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ORIGINAL RESEARCH

Are Any Changes in Carotid Intima–Media Thickness Associated with Cardiometabolic Risk Among Adult Bantu Central African Hypertensive Patients from Monkole and Biamba Marie Mutombo Hospitals?

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Background: Several classic/traditional risk factors are associated with intima–media thickness (IMT), a novel risk of cardio metabolic risk (CMR) in the literature but not in Kinshasa, a megacity prone to CMR. Thus, the objective of this study was to evaluate potential correlations between inflammation, kidney function, psychological stress, hemodynamics, and changes in IMT.

Methods: This cross-sectional study was carried out between 2018 and 2021 within Monkole and Biamba Marie Mutombo Hospitals, respectively, and randomly selected from 10 health structures from East and West of Kinshasa, Capital of Democratic Republic Congo (DRC). A random sample of adult hypertensive Bantu Central Africans was examined after bivariate correlations and multiple linear regression.

Results: Out of 280 patients with 140 men and 140 women aged 62 ± 11 years, the mean carotid intima–media thickness (CIMT) was 1.06 ± 0.5 mm and 73% (n = 204) patients had uncontrolled hypertension. After controlling for confounders, 52.9% variations (R2) of CIMT were independently and significantly (P = 0.037) predicted by CRP, 24-hour proteinuria, urinary albumin/creatinine ratio, duration of hypertension, heart rate, hip circumference, and psychological stress with Equation Y = 0.717 + 0.87 × CRP + 0.02 × 24 H – proteinuria + 0.005 × urinary albumin/creatinine ratio + 0.05 × duration of hypertension + 0.001 × heart rate + 0.006 × hip circumference + 0.017 × psychological stress.

Conclusion: There is an urgent need to control inflammation, impaired renal function, cardiac rhythm, peripheral obesity, longer duration of hypertension management, and stress, which are emerging as specific novel determinants of the subclinical atherosclerosis for those Bantu Central African hypertensive patients.

Keywords: carotid intima–media thickness, subclinical atherosclerosis, Central Africans

Introduction

The Evidence-based Medicine defines cardiometabolic risk (CMR) as a clustering of several traditional cardiovascular risk factors (genetics, aging, obesity, physical inactivity, psychologic stress)[1–3] and emerging novel cardiovascular risk factors (environmental, chronic kidney disease, and carotid intima–media thickness/CIMT, inflammatory, hemodynamic, infectious, metabolic and pharmacological/toxic).[4–9]

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Sub-Saharan Africa, including the Democratic Republic of Congo (DRC), is also vulnerable to classic/traditional cardiometabolic risk factors (arterial hypertension, obesity, diabetes mellitus, hyperlipidemia, advancing age, smoking, psychological stress and sedentary lifestyle)[1–3] and in the face of emerging risk factors (thrombogenic conditions, homocysteine, markers of inflammation and infection, heredity (discomfort and susceptibility), chronic kidney disease and structural markers (medical imaging for CIMT/subclinical atherosclerosis without plaque versus overt clinical atherosclerosis with plaque).[2,10–12]

However, the reliable, predictive and reproducible measurement of some traditional and new CMR factors to predict differently increasing the CIMT on ultrasound is not yet better defined in hypertension, which is often severe and uncontrolled in Black Bantu Central Africans from Congolese clinical practice.[13]

Thus, the objective of this study was to evaluate potential correlations between inflammation, kidney function, psychological stress, hemodynamics, and changes in IMT.

This is what justified the initiation of the present study with the objective of establishing the variations of the thickening of the CIMT in hypertensive patients at high cardiometabolic risk in a hospital environment in Kinshasa.

Materials and Methods

This cross-sectional study was carried out between September 2018 and January 2021 within Monkole and Biamba Marie Mutombo Hospitals, respectively, and randomly selected from 10 health structures from East and West of Kinshasa, Capital of DR Congo. A random sample of adult hypertensive Bantu Central Africans was examined after bivariate correlations and multiple linear regression.

A total of 280 consecutive hypertensive patients (50% male, ≥45 years old) participated in the study. This sample size was sufficient to test all study hypotheses at 5% significance level with 80% power (β= 0.80).

A convenience sampling procedure was followed to select subjects. The available lifestyle data included self-reported alcohol and smoking habits. Patients who drank alcohol or smoked cigarettes regularly were considered drinkers and smokers. Data were also available for the duration of hypertension, family and personal history of diabetes, hypertension, and current antihypertensive medications.

Atherogenicity indices included CT/HDL-c, TG/HDL-c, LDL-c/HDL-c ratio, Body Fat Index, Visceral Adiposity Index), Height-Obesity Index.[14,15]

After 5 minutes of relaxation, seated blood pressure (BP) was measured at each subject's left arm using an Omron MI digital electronic blood pressure monitor/pulse monitor (OMRON Corporation, Tokyo); 3 BP measurements were taken and averaged for analysis.

According to the SEH/SEC 2018 guidelines, hypertension was defined as BP ≥ 140/90 mm Hg or current use of antihypertensives regardless of BP level.[16]

All patients had the following measurements after 12 hours of fasting: total cholesterol (TC), high-density lipoprotein (HDL), triglycerides, blood glucose, serum creatinine, uric acid and CRP.

