International Journal of Research in Medical Sciences
Sayouba JPD et al. Int J Res Med Sci. 2020 Jun;8(6):2017-2022
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20202236

Original Research Article

Electrolyte imbalance in type 2 diabetes: a case study from the West region of Cameroon

Jean Pierre D. Sayouba[1,2]*, Milca Asanghanwa[1,3], Abel J. Njouendou[1], Henri L. Kamga[3], Jules C. N. Assob[1]

[1]Department of Medical Laboratories Sciences, University of Buea, P.O. Box 63 Buea, Cameroon
[2]Complexe Prive de Formation du Personnel de Sante de Mbouo-Bandjoun, P.O. Box 27 Bandjoun, Cameroon
[3]Department of Medical Laboratories Sciences, University of Bamenda, PO Box 39 Bambili-Bamenda, Cameroon

Received: 24 April 2020
Accepted: 28 April 2020

***Correspondence:**
Jean Pierre D. Sayouba,
E-mail: jpsayouba@yahoo.fr

ABSTRACT

Background: Diabetes mellitus remains a global public health challenge despite advances in medicine, with Cameroon harboring about half a million patients. Electrolyte imbalance has been reported to contribute to the complications observed in diabetes. The aim of this study was to investigate electrolyte disturbances in type 2 diabetic (T2D) patients under follow up in two health facilities (Dschang District Hospital and Bafoussam Regional Hospital) of the West Region of Cameroon.
Methods: The study involved 200 T2D patients and 50 non-diabetic control subjects. A questionnaire was used to acquire demographic, anthropometric, clinical and psychosocial data. Fasting blood samples were collected for the determination of fasting plasma glucose (FPG), glycated haemoglobin, calcium, potassium and sodium levels. The diabetic population was divided into two and three groups according to their glycated hemoglobin and FPG levels respectively. The Student's t-test was used to compare mean values between patients and controls, while the chi square test was used to assess for differences between categorical variables. The significance level was set at 5%.
Results: Almost all diabetic patients were diagnosed of hypernatremia (98%) versus 70% for the control group ($p<0.001$). There was no record of hyponatremia. Hypercalcemia was observed in 30% of the diabetic patients and hypocalcemia in 48%. The prevalence of hyperkalemia was comparable between patients and controls, while control subjects tended to be more hypokalemic ($p=0.038$). For all three electrolytes investigated, more than 70% of the imbalances were observed in patients with hyperglycemia when compared to patients having normal FPG or hypoglycemia.
Conclusions: Electrolyte imbalance is common in type 2 diabetic patients from the West Region of Cameroon, especially those presenting with hyperglycemia.

Keywords: Diabetes, Electrolytes, Hypocalcemia, Hyperkalemia, Hypernatremia

INTRODUCTION

Diabetes mellitus is a multi-factorial and complex disease characterized by absolute or relative deficiencies in insulin secretion and/or insulin action leading to chronic hyperglycemia and disturbances of carbohydrate, lipid and protein metabolism.[1,2] It is recognized as an important cause of premature death and disability. The number of cases and the prevalence of diabetes have been steadily increasing over the past decades.[3] The estimated number of adults with diabetes in the world is predicted to increase by 55%, from 381.8 million in 2013 to 591.9 million in 2035, with the largest increase expected in sub-Saharan Africa.[4,5] It is an important public health problem, one of four priority non communicable diseases targeted for action by world leaders.[2] In Cameroon, the

prevalence of diabetes is 4.7% (4.5% for males and 4.9% for females) with the main risk factors being, overweight (29.5%), obesity (9.6%) and physical inactivity (29.3%).[6] The complications of diabetes mellitus are numerous, resulting in reduced quality of life and premature mortality. Early detection and treatment is mandatory for reducing this burden.[7] Diabetes mellitus is included among the diseases with increased frequency of electrolyte abnormalities. This may be related to hyperglycemia induced osmotic fluid shifts or of total-body deficits resulting from osmotic diuresis.[8] Diabetes patients may suffer from electrolyte disorders due to the complications of the disease and/or the medications received, and changes in the serum concentrations of these electrolytes can give a good indication of disease progression,[9] necessitating the consideration of electrolyte disturbances in diabetes surveillance.[10] Meanwhile, most of the studies that investigated electrolyte imbalances were carried out in western population; very few studies in sub-Saharan Africa,[10,11] but with none to our knowledge from Cameroon. We have therefore in this study investigated electrolyte levels of diabetes patients receiving care at two health facilities of the West Region of Cameroon.

