [6]. In particular, hyperphosphatemia, is independently associated with an increased risk of cardiovascular disease and subclinical atherosclerosis in patients with chronic kidney disease (CKD), potentially through mechanisms involving de novo cholesterol synthesis in vascular cells and macrophages [6,7]. Carotid intima-media thickness (CIMT) measurement is a cost-effective, non-invasive tool that can be used to diagnose subclinical atherosclerosis [2]. In sub-Saharan Africa, few studies have been conducted on carotid atherosclerosis in hemodialysis patients. This study aimed to assess CIMT and its correlations with cardiovascular risk factors in patients undergoing maintenance hemodialysis.

2. Patients and Methods

This cross-sectional study was conducted from 1 July to 31 December 2012 in the Nephrology Department at the Aristide Le Dantec University Hospital (CHU-ALD) in Dakar, Senegal.

3. Study Population and Clinical Data

All patients with end-stage renal disease (ESRD), undergoing haemodialysis for at least six months were included in the study. Clinical data were collected using a questionnaire and physical examination. Blood pressure (BP) was measured before and after dialysis, after a 10–15-minute rest period. The average of the BP measurements taken during the month prior to data collection was used for analysis. Hypertension was defined as the use of antihypertensive medication and/or a systolic blood pressure (SBP) of 140 mmHg and/or a diastolic blood pressure (DBP) of 90 mmHg [8]. Pulse pressure (PP) was calculated as the difference between the systolic and diastolic blood pressures. PP ≥60 mmHg was considered high. BMI was calculated by dividing “dry weight” (kg) by height squared (m2).

4. Biological Parameters

Fasting blood tests -hemoglobin, albumin, calcium, phosphate, intact parathyroid hormone (iPTH), total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides, C-reactive protein (CRP)- were performed. The following abnormalities were identified: high CRP (CRP ≥ 6mg/l); hypoalbuminemia (albumin <35g/l); hypocalcemia (calcium <88mg/l); hyperphosphatemia (phosphate ≥49mg/l); high total cholesterol (cholesterol ≥2.4g/l); low HDL cholesterol (HDL cholesterol <0.4g/l); high LDL cholesterol (LDL cholesterol ≥1.6g/l) and hypertriglyceridaemia (triglycerides ≥2g/l). Secondary hyperparathyroidism was defined as an iPTH level greater than 585 pg/ml (> 9 x the upper normal limit) [9].

5. CIMT Measurement

Patients were examined in the supine position with their heads slightly extended and rotated in the opposite direction to the side under examination. This was performed by a single operator using a Hitachi® Doppler ultrasound device equipped with a 7.5 MHz linear transducer. A two-dimensional longitudinal section of the common carotid artery was performed 1 to 2 cm below the carotid bifurcation. CIMT was measured in plaque-free areas on the far wall of the right and left common carotid arteries, defined as as the distance between the leading edge of the first echogenic line (lumen-intima interface) and the second echogenic line (media-adventitia interface) [10]. Three measurements were taken on each side. The average of the six CIMT measurements was calculated and used in this study. Carotid plaque was defined as focal lesion protruding into the arterial lumen, at least 0.5mm or 50% greater than the adjacent wall, or a CIMT greater than 1.5 mm [10].

6. Statistical Analysis

Statistical analyses were performed using R software version 3.5.3. The data were tested for normal distribution using quantile-quantile (QQ) plots and the Shapiro-Wilk test. Continuous variables were expressed as mean ± standard deviation if they were normally distributed or as median (interquartile range) if they were not. Categorical variables were expressed as number (%). Continuous variables were compared using the Mann-Whitney U test or Student’s t test as appropriate. The relationship between continuous variables were examined using the Pearson’s test for normally distributed variables, and the Spearman's test for non-normal distribution. A p-value <0.05 was considered statistically significant.

7. Results

A total of 57 patients were included in the study. The mean age was 48.36 ± 14.93 years (range 18–81 years). Of these, 24 were male (42.1%). The most common medical antecedents were hypertension and smoking, present in 91.2% and 19.3% of patients, respectively. Half of the patients (50.9%) had hypertensive nephropathy. Thirteen patients (22.8%) had a history of peripheral arterial disease (PAD), and 20 patients (35.1%) had carotid atherosclerotic plaques (Table 1).

