

Glucose homeostasis abnormalities among Cameroon patients with newly diagnosed hypertension

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The authors assessed the frequency of glucose homeostasis abnormalities among 839 Cameroonians with newly diagnosed hypertension (mean age: 50.8±11 years; 49.9% female) in a cross-sectional survey conducted at the Douala General Hospital, Douala, Cameroon. In all participants, blood pressure, fasting plasma glucose (FPG), and lipids were recorded. Impaired fasting glycemia was described as an FPG level between 100 and 125 mg/dL and provisional diabetes as an FPG level ≥126 mg/dL. The FPG was 101±30 mg/dL. The overall proportion of abnormal glucose homeostasis was 38.3%, while 7.7% of patients (n=65) had known diabetes. A total of 23.7% (n=199) had impaired fasting glycemia and 6.8% (n=57) had provisional diabetes. Multivariable logistic regression revealed that male sex (odds ratio [OR], 1.53; 95% confidence interval [CI], 1.15–2.06), age older than 55 years (OR, 1.55; 95% CI, 1.15–2.09), and low-density lipoprotein cholesterol >1 g/L (OR, 1.34; 95% CI, 1.00–1.82) were independently associated with abnormal glucose homeostasis (all *P*<.05). Glucose homeostasis abnormalities are highly prevalent among Cameroonian patients with newly diagnosed hypertension.

1 | INTRODUCTION

Hypertension and abnormalities of glucose homeostasis including type 2 diabetes mellitus (T2DM) and impaired glucose tolerance (IGT) are recognized risk factors of cardiovascular diseases.^{1,2} Abnormalities of glucose homeostasis are comorbid with essential hypertension,³ insulin resistant states⁴ and represent an independent risk factor for incident T2DM.⁵ In hypertensive patients, the prognostic outlook deteriorates after diabetes onset.⁶ Impaired fasting glycemia (IFG; dysglycemia), ie, fasting plasma glucose (FPG) values in the upper normal limits but below the diabetes mellitus-defining threshold, is known as a prediabetic category created in 1997 to improve the early identification of persons at high risk for incident diabetes.⁷ Limits for IFG, originally set in the 110 to 125 mg/dL interval,⁸ were lowered to 100 to 125 mg/dL in 2003 by the American Diabetes Association (ADA) in an effort to increase the sensitivity of that parameter for screening of individuals at risk for future diabetes and, possibly, at higher risk for cardiovascular events.⁷

In recognition of its clinical and pathophysiological relevance, an FPG level >100 mg/dL has been included among the major risk factors in the 2007 guidelines jointly released by the European Society of Hypertension and the European Society of Cardiology.⁹ Despite that important endorsement, knowledge remains scarce on the distribution and clinical correlation of different degrees of IFG in hypertensive patients. In fact, the existing evidence about prediabetes in hypertension relies mainly on IGT,^{10,11} a pathophysiologically distinct prediabetic condition diagnosed through glucose loading tests.¹²

The prevalence of T2DM is increasing worldwide, particularly in low- and middle-income countries, such as Cameroon, where appropriate healthcare is often unavailable or inaccessible. Information on risk factors at local and regional levels is of utmost importance for tailored prevention programs to curb the rise in T2DM. Cameroon, a low- to middle-income country in Central Africa, is facing an increased burden of prevalent and incident diabetes (mostly T2DM), with an estimated national prevalence rate of 4.8% among adults.¹³

To date, data related to the distribution of glucose homeostasis abnormalities (known diabetes, IFG, and provisional diabetes [PD]) among Cameroonian hypertensive patients are scarce. This study therefore aimed to determine the frequency and determinants of T2DM, IFG, and PD among newly diagnosed black hypertensive patients living in Cameroon.