METHODS

This was a case control study conducted from January to July 2019. Study participants included in total 200 clinically classified type 2 diabetes patients.[12] Attending the Dschang District Hospital and the Bafoussam Regional Hospital of the West Region of Cameroon, and 50 age- and sex-matched non-diabetic controls recruited among persons attending any of these two hospitals for reasons such as the acquisition of a hospital-related document, a minor surgery, dental problems, patient caregivers and among health workers. Controls were healthy, did not have a first degree relative (mother, father, sibling or child) with diabetes and had normal HbA1c (<6.5%) and glycemia levels (<1.2g/L for fasting plasma glucose or <1.4g/L postprandial plasma glucose levels).

The study design was reviewed and approved by the Ethical Committee of the Faculty of Health Sciences, University of Douala - Cameroon (N° 1642 CEI-Udo/06/2018/T of 7 June 2018). The anonymity of patients was ensured throughout by assigning codes to all samples. Confidentiality of all participants' information was strictly respected by the use of codes assigned to samples during analysis. Informed consent was obtained from participants before the acquisition of anthropometric or socio-demographic data (using questionnaires) and the collection of biological specimen.

Biochemical analysis

Following an overnight fast, 15ml of blood was collected from each research participant and distributed into three sterile tubes (EDTA tubes, dry tubes and sodium fluoride tubes). These tubes before sample analysis were stored at 4°C; and centrifugation to obtain plasma or serum was performed for 10 minutes at 1500g. Plasma from the fluoride tubes was used for the glucose test, while serum from the dry tubes was used for the assessment of sodium, potassium and calcium levels. The whole blood from the EDTA tubes (manufactured by Endo Indonesia) was used to assess for glycated heamoglobin within 3 days of sample collection. The blood glucose level was measured using a colorimetric kit (GOD-PAP, LS, SIGMA Diagnostics) based on the principle of glucose oxidase associated with peroxidase reaction. Calcemia was determined using O-Cresolphthalein test, a colorimetric method (Prestige diagnostic complex). The colorimetric kits (Atlas Medical) were used to determine the levels of potassium and sodium. The hemoglobin kit (HbA1c Test kit, Cat N° HBA11CK40TGD, Global diagnostics B), which is based on a latex turbidimetric immunoassay was used for the quantitative determination of glycohemoglobin in blood. All these tests were performed manually using a spectrophotometer (micro touch 1300, Global Diagnostic B).

According to the guidelines of the WHO, diabetes was defined as fasting plasma glucose level greater than 1.2 g/L, postprandial 1.4g/L.[13] Reference ranges used for serum electrolytes were: Calcemia: 8.8-10.2mg/dL, natremia: 136-145meq/L, kalemia: 3.5-4.5meq/L.[14] Based on these biochemical analysis, the diabetic population was stratified into three groups: Group I (hypoglycemic) with fasting plasma glucose level less than 0.8g/L; group II (normoglycemic) with fasting plasma glucose level between 0.8g/L and 1.2g/l and group III (hyperglycaemic) when the glucose level was greater than 1.2g/L. Participants were also stratified according to their level of glycated haemoglobin in two groups namely; group A (normo glycated haemoglobin) with value of glycated haemoglobin less than 6.5% and group B with values greater than 6.5%.

Statistical analysis

Data were analyzed with Statistical Package for Social Sciences (SPSS) version 23.0. The results were expressed as proportion of subjects with abnormal or normal values in the diabetic population and control group. The Chi-square test was used to assess differences involving categorical variables. For each group, the mean values of the parameters were compared to those of the control group using the Student's t-test. The significance level was set at 5%.

RESULTS

Socio-demographic characteristics of the participants

Overall 250 participants were included in the study; 200 patients and 50 controls. The mean age (interquartile range) for the patient group was 58 (51-68) years and that for the control group was 52 (44-56) years.

Table 1: Socio-demographic characteristics of the study population.

Parameters	Group	Diabetic patients n (%)	Control n (%)	Total n (%)
Age (years)	<40	20 (10)	4 (8.0)	24 (9.6)
	40-65	114 (57)	42 (84)	156 (62)
	>65	66 (33)	4 (8.0)	70 (28.0)
Sex	Female	120 (60)	38 (76)	158 (63)
	Male	80 (40)	12 (24)	92 (37)
Marital status	Single	10 (5.0)	8 (16)	18 (7.0)
	Married	144 (72)	25 (50)	169 (68)
	Widowed	44 (22)	15 (30)	59 (24)
	Divorced	2 (1.0)	2 (4.0)	4 (2.0)
Profession	House keeper	72 (36)	3 (6.0)	75 (30)
	Independant job	63 (32)	15 (30)	78 (31)
	Salaries	16 (8.0)	21 (42)	37 (15)
	Retired	