Cholesterol (Cholesterol Test Kit, Wybenga and Pileggi-One Step Method, Span Diagnostics Ltd) and Triglycerides (Triglyceride Test, GPO-PAP Enzymatic Method, Span Diagnostics Ltd) were measured using enzymatic methods. Low-density lipoprotein-cholesterol (LDL) was calculated according to Friedewald.[17] The Combur test was used to assess proteinuria. Turbidimetry with automatic analyzer was used for CRP.

Metabolic syndrome was defined according to the NCEP-ATP III criteria as, in addition to hypertension, two of the following: waist circumference >88 cm in women and >102 cm in men (central obesity), triglycerides ≥1.69 mmol/L, HDL < 1.30 mmol/L in women and <1.04 mmol/L in men, glucose ≥6.11 mmol/L.[18]

We estimated the glomerular filtration rate (GFR) using four variables, kidney disease diet modification equation (MRAMR)[19] and creatinine clearance (Cl Cr) using Cockcroft's formula-Gault (CG).[20]

Reduced renal function was defined as a GFR < 60 mL/min/1.73 m2 or a Cl Cr <60 mL/min according to the guidelines of the Kidney Disease Outcomes Quality Initiative.[21] A B-mode carotid ultrasound was performed for each patient by a qualified physician at the Center Hospitalier Mère et Enfant (CHME) Monkole, Biamba Marie Mutombo Hospital (HBMM) to determine the CIMT.

Carotid intima–media thickness was measured at the level of the distal wall of two common carotid arteries, two centimeters upstream of the bifurcation, over a length of 10 to 20 mm using two high-definition ultrasound scanners (Acuson NX 3 from Siemens and Voluson E8 from General Electric) in Mode B with a high-frequency linear probe of 12 MHz associated with a construction system with multi-incidence scans in order to reduce artefacts and increase the dynamics of contrast.[22,23]

Using automatic wall detection software loaded onto the system, carotid peak and mean IMT values were obtained. An elevation of the CIMT was defined as a CIMT > 0.8 mm and < 1.49 mm according to the generally accepted threshold [35] or >75th percentile (0.8 mm). The patients were finally classified into two groups according to their CIMT: patients with CIMT > 0.8 mm and those with CIMT ≤ 0.8 mm.

Statistical Analysis

The categorical variable (sex) was presented as frequency (n) and proportion (%).

The others were summarized as mean ± standard deviation with extremes.

The bivariate correlation between the qualitative independent variables and the dependent variable CIMT was calculated using the Pearson coefficient (r) in the case of normal distribution of the quantitative variables.

The multivariate analysis of the multiple linear regression type with a stepwise ascending strategy was used to calculate the variations of the CIMT predicted by certain significant variables in the bivariate correlation after excluding certain confounding variables from the equation.

A value of $P < 0.05$ was considered significant for the differences.

All analyses were entered and performed using SPSS (the Statistical Package for the Social Sciences) version 26 software for Windows (IBM Inc., Chicago, Illinois, USA).

Results

A total of 280 patients including 50% of men (n = 140) and 50% of women (n = 140) were examined for essential arterial hypertension, including 73% of cases of uncontrolled hypertension (n = 204).

The mean CIMT was 1.06 ± 0.5 mm with the extreme (0.2 mm minimum and 1.20 mm maximum).

Except for IMG, HDL and height not correlated ($P > 0.05$) with variations in CIMT, the rest of the quantitative variables were significantly ($P < 0.05$) correlated with variations in CIMT (Table 1).

After adjusting for confounding factors (SBP, body weight, fasting glucose, CT/HDL-c, TG/HDL-c, TT/T), exclude from the multiple linear regression model equation, only CRP, 24-hour proteinuria, urinary albumin/creatinine ratio, duration of hypertension, radial pulse, hip circumference and number of children were retained as independent, important and significant variables ($P < 0.05$) predicting 52.9% (R^2, P change = 0.037) changes in CIMT (Table 2), Figures 1 and 2.

Thus, the regression line calculating the equation Y (CIMT predicted by the following Co variables) = 0.717 + 0.87 + 0.02 + 0.008 + 0.015 + 0.01 + 0.006 + 0.017.

Discussion

The present study identified emergent factors and conventional/classical factors of carotid atherosclerosis in hypertensive patients across the city of Kinshasa (DRC).

Emerging factors: inflammation (CRP) and renal dysfunction (24-hour proteinuria and albumin/creatinine ratio) were the most powerful covariates according to their bivariate coefficient/multivariate coefficient to predict the increase in CIMT in Bantu patients who are often vulnerable to severe arterial hypertension.[10,24–26]

The present study corroborated the results of the epidemioclinical and carotid echo-Doppler literature, which recently established one of the serum markers of inflammation and an independent and important cardiovascular risk factor.[3,10,27,28]

This cardiometabolic and syndromic risk includes vascular dysfunctions (dysfunctions) (raised blood pressure and endothelial dysfunction), hyperglycemia-insulin resistance (abnormal glucose tolerance, fasting hyperglycemia and type 2 diabetes mellitus), a pro thrombotic and vascular inflammation, abdominal obesity and atherogenic dyslipidemia.[4,6,29–31]