Parameters	All (N=57)
Age (years)	
≥50	30 (52.6)
<50	27 (47.4)

Gender	
Male	24 (42.1)
Female	33 (57.9)
Dialysis (sessions per week)	
2	9 (15.8)
3	48 (84.2)
History	
Hypertension	52 (91.2)
Diabetes	3 (5.2)
Former smoker	11 (19.3)
Peripheral artery disease	13 (22.8)
Primary disease	
Nephroangiosclerosis	29 (50.9)
Glomerulonephritis	9 (15.8)
Diabetic nephropathy	2 (3.5)
ADPKD	4 (7)
Unknown nephropathy	8 (14)
Other*	5 (8.8)
Medications	
RAAS inhibitors	46 (80.7)
Calcium-channel blockers	33 (57.9)
Beta-blocker	32 (56.1)
Centrally acting antihypertensive drugs	10 (17.6)
Diuretics	27 (47.4)
Aspirin	13 (22.8)
Statins	15 (26.3)
Calcium supplementation	32 (56.1)
Phosphate binders	5 (8.8)
Vitamin D	8 (14)
CIMT: carotid intima-media thickness; CRP: C-reactive protein; DBP: diastolic blood pressure; HDL: high density lipoprotein; iPTH: intact parathyroid hormone; LDL: low density lipoprotein; RAAS: renin-angiotensin-aldosterone system; SBP: systolic blood pressure. *Chronic tubulo-interstitial nephritis (2), reflux nephropathy (1), lupus nephritis (1); eosinophilic granulomatosis with polyangitis (1).	

Table 1: Baseline Characteristics of Study Population (N=57)

The mean CIMT was 0.835 ±0.21 mm (range: 0.12 to 1.39 mm), with no significant difference observed between men (0.86 ± 0.25 mm) and women (0.83±0.23 mm). CIMT was significantly higher in patients who were aged ≥50 years (p=0.005), in former smokers (p=0.034) or those who had a history of PAD (p=0.02). It was also higher in patients with predialysis SBP ≥140 mmHg (p=0.039) and predialysis PP ≥60 mmHg (p=0.029) (Table 2). No statistically significant differences in CIMT were found in patients with a history of hypertension, diabetes, or for the following parameters: post-dialysis SBP, post-dialysis PP, CRP, hyperphosphatemia, dyslipidemia, or the presence of carotid plaques (Table 2).

Parameters	**CIMT (mm) (median (interquartile range))**	***p*-value**
Age (years)		
≥50	0.9 (0.8-0.97)	**0.005**
<50	0.75 (0.7-0.85)	
Gender		
Male	0.82 (0.745-1.02)	0.393
Female	0.84 (0.7-0.91)	
History		

Hypertension Yes No	 0.86 (0.73-0.95) 0.75 (0.69-0.83)	0.071
Diabetes Yes No	 1.1 (0.925-1.23) 0.82 (0.7-0.91)	0.154
Former smoker Yes No	 0.95 (0.83-1.03) 0.8 (0.7-0.9)	**0.034**
PAD Yes No	 0.9 (0.7-1.04) 0.79 (0.7-0.91)	**0.02**
Pre-dialysis BP (mmHg)		
SBP ≥140 <140	 0.9 (0.77-0.92) 0.759 (0.68-0.91)	**0.039**
DBP ≥90 <90	 0.85 ± 0.22 0.83 ± 0.22	0.899*
PP ≥60 <60	 0.91 (0.76-0.96) 0.78 (0.7-0.89)	**0.029**
Post-dialysis BP (mmHg)		
SBP ≥140 <140	 0.9 (0.75-0.95) 0.78 (0.7-0.9)	0.155
DBP ≥90 <90	 0.83 ± 0.15 0.84 ± 0.23	0.684*
PP ≥60 <60	 0.88 (0.75-0.92) 0.78 (0.7-0.92)	0.246
Hemoglobin (g/dl) <10 ≥10	 0.82 (0.7-0.9) 0.87 (0.73-0.98)	0.317
CRP (mg/l) ≥6 <6	 0.9 (0.71-0.94) 0.78 [0.7-0.9]	0.373
Albumin (g/l) <35 ≥35	 0.77 (0.68-0.85) 0.8 (0.7-0.93)	0.582
Calcium (mg/l) <88 ≥88	 0.8 (0.7-0.89) 0.85 (0.7-0.95)	0.308
Phosphorus (mg/l) ≥49 <49	 0.89 (0.66-1.06) 0.82 (0.7-0.9)	0.624
iPTH (pg/ml) >585 ≤585	 0.82 (0.71-0.9) 0.88 (0.72-0.94)	0.492
Total Cholesterol (g/l) ≥2,4 <2,4	 0.9 (0.7-0.95) 0.81 (0.7-0.91)	0.778
HDL cholesterol (g/l) <0,4 ≥0,4	 0.9 (0.74-0.9) 0.75 (0.7-0.94)	0.757