2 | PATIENTS AND METHODS

2.1 | Study design and data collection

Between January and December 2012, we performed a hospital-based cross-sectional study in the outpatient section of the cardiology unit of the Douala General Hospital, Douala city, Cameroon. Our study population consisted of 839 patients with newly diagnosed and treatment-naïve hypertension (mean age, 50.9 years; 49.1% males). Patients who consented to participate in the survey were consecutively screened for glucose homeostasis abnormalities (known diabetes, IFG, and PD) by measuring their FPG levels. The ADA diagnostic criteria were used to classify participants by category of glucose profiles: normal glucose tolerance was defined as an FPG value <100 mg/dL, IFG was defined as an FPG value ≥ 100 but <126 mg/dL, and PD was defined as an FPG value ≥ 126 mg/dL.^{7,14}

Screening was conducted by trained medical observers (two trained general practitioners). All participants underwent face-to-face interview and physical examination. Data were collected using a standardized questionnaire providing sociodemographic characteristics, education level, personal and family history of established hypertension, presence of diabetes and cardiovascular diseases, current antihypertensive and glucose-lowering medications, smoking habits, habitual ethanol intake, and leisure-time physical activity. The physical examination included body height, weight, body mass index (BMI), and waist circumference (WC) measurements. Weight was measured in kilograms to the nearest 0.5 kg with an electronic medical scale (seca, Hamburg, Germany). Height in meters was measured to the nearest 0.5 cm with a fixed stadiometer (seca). BMI was calculated as weight in kilograms divided by the square of height in meters (kg/m^2). Overweight was defined as a BMI $\geq 25 \text{ kg}/\text{m}^2$ and obesity as a BMI $>30 \text{ kg}/\text{m}^2$. WC was measured using a scaled band and abdominal obesity was defined as a WC ≥ 102 cm for men and ≥ 88 cm for women.^{15,16}

Blood pressure (BP) measurement was performed after 10 minutes of rest in the supine position in a quiet room. Brachial systolic BP (SBP) and diastolic BP (DBP) were assessed in duplicate with patients in the supine position on the right arm 5 minutes apart on one session using an automated sphygmomanometer (HEM-705 CP, Omron Corporation, Tokyo, Japan). The average of the two BP readings was used. Mean arterial pressure (MAP) was calculated as diastolic BP plus one third of SBP minus DBP. Hypertension was defined as an average SBP ≥ 140 mm Hg and/or DBP ≥ 90 mm Hg.⁹

Blood samples were subsequently collected after an 8-hour overnight fast and sent to the biochemistry laboratory of Douala General Hospital for analysis. Creatinine, potassium, uricemia, plasma glucose,

total cholesterol, triglycerides, and high-density lipoprotein (HDL) cholesterol values were measured using enzymatic colorimetric methods. Low-density lipoprotein (LDL) cholesterol was calculated using the Friedewald formula ($\text{LDL-C} = \text{total cholesterol} - \text{HDL-C} - \text{triglycerides}/5$ [md/dL], if triglycerides <4 g/L). Lipid profile was classified using the National Cholesterol Education Program in Adult Treatment Panel III cutoff values as follows: total cholesterol <2 g/L, LDL cholesterol <1 g/L, HDL cholesterol >0.40 g/L, and triglycerides <1.5 g/L.⁸ Hyperuricemia was defined as a serum uric acid (SUA) level >7.0 mg/dL in men and >5.7 mg/dL in women, based on the laboratory definitions of the Third National Health and Nutrition Examination Survey.¹⁷

All participants were informed on the goals of the study and written signed consent was provided by each participant before inclusion in the survey. Ethical approval of the study protocol was granted by the institutional review board of Douala General Hospital and by Cameroon's national ethics committee