In addition, emerging cardiometabolic risk factors not yet well understood are thrombogenic conditions, homocysteine, markers of inflammation and infection, heredity (discomfort and susceptibility), chronic kidney disease, and

Table 1 Bivariate Correlations Between the Explanatory Variables and the Variations of the CIMT in the Study Population

Explanatory Variables	Change in CIMT	P
	r-value	
Age (years)	−0.029	0.629
Number of children	0.163	0.006
MV duration (year)	0.432	< 0.0001
SBP (mm Hg)	0.230	< 0.0001
DBP (mmHg)	0.053	0.381
PPP (mmHg)	0.232	< 0.0001
Pulse (beats/min)	0.138	0.021
Weight (Kg)	0.278	< 0.0001
TT (cm)	0.278	< 0.0001
TH (cm)	0.289	< 0.0001
Fasting blood glucose (mg/dl)	0.439	< 0.0001
24h proteinuria (g/24h)	0.444	< 0.0001
Albumin/Creatinine (mg/gr)	0.503	< 0.0001
PCR (mg%)	0.533	< 0.0001
TC (mg/dl)	0.190	< 0.0001
HDL-c (mg/dl)	−0.006	0.919
LDL-c (mg/dl)	0.209	< 0.0001
TG (mg/dl)	0.209	< 0.0001
BMI (%)	0.089	0.137
TG/HDL-c	0.212	< 0.0001
TT/T	0.235	< 0.0001
Cut	0.107	0.073

Table 2 Multiple Linear Regression of Variables Predicting Variations in the CIMT

Variables	B	Standard Error	P	CI
PCR (mg%)	0.87	0.014	< 0.0001	[0.055–0.110]
24h proteinuria (g/24h)	0.002	< 0.0001	< 0.0001	[0.001–0.003]
Albumin/Creatinine (mg/gr)	0.005	0.002	< 0.0001	[0.012–0.503]
Duration of hypertension (year)	0.015	0.004	< 0.0001	[0.008–0.022]
Radial pulse (beat/min)	0.001	< 0.0001	0.008	[0.000–0.002]
TH (cm)	0.006	0.002	0.014	[0.001–0.011]
Number of children	0.017	0.008	0.037	[0.001–0.033]

structural markers (medical imaging: thickening/CIMT/subclinical atherosclerosis without plaque versus manifest clinical atherosclerosis with plaque).[10,32–34]

The global burden of CMR is highlighted by many longitudinal epidemiological studies:[35] 17.5 million people with CMR in 2005 being projected to 23.6 million in 2030.[36,37]

Renal dysfunction, recently recognized and reported in the literature,[38] is characterized by an elevation of 24-hour proteinuria and of the albumin/creatinine ratio was identified as an independent, important and significant predictor of the increase in the CIMT in the present study mainly in Japanese men,[39,40] in the Taiwanese population[41,42] and in elderly non-hypertensives.

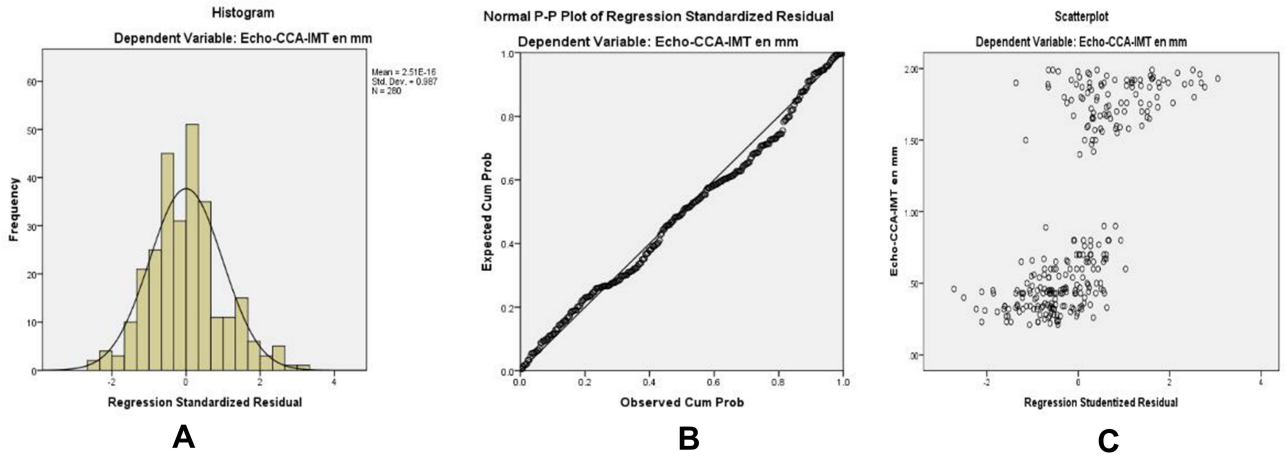

Figure 1 Draws the histogram of the distribution of the CIMT according to the standardized (**A**) and reproducible regression (**B**) corresponds to the expected cumulative probability of variations in the CIMT (**C**).