LDL cholesterol (g/l) ≥1,6 <1,6	 0.79 (0.7-0.93) 0.85 (0.7-0.9)	 0.744
Triglycerides (g/l) ≥2 <2	 0.9 (0.82-0.95) 0.76 (0.7-0.8)	 0.434
Atherosclerotic plaques Yes No	 0.9 (0.78-0.98) 0.78 (0.7-0.9)	 0.056
Vascular calcifications Yes No	 0.9 (0.77-0.95) 0.81 (0.7-0.9)	 0.182
BMI: body mass index; BP: blood pressure; CIMT: carotid intima-media thickness; CRP: C-reactive protein; DBP: diastolic blood pressure; HDL: high density lipoprotein; iPTH: intact parathyroid hormone; LDL: low density lipoprotein; PAD: peripheral artery disease; PP: pulse pressure; SBP: systolic blood pressure. **Stutent t test*		

Table 2: Median (Interquartile Range) of CIMT According to the Variable Studied

A positive correlation was found between CIMT and age (r=0.38; p=0.004), pre-dialysis SBP (r=0.32; p=0.015), pre-dialysis and PP (r=0.33; p=0.013), post-dialysis SBP (r=0.26; p=0.047) and post-dialysis PP (r=0.26; p=0.049). In contrast, no significant correlation was observed with serum phosphate levels ((r= -0.03; p=0.83) (Table 3).

Parameters	**r**	**p-value**
Age (years)	0.38	0.004
Hemodialysis vintage	-0.11	0.41
Pre-dialysis BP (mmHg)		
SBP	0.32	0.015
DBP	0.22	0.096*
PP	0.33	0.013
Post-dialysis BP (mmHg)		
SBP	0.26	0.047
DBP	0.19	0.161*
PP	0.26	0.049
BMI (kg/m2)	0.1	0.444
CRP (mg/l)	0.05	0.726
Albumin (g/l)	0.08	0.595
Calcium (mg/l)	0.12	0.366
Phosphorus (mg/l)	-0.03	0.83
Calcium-phosphate product (mg2/dl2)	-0.05	0.74
iPTH (pg/ml)	-0.07	0.67
Total cholesterol (g/l)	0.09	0.539
HDL cholesterol (g/l)	-0.14	0.396
LDL cholesterol (g/l)	0.19	0.247
Triglycerides (g/l)	0.25	0.129
BMI: body mass index; BP: blood pressure; cIMT: carotid intima-media thickness; CRP: C-reactive protein; DBP: diastolic blood pressure; HDL: high density lipoprotein; iPTH: intact parathyroid hormone; LDL: low density lipoprotein; PAD: peripheral artery disease; PP: pulse pressure; SBP: systolic blood pressure. * *Pearson's test*		