2.2 | Statistical analysis

We used STATA 12.0 for Windows (StataCorp, College station, TX) for data analysis. We reported participant characteristics as number and percentages, and mean and standard deviation, and compared them across major subgroups via chi-square tests. The main outcome of the study was glucose homeostasis abnormalities among patients with hypertension including known diabetes, IFG, and PD. To assess potential associations, we categorized biochemical parameters using clinical cutoffs whenever possible or medians and compared them with our outcome of interest in a 2×2 table using Pearson chi-square test. Continuous variables that could not be categorized were compared with the main outcome using Student *t* test. We further calculated odds ratios (ORs) and their 95% confidence intervals (CIs) using univariable logistic regression models. Furthermore, all marginally significant ($P < .10$) variables were introduced in the multivariable logistic regression model to determine parameters that independently increased the likelihood of having glucose homeostasis abnormalities, and results were reported as adjusted ORs (AORs) and their 95% CI. The threshold for significance was set at 5%.

3 | RESULTS

Table 1 shows the baseline characteristics of the study population. The mean age of patients was 50.9 ± 11 years, with male sex at 49.1% (412). Mean systolic and diastolic BPs were 167 (16) mm Hg, and 100 (11) mm Hg, respectively. Of the 839 participants, 65 (7.7%) had known diabetes with a mean fasting blood glucose level of 101 (30) mg/dL. The mean BMI was 30 (5.8) kg/m^2 , and 47.3% ($n=397$) were obese.

The proportion of patients with IFG was 23.7% ($n=199$), while that of patients with PD was 6.8% ($n=57$). Overall, the proportion of patients with abnormal glucose homeostasis was 38.3% ($n=321$). From 2×2 cross tabulations, sex ($P=.001$), age ($P=.008$), family history of hypertension (0.014), and education ($P=.013$) were associated with the outcome of interest (Table 2) at a type 1 error threshold of 0.05. After

TABLE 1 Baseline characteristics of the study population

Variables	Number (%)	Mean (SD)
No. (%)	839 (100)	
Age, y		50.9 (11.0)
Male sex, No. (%)	412 (49.1)	
Known diabetes, No. (%)	65 (7.7)	
History of hypertension, No. (%)	76 (9.1)	
Education, No. (%)		
None	12 (1.4)	
Primary school	90 (10.7)	
Secondary school	461 (54.9)	
Tertiary education	276 (32.9)	
Marital status, No. (%)		
Single	58 (6.9)	
Married	664 (79.1)	
Widowed	107 (12.7)	
Divorced	10 (1.2)	
Smoking, yes	47 (5.6)	
WC >102 cm in men and >88 cm in women	274 (32.7)	93 (36)
BMI ≥ 30 kg/m ²	397 (47.3)	30.0 (5.8)
Systolic blood pressure, mm Hg		167 (16)
Diastolic blood pressure, mm Hg		100 (11)
Fasting plasma glucose, g/L		1.01 (0.30)
Potassium, mEq/L		3.8 (0.7)
Uricemia >70 g/L in men and >60 g/L in women	267 (31.8)	60.5 (16.5)
Total cholesterol ≥ 2 g/L	339 (40.4)	1.92 (0.49)
HDL cholesterol <0.40 g/L	156 (18.6)	0.62 (0.26)
LDL cholesterol ≥ 1 g/L	512 (61.03)	1.15 (0.46)
Triglycerides ≥ 1.5 g/L	80 (9.5)	0.95 (0.44)
eGFR <60 mL/min/1.73 m ²	104 (12.4)	94.4 (33.3)

Abbreviations: BMI, body mass index; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein; LDL, low-density lipoprotein; SD, standard deviation; WC, waist circumference.

including all significant and relevant factors (at the level of 0.10) in the multivariable logistic regression model (833 eligible participants), age older than 55 years (OR, 1.55; 95% CI, 1.15–2.09), education (OR, 1.36; 95% CI, 0.99–1.85), familial history of hypertension (OR, 1.61; 95% CI, 0.99–2.61), male sex (OR, 1.53; 95% CI, 1.15–2.06), and LDL cholesterol >1 g/L (OR, 1.34; 95% CI, 1.00–1.82) independently increased the likelihood of having glucose homeostasis abnormalities in our study population (Table 2).