Indeed, male gender, advancing age, physical inactivity, very low HDL, abdominal obesity, inflammation, Asian ethnicity, smoking, excess alcohol, and albumin ratio/creatinine are, respectively, associated with an increase in the CIMT.[30,43,44]

The increase in values (duration of hypertension, radial pulse, hip circumference and number of children) and classic cardiovascular risk factors for atherosclerosis[45–47] has also demonstrated a very significant multivariate association with proportionally direct increase in the CIMT in the present study.[26,48]

Besides emerging risk factors for atherosclerosis such as elevated CRP/inflammation, proteinuria and elevated albumin/creatinine ratio/kidney dysfunction, the present study also confirmed a significant association between cardiovascular risk factors. Classical cardiometabolic/atherosclerosis risk such as systolic blood pressure, pulse pressure, weight, waist circumference, hip circumference, hyperglycemia, total cholesterol, LDL-cholesterol, triglyceride, circumference of the height (TT)/height (T), TG/HDL-cholesterol and the increase in EIMc.[10,32,49]

In the middle of sub-Saharan Africa, poverty and political instability[38,48,50] worsen uncontrolled hypertension.[38,51]

The constellation of cardiometabolic risk and the coexistence of advancing age as a pro-oxidant factor[52] with classic and/or emerging atherogenic risk factors in uncontrolled urbanization coupled with health transitions (epidemiological, demographic and nutritional) promote subclinical atherosclerosis measured by the elevation of the CIMT in the present study.[53–58]

Implications of Carotid Bioimaging

Current results will have implications for routine practice, education, capacity building and research in the pre-diagnosis of atherosclerotic and metabolic diseases in Kinshasa.

There is an urgent need to convince Congolese political, academic and scientific decision-makers to anticipate personalized early medicine, precision medicine, participatory medicine (involvement of the community and patients), evidence medicine, preventive medicine and political governance.[10,59]

Indeed, the radiologist and the clinician are invited to adopt a holistic and integrative approach to the thickening of the carotid intima media at all levels of the health system (primordial, primary, secondary, tertiary and quaternary).

Strength and Limitations of the Study

The strength of this study lies in the courage to carry out the first work around subclinical atherosclerosis and biomarkers of inflammation, hemodynamics, obesity, dyslipidemia and renal dysfunction in the Democratic Republic of the Congo (DRC).

However, the limits of this work reside in the absence of follow-up of patients at high cardiometabolic risk in hypertensives, essential predictors of overt clinical atherosclerosis.[26,60,61]