Table 3: Correlations of CIMT with Clinical and Paraclinical Parameters

8. Discussion

Carotid atherosclerosis is a surrogate marker of systemic atherosclerotic disease. CIMT is an independent predictor of cardiovascular mortality.The mean CIMT of the patients in this study was 0.835 ± 0.21 mm, which is comparable to the values reported by Vieira et al. [11] in Brazil, but lower than those reported in older

populations [5,12,13]. This variability between studies reflects the influence of factors such as age, gender, ethnicity and geography on CIMT [14]. Traditional cardiovascular risk factors (CVRFs) such as age, male gender, hypertension, diabetes, smoking, and dyslipidemia are key contributors to the development of atherosclerosis [1,3,15]. Age and male gender are major non-modifiable risk factors for atherosclerosis [16]. CIMT increases with ageing, regardless of the presence of CVRFs or pre-existing CVD [16,17]. However, this increase in CIM with age is significantly greater in the presence of CVRFs or pre-existing CVD [17]. Consistent with previous studies, age was positively correlated with CIMT [12,18-21]. Regardless of age, men have a higher average CIMT than women [16]. In CKD, vascular remodelling involves both atherosclerosis and arteriosclerosis and these two processes contribute to the high morbidity and mortality observed in patients with CKD [22].

Atherosclerosis compromises arterial "conduit" function and begins with an increase in IMT; this is followed by the development of atherosclerotic plaques, which can lead to ischemic events (acute coronary syndromes, stroke, PAD) when the plaques become occlusive [22,23]. Increased IMT is an independent predictor of cardiovascular mortality and reflects systemic vascular disease, which is consistent with our finding of its association with peripheral artery disease (PAD) (p=0.02) [2]. Arteriosclerosis is characterized by a stiffening of the arterial tree, altering their viscoelastic properties This results in an elevated pulse pressure (PP) due to increased systolic blood pressure (SBP) and decreased diastolic blood pressure (DBP) [24]. An elevated PP is associated with higher rates of cardiovascular events and mortality [23,24].

Hypertension plays an important role in the pathogenesis of atherosclerosis [21,22]. As reported by some authors, we found a correlation between CIMT and SBP and PP, but not DBP [12,18-20]. A history of smoking was also significantly associated with increased CIMT (p=0.034). Diabetes is associated with carotid atherosclerosis, from the early stage of increased carotid intima-media thickness to the advanced stage [3,21].

Although dyslipidemia is implicated in atherosclerosis, supported by evidence that statins slow CIMT progression, we found no significant correlation between standard quatitative lipids parameters (total cholesterol, HDL cholesterol, LDL cholesterol, triglycerides) and CIMT [25]. Qualitative lipid abnormalities have been described in CKD that could contribute to a higher atherogenic profile, including an accumulation of very-low-density lipoprotein (VLDL), the oxidation, glycation and carbamylation of LDL and HDL, and elevated lipoprotein(a) [4].

In addition to traditional cardiovascular risk factors, patients with CKD are exposed to specific risk factors, including disorders of mineral and bone metabolism [4,6]. Hyperphosphatemia, which is common in patients with CKD is associated with increased cardiovascular morbidity and mortality [6]. This is because it promotes atherosclerosis through endothelial dysfunction, vascular calcification, and altered lipid metabolism in vascular smooth muscle cells [6,7]. Many studies have established a link between hyperphosphatemia and increased CIMT [12,18,20]. But in our study, no significant association was found with hyperphosphatemia as reported by other authors [5,26]. This could be explained by the smaller sample size, younger population or potential ethnic variations. In the United States, for example, African-American haemodialysis patients have more severe hyperparathyroidism, but paradoxically have fewer vascular calcifications and lower cardiovascular and overall mortality than non-Hispanic white patients [27].

Inflammation contributes to the development of atherosclerosis [3,21]. Consistent with the findings of Kuang *et al*. and Sharma *et al*., we found no association between CIMT and C-reactive protein (CRP) [12,18]. However, some risk factors such as male gender, diabetes mellitus, and hypercholesterolemia appear to influence this association [28].

Our study had certain limitations: it cross-sectional design which did not allow us to establish a causal relationship, the small sample size that may underpower associations and the single-point biological measurements. Despite these limitations, our study provides valuable preliminary data. Larger cohort studies are needed to identify CIMT risk factors in in West African hemodialysis patients.

9. Conclusion

CIMT measurement is a non-invasive method of detecting subclinical atherosclerosis. Hemodialysis patients are at high cardiovascular risk due to the high prevalence of traditional CVRFs and risk factors specific to uremia. This study found an association between CIMT and age, smoking, systolic blood pressure (SBP), pulse pressure (PP) and peripheral arterial disease (PAD).

Conflicts of interest: None

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