4 | DISCUSSION

This study is the first to have documented the high frequency of abnormal glucose homeostasis among black Cameroonians with newly

diagnosed hypertension living in Cameroon, with advanced age, education level, familial history of hypertension, male sex, and LDL cholesterol being among determinants that increase the likelihood of hyperglycemia.

Except for LDL cholesterol, these results are similar to those observed in a study of 982 nondiabetic Caucasians with hypertension, with a mean age of 56 years and an obesity prevalence of 24%.¹⁸ In another survey, age and city living were among determinants of T2DM among South Kivu Congolese.¹⁹ In the present study, 7.7% of participants had known diabetes. Findings from the Framingham study showed that 6.3% of patients with established hypertension had diabetes compared with 4.3% of men with normotension and 2.1% of women with normotension.²⁰ Mean fasting glucose in this study was 101 mg/dL, and mean systolic and diastolic BPs were 167 (16) mm Hg and 100 (11) mm Hg, respectively, which were comparable with those documented in a Caucasian population whose mean values were 69 mg/dL for FPG, 159 mm Hg for SBP, and 96 mm Hg for DBP.

In the present survey, 23.7% of patients had IFG and 6.8% had PD, yielding an overall frequency of abnormal glucose homeostasis of 38.3%. These findings are similar to those observed in developed countries, with regard to the aforementioned study on 982 nondiabetic Caucasian patients with hypertension in whom 33% had IFG.²¹ A US study of 1547 adult nondiabetic participants using the 2003 ADA criteria recorded a 34.6% prevalence of prediabetes and a 19.4% prevalence of IFG.²² In a Canadian study of 936 multiethnic participants, IGT was found in 15.2% of cases.²³ In another study of 1122 individuals in the United Kingdom, "IGT" was reported in 16.7% of the study population,¹⁸ with the proviso that FPG was used to diagnose abnormal glucose tolerance.

The second outcome of this study was to identify factors associated with the likelihood of having glucose homeostasis abnormalities in a sub-Saharan African population. As mentioned above, age older than 55 years, male sex, education level, familial history of hypertension, and LDL cholesterol >1 g/L emerged as independent risk factors that increased the odds of having hyperglycemia. Even though extremely high levels of LDL cholesterol are considered protective with regard to incident T2DM, the finding of LDL cholesterol among variables associated with hyperglycemia may not be directly involved in β -cell dysfunction and may represent a marker of other underlying causes, including unhealthy lifestyles and/or sedentarity. That BMI was not reflected as an independent risk factor is not surprising in a sub-Saharan population, given the complex relationship between anthropometry, abdominal obesity, and insulin resistance in black populations.²⁴

Apart from LDL cholesterol, the present findings are in keeping with those reported from a US survey (2005–2006) on 1547 adults without diabetes, which showed that male sex (OR, 2.30; 95% CI, 1.75–3.01 [$P < .001$]) and age (OR, 1.58; 95% CI, 1.45–1.72 [$P < .001$]) were independently associated with prevalent prediabetes.²²

In Finland, it has been estimated that the excess costs of treating T2DM in patients with complications is 24 times higher than treating T2DM patients with no complications.²⁵ This highlights, in accordance with our findings, the public health importance of early diagnosis of