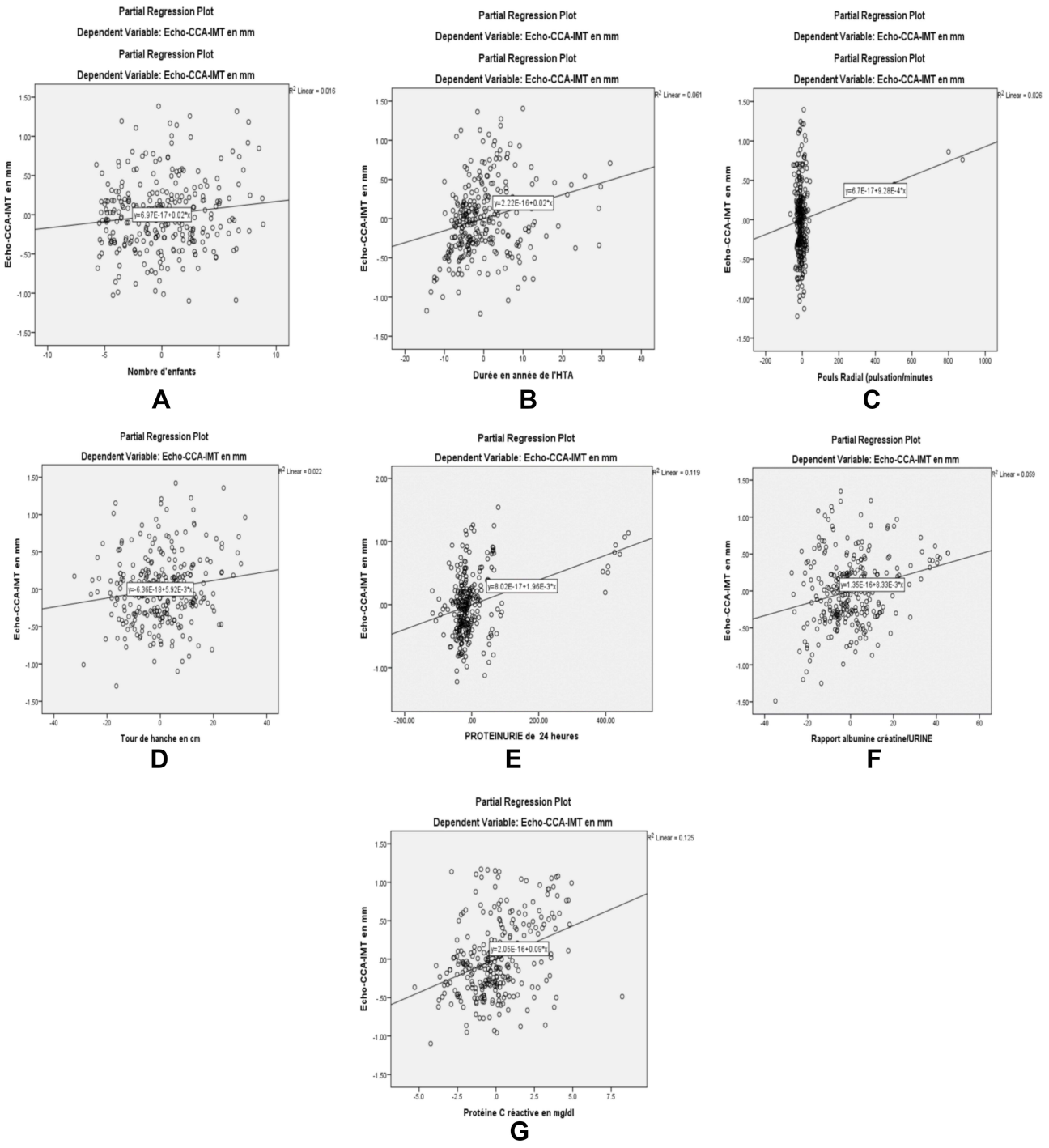

Figure 2 Corresponds to the expected cumulative probability of variations in the CIMT. Figures draw the different regression lines showing the number of children (**A**), the duration in years of hypertension (**B**), the radial pulse (**C**), the Hip circumference (**D**), the 24-hour proteinuria (**E**), the urinary albumin/creatinine ratio (**F**), and the significant multivariate correlations between the CIMT and the CRP (**G**).

Ethical Considerations

To carry out this study, the protocol was submitted to the scientific committee of the Department of Internal Medicine of the University Clinics of Kinshasa and to the ethics committee of the School of Public Health of the University of Kinshasa acting as the national ethics committee (Approval number: ESP/CE/076/2018).

After explanation of the objectives of the study, its progress, its safety and its merits, an informed consent was obtained from the participants in the study while respecting confidentiality in accordance with the Helsinki protocol.

Conclusion

There is an urgent need to control inflammation, Impaired renal function, cardiac rhythm, peripheral obesity, longer duration of hypertension management, and stress, which are emerging as specific novel determinants of the subclinical atherosclerosis for those Bantu Central African hypertensive patients.

Disclosure

The authors report no conflicts of interest in relation to this work.

References

1. Nkoy Belila J. Facteurs de risque cardiovasculaire, maladies cardiovasculaires et gradient social en milieu professionnel (cas de la Société Nationale d'Electricité) [Cardiovascular risk factors, cardiovascular disease and the social gradient in the workplace (case of the Société Nationale d'Electricité)]. University of Kinshasa; 2002. Available from: https://www.memoireonline.com/12/07/846/m_facteurs-risque-cardiovasculaires-gradient-social-milieu-pro0.html. Accessed March 12, 2022. French.
2. Nonterah EA, Crowther NJ, Oduro A, et al. Poor cardiovascular health is associated with subclinical atherosclerosis in apparently healthy sub-Saharan African populations: an H3Africa AWI-Gen study. *BMC Med*. 2021;19(1):30. doi:10.1186/s12916-021-01909-6
3. Forouzanfar MH, Afshin A, Alexander LT, et al. Global, regional, and national comparative risk assessment of 79 behavioural, environmental and occupational, and metabolic risks or clusters of risks, 1990–2015: a systematic analysis for the global burden of disease study 2015. *Lancet*. 2016;388(10053):1659–1724. doi:10.1016/S0140-6736(16)31679-8
4. Desmoulins C. Lancet met les maladies CardioVasculaire à l'honneur [Lancet puts cardiovascular disease in the spotlight]. Medscape; 2009. Available from: http://francais.medscape.com/voirarticle/2992041. Accessed March 12, 2022. French.
5. Corone S. INTERHEART » Le stress, nouveau facteur de risque professionnel [Stress, a new occupational risk factor]. Abstract Congres CŒUR ET TRAVAIL; 2008:1. French.
6. Dallongeville J, Bringer J, Bruckert E, et al. Abdominal obesity is associated with ineffective control of cardiovascular risk factors in primary care in France. *Diabetes Metab*. 2008;34(6 Pt 1):606–611. doi:10.1016/j.diabet.2008.07.001
7. Arnold JM, Fitchett DH, Howlett JG, Lonn EM, Tardif JC. La fréquence cardiaque au repos: un indicateur pronostique modifiable du risque et des issues cardiovasculaires? [Resting heart rate: a modifiable prognostic indicator of cardiovascular risk and outcome?] *Can J Cardiol*. 2008;24 (SupplA):9A–15A. French.
8. Le Bruit KP. Effets Sanitaires et Réglementations[Health Effects and Regulations]. 2022:26. French.
9. Darioli R, Mooser V, Perdrix J, et al. Répercussions de la sédentarité sur le profil des facteurs de risque cardiovasculaire et le risque d'accident coronarien chez les employés d'entreprises du canton de Vaud [Repercussion of sedentarity on cardiovascular risk profile among employees of companies in Western Switzerland]; 2002. Available from: https://www.semanticscholar.org/paper/R%C3%A9percussions-de-la-s%C3%A9dentarit%C3%A9-sur-le-profil-des-Darioli-Mooser/59219271840a3156aa08780971eab9c4c8565646. Accessed March 13, 2022. French.
10. Businge CB, Longo-Mbenza B, Adeniyi OV, et al. Diagnostic performance of several biomarkers for identification of cases of non-communicable diseases among Central Africans. *Afr Health Sci*. 2018;18(4):909–916. doi:10.4314/ahs.v18i4.9
11. Kengne AP, Bentham J, Zhou B; NCD Risk Factor Collaboration (NCD-RisC) – Africa Working Group. Trends in obesity and diabetes across Africa from 1980 to 2014: an analysis of pooled population-based studies. *Int J Epidemiol*. 2017;46(5):1421–1432. doi:10.1093/ije/dyx078
12. Ramsay M, Crowther NJ, Agongo G, et al. Regional and sex-specific variation in BMI distribution in four sub-Saharan African countries: the H3Africa AWI-Gen study. *Glob Health Action*. 2018;11(Suppl 2):1556561. doi:10.1080/16549716.2018.1556561
13. Yanda S, Lepira FB, Makulo JR, et al. Increased carotid intima-media thickness and associated risk factors among Congolese hypertensive patients in Kinshasa. A cross-sectional study Elévation de l'épaisseur intima-media de l'artère carotide et facteurs de risque associés chez les hypert. *Ann africaines de médecine*. 2011;5(1):912–919.
14. Nordestgaard BG, Chapman MJ, Ray K, et al. Lipoprotein(a) as a cardiovascular risk factor: current status. *Eur Heart J*. 2010;31(23):2844–2853. doi:10.1093/eurheartj/ehq386
15. White J, Swerdlow DI, Preiss D, et al. Association of lipid fractions with risks for coronary artery disease and diabetes. *JAMA Cardiol*. 2016;1 (6):692–699. doi:10.1001/jamacardio.2016.1884
16. Williams B, Mancia G, Spiering W, et al. 2018 ESC/ESH Guidelines for the management of arterial hypertension. *Eur Heart J*. 2018;39 (33):3021–3104. doi:10.1093/eurheartj/ehy339
17. Wt F, Ri L, Ds F. Estimation of the concentration of low-density lipoprotein cholesterol in plasma, without use of the preparative ultracentrifuge. *Clin Chem*. 1972;18(6):499–502.
18. Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults. Executive summary of the third report of The National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). *JAMA*. 2001;285(19):2486–2497. doi:10.1001/jama.285.19.2486
19. Levey AS, Coresh J, Greene T, et al. Using standardized serum creatinine values in the modification of diet in renal disease study equation for estimating glomerular filtration rate. *Ann Intern Med*. 2006;145(4):247–254. doi:10.7326/0003-4819-145-4-200608150-00004
20. Cockcroft DW, Gault MH. Prediction of creatinine clearance from serum creatinine. *Nephron*. 1976;16(1):31–41. doi:10.1159/000180580
21. National Kidney Foundation. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. *Am J Kidney Dis*. 2002;39(2 Suppl 1):S1–266.