TABLE 2 Factors associated with glucose homeostasis abnormalities

Variables	Glucose Homeostasis Abnormalities			Unavailable Model	Multivariable Model*	
	Yes	No	χ^2 P Value	OR (95% CI)	AOR (95% CI)	P Value
Male/female	181/140	231/287	.001	1.61 (1.21–2.13)	1.53 (1.15–2.06)	.004
Age >55 y/≤55 y	125/196	156/362	.008	1.48 (1.10–1.99)	1.55 (1.15–2.09)	.004
Family history of hypertension, yes/no	39/284	37/481	.014	1.79 (1.12–2.89)	1.61 (0.99–2.61)	.055
Education, ≥secondary/<secondary	122/199	154/364	.013	1.45 (1.08–1.95)	1.36 (0.99–1.85)	.051
Marital status, married/alone	249/72	415/103	.378	0.86 (0.61–1.21)		
Smoking, yes/no	24/296	23/495	.061	1.75 (0.97–3.15)	1.57 (0.86–2.88)	.145
WC >102 cm in men, >88 cm in women/≤102 in men, ≤92 in women	109/212	165/353	.528	1.10 (0.82–1.48)		
BMI ≥30 kg/m ² / <30 kg/m ²	155/166	242/276	.658	1.06 (0.81–1.41)		
Hyperuricemia/normal uricemia	106/215	161/357	.558	1.09 (0.81–1.47)		
Potassium, per mEq/L	3.82 (0.6)	3.79 (0.7)	.530**	1.07 (0.87–1.30)		
Total cholesterol, >2 g/L/≤2 g/L	138/183	201/317	.230	1.19 (0.89–1.58)		
HDL cholesterol, ≥0.4 g/L/<0.4 g/L	255/66	428/90	.249	0.81 (0.57–1.16)		
LDL cholesterol, >1 g/L/≤1 g/L	208/113	304/214	.078	1.29 (0.97–1.73)	1.34 (1.00–1.82)	.052
Triglycerides, >1.5 g/L/≤1.5 g/L	38/283	42/476	.074	1.52 (0.96–2.42)	1.30 (0.80–2.11)	.283
eGFR, <60 mL/min/1.73 m ² /≥60 mL/min	40/281	64/454	.964	1.01 (0.67–1.54)		

Glucose homeostasis abnormalities include impaired fasting glycemia (fasting plasma glucose: 100–125 mg/dL), provisional diabetes (fasting plasma glucose ≥126 mg/dL), and known diabetes. *Marginally significant ($P < .10$) factors from the univariate analysis were all introduced in the final logistic regression model. **P value calculated by the Student *t* test. Abbreviations: AOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; eGFR, estimated glomerular filtration rate; HDL, high-density lipoprotein; LDL, low-density lipoprotein; OR, odds ratio; WC, waist circumference.

glucose abnormal homeostasis in at-risk black African patients before any complications have developed.

4.1 | Study limitations

There are some limitations to this study. First, even though T2DM and essential hypertension are mutually comorbid, the present frequencies cannot be extrapolated to other cardiometabolic states or patients without hypertension. Second, the hospital-based and self-selected nature of participants may not necessarily represent the magnitude of glucose homeostasis abnormalities among all patients with hypertension in the community. Thus, we cannot rule out the possibility that participants in the study, as well the glucose homeostasis frequency, could differ from the general population. Moreover, obesity parameters such as WC and BMI were assessed in the present study using cutoff sizes and definitions gathered from studies performed essentially in Caucasian patients, which might not absolutely reflect the reality in the African context, especially in patients of black African ancestry born and living in Africa. Therefore, caution should be exercised when extrapolating our estimates to a broader population in the same setting. Nevertheless, our study was based on a larger sample of participants from an area not traditionally extensively covered by major previous population-based surveys in Cameroon. We have further used standardized measurement procedures to collect data in an accurate and reproducible way, and used robust analytic methods to generate estimates that will facilitate comparisons with evidence from elsewhere.

5 | CONCLUSIONS

This study reveals a high prevalence of glucose homeostasis abnormalities among black Cameroonians with newly diagnosed hypertension, which was largely driven by advanced age, male sex, and LDL cholesterol. Our data outline the importance of routine screening of these anomalies in patients with hypertension and those with other cardiovascular diseases. Further large-scale community-based studies are needed to improve and understand the determinants and the scope of glucose homeostasis abnormalities in black African patients with high BP living in sub-Saharan Africa.

DISCLOSURE OF INTEREST

The authors declare that they have no competing interest.

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