22. Salez J. Évolution de l'épaisseur intima-média de l'artère carotide commune droite en milieu extrême et chez des patients cardiovasculaires [Evolution of intima-media thickness of the right common carotid artery in extreme settings and in cardiovascular patients]; 2016:42. French.
23. Labriolle A. Caractérisation Échographique de La Pathologie Carotidienne Athéromateuse Étude Des Corrélations Entre La Pathologie Athéromateuse Carotidienne et Coronaire [Ultrasonographic Characterization of Carotid Atheromatous Pathology Study of Correlations Between Carotid and Coronary Atheromatous Pathology]. Université François - Rabelais de Tours; 2019. Available from: http://www.applis.univ-tours.fr/theses/2009/axel.champagnedelabriolle_3043.pdf. Accessed June 14, 2022. French.
24. Vedanthan R, Choi BG, Baber U, Narula J, Fuster V. Bio-imaging and subclinical cardiovascular disease in low- and middle-income countries. *J Cardiovasc Transl Res*. 2014;7(8):701–710. doi:10.1007/s12265-014-9588-y
25. Feinstein MJ, Kim JH, Bibangambah P, et al. Ideal cardiovascular health and carotid atherosclerosis in a mixed cohort of HIV-infected and uninfected Ugandans. *AIDS Res Hum Retroviruses*. 2017;33(1):49–56. doi:10.1089/aid.2016.0104
26. Soya E, N'djessan J, Ekou A, et al. Athérosclérose infra clinique dans une population d'hypertendus suivis à l'Institut de Cardiologie d'Abidjan (Côte d'Ivoire) [Subclinical atherosclerosis in a population of hypertensive patients followed at the Abidjan Heart Institute (Ivory Coast)]. *Cardiol Trop*. 2013. Available from: http://tropical-cardiology.com/Accueil/index.php/fr/2013-08-10-06-44-55/n-153-juil-aout-sep-2018/355-atherosclerose-infra-clinique-dans-une-population-d-hypertendus-suivis-a-l-institut-de-cardiologie-d-abidjan-cote-d-ivoire. French.
27. Decelle L, Francart J, Hammer F, Wallemacq P, Robert A, Boland B. Athérosclérose et marqueurs inflammatoires sériques. Etude chez 297 patients de la consultation de prévention de l'athérosclérose [Atherosclerosis and serum inflammatory markers. Study in 297 patients of the atherosclerosis prevention consultation]. *Louvain Méd*. 2002;121:415. French.
28. Sathi S, Mahapatra H, Sunder S, et al. Nontraditional cardiovascular biomarkers and estimation of cardiovascular risk in predialysis chronic kidney disease patients and their correlations with carotid intima media thickness. *Nephrourol Mon*. 2014;6(6):e22112. doi:10.5812/numonthly.22112
29. Ministry of Health and Family Planning, World Health Organization - WHO. Madagascar - Enquête sur les facteurs de risque des maladies non transmissibles à Madagascar (2005), selon l'approche STEPS de l'OMS [Madagascar -Survey on risk factors for non-communicable diseases in Madagascar (2005), using the WHO STEPS approach]; 2005. Available from: https://demostaf.web.ined.fr/index.php/catalog/185. Accessed March 12, 2022. French.
30. Herrington W, Lacey B, Sherliker P, Armitage J, Lewington S. Epidemiology of atherosclerosis and the potential to reduce the global burden of atherothrombotic disease. *Circ Res*. 2016;118(4):535–546. doi:10.1161/CIRCRESAHA.115.307611
31. Bagyura Z, Takács A, Kiss L, et al. Level of advanced oxidation protein products is associated with subclinical atherosclerosis. *BMC Cardiovasc Disord*. 2022;22(1):5. doi:10.1186/s12872-021-02451-2
32. Takiuchi S, Kamide K, Miwa Y, et al. Diagnostic value of carotid intima-media thickness and plaque score for predicting target organ damage in patients with essential hypertension. *J Hum Hypertens*. 2004;18(1):17–23. doi:10.1038/sj.jhh.1001628
33. Herinirina NF, Rajaonarison LH, Herijoelison AR, Ahmad A. Epaisseur de l'intima-média carotidienne et facteurs de risque cardio-vasculaires [Carotid intima-media thickness and cardiovascular risk factors]. *Pan Afr Med J*. 2015;21(153). doi:10.11604/pamj.2015.21.153.6876 French.
34. Talari HR, Moniri R, Mollaghanbari M, Haddad Kashani H, Jalalian MN. Evaluating the relationship between Helicobacter pylori infection and carotid intima-media thickness a cross sectional study. *Ann Med Surg*. 2021;69:102659. doi:10.1016/j.amsu.2021.102659
35. Paillard F. Pontchaillou. Les nouveaux visages du risque cardiométabolique [The new faces of cardiometabolic risk]. *Am J Drug Alcohol Abuse*. 2011. French. doi:10.3109/00952990.2011.569623
36. Reeves F. Prévenir l'infarctus ou y survivre par Francois Reeves | santé | guide pratique | leslibraires.ca [Preventing or surviving a heart attack by Francois Reeves | health | practical guide | leslibraires.ca]. MultiMondes; 2007. Available from: https://www.leslibraires.ca/livres/prevenir-l-infarctus-ou-y-survivre-francois-reeves-9782895441076.html. Accessed March 12, 2022. French.
37. Dujardin JJ, Cambou JP. Épidémiologie de l'infarctus du myocarde [Epidemiology of myocardial infarction]. *EMC Cardiol*. 2006;1(1):1–9. French. doi:10.1016/S1166-4568(05)40583-5
38. Nimi BM, Nkemfuni TM, Zeba GK, et al. Factors of uncontrolled blood pressure in hypertensive patients with chronic kidney disease in the city of boma. *Eur J Prev Med*. 2020;10:1–6.
39. Kimura T, Ueno T, Doi S, et al. High-normal albuminuria is associated with subclinical atherosclerosis in male population with estimated glomerular filtration rate ≥60 mL/min/1.73 m2: a cross-sectional study. *PLoS One*. 2019;14(8):e0218290. doi:10.1371/journal.pone.0218290
40. Li MF, Tu YF, Li LX, et al. Low-grade albuminuria is associated with early but not late carotid atherosclerotic lesions in community-based patients with type 2 diabetes. *Cardiovasc Diabetol*. 2013;12(1):110. doi:10.1186/1475-2840-12-110
41. Liu CS, Li CI, Guo YC, et al. Independent associations of urinary albumin-to-creatinine ratio and serum cystatin C with carotid intima-media thickness in community-living Taiwanese adults. *BMC Nephrol*. 2020;21(1):454. doi:10.1186/s12882-020-02123-x
42. Nezu T, Hosomi N, Aoki S, Matsumoto M. Carotid intima-media thickness for atherosclerosis. *J Atheroscler Thromb*. 2016;23(1):18–31. doi:10.5551/jat.31989
43. Takase H, Sugiura T, Murai S, Yamashita S, Ohte N, Dohi Y. Carotid intima-media thickness is a novel predictor of new onset of hypertension in normotensive subjects. *Medicine*. 2017;96(31):e7710. doi:10.1097/MD.0000000000007710
44. Piepoli MF, Hoes AW, Agewall S, et al. 2016 European Guidelines on cardiovascular disease prevention in clinical practice: the Sixth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of 10 societies and by invited experts) Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR). *Eur Heart J*. 2016;37(29):2315–2381. doi:10.1093/eurheartj/ehw106
45. Collège des Enseignants de Médecine vasculaire et Chirurgie vasculaire. Item 128: athérogénèse, athérome: épidémiologie et traitement [College of Teachers of Vascular Medicine and Vascular Surgery. Item 128: Atherogenesis, atheroma: epidemiology and treatment]; 2011. French,
46. World Health Organization. Global status report on noncommunicable diseases 2010; 2011. Available from: https://apps.who.int/iris/handle/10665/44579. Accessed March 12, 2022.
47. Yusuf S, Reddy S, Ounpuu S, Anand S. Global burden of cardiovascular diseases: part II: variations in cardiovascular disease by specific ethnic groups and geographic regions and prevention strategies. *Circulation*. 2001;104(23):2855–2864. doi:10.1161/hc4701.099488
48. Katchunga PB, Mirindi P, Baleke A, Ntaburhe T, Twagirumukiza M, M'buyamba-Kabangu JR. The trend in blood pressure and hypertension prevalence in the general population of South Kivu between 2012 and 2016: results from two representative cross-sectional surveys-The Bukavu observational study. *PLoS One*. 2019;14(8):e0219377. doi:10.1371/journal.pone.0219377

49. Zhou B, Carrillo-Larco RM, Danaei G, et al. Worldwide trends in hypertension prevalence and progress in treatment and control from 1990 to 2019: a pooled analysis of 1201 population-representative studies with 104 million participants. *Lancet*. 2021;398(10304):957–980. doi:10.1016/S0140-6736(21)01330-1
50. Essayagh T, Essayagh M, El Rhaffouli A, et al. Prevalence of uncontrolled blood pressure in Meknes, Morocco, and its associated risk factors in 2017. *PLoS One*. 2019;14(8):e0220710. doi:10.1371/journal.pone.0220710
51. M'Buyamba-Kabangu. Recommandations pratiques pour le diagnostic, l'évaluation et le traitement de l'hypertension artérielle. Symposium sur l'Hypertension Artérielle [Practical recommendations for the diagnosis, assessment and treatment of hypertension. Symposium on High Blood Pressure]; 2021. French.
52. Simon A, Gariepy J, Chironi G, Megnien JL, Levenson J. Intima-media thickness: a new tool for diagnosis and treatment of cardiovascular risk. *J Hypertens*. 2002;20(2):159–169. doi:10.1097/00004872-200202000-00001
53. Miranda JJ, Kinra S, Casas JP, Davey Smith G, Ebrahim S. Non-communicable diseases in low- and middle-income countries: context, determinants and health policy. *Trop Med Int Health*. 2008;13(10):1225–1234. doi:10.1111/j.1365-3156.2008.02116.x
54. Young F, Critchley JA, Johnstone LK, Unwin NC. A review of co-morbidity between infectious and chronic disease in Sub Saharan Africa: TB and diabetes mellitus, HIV and metabolic syndrome, and the impact of globalization. *Global Health*. 2009;5(1):9. doi:10.1186/1744-8603-5-9
55. Belue R, Okonor T, Iwelunmor J, et al. An overview of cardiovascular risk factor burden disease comorbidity between infectious disease and chronic disease in sub-Saharan African countries: a socio-cultural perspective. *Global Health*. 2009;5:10. doi:10.1186/1744-8603-5-10
56. Amigoni S, Morelli P, Parazzini F, Chatenoud L. Determinants of elevated blood pressure in women around menopause: results from a cross-sectional study in Italy. *Maturitas*. 2000;34(1):25–32. doi:10.1016/s0378-5122(99)00089-4
57. Böhm F, Pernow J. The importance of endothelin-1 for vascular dysfunction in cardiovascular disease. *Cardiovasc Res*. 2007;76(1):8–18. doi:10.1016/j.cardiores.2007.06.004
58. Boulanger CM, Vanhoutte PM.Vasomotricité d'origine endothéliale. Rôle des protéines G. Sang Thrombose Vaisseaux. [Endothelial Vasomotricity. Role of G proteins. Blood Thrombosis Vessels]. 1997;9(1):22–30. French.
59. Kousios A, Kouis P, Hadjivasilis A, Panayiotou A. Cardiovascular risk assessment using ultrasonographic surrogate markers of atherosclerosis and arterial stiffness in patients with chronic renal impairment: a narrative review of the evidence and a critical view of their utility in clinical practice. *Can J Kidney Health Dis*. 2020;7:2054358120954939. doi:10.1177/2054358120954939
60. Elbaz AJF. Dysfonction endothéliale et athérosclérose. Réalités Cardiologiques [Endothelial dysfunction and atherosclerosis. Réalités Cardiologiques]; 2006. Available from: https://www.realites-cardiologiques.com/2006/03/31/dysfonction-endotheliale-et-atherosclerose/. Accessed March 13, 2022. French.
61. Abdessalem S, Majadlah S, Bouslimi N, Mourali S, Mechemeche R. L'étude de la fonction endothéliale permet de prédire l'existence et la sévérité de la maladie coronaire [The study of endothelial function can predict the existence and severity of coronary disease]. *Tunis Med*. 2009;87:8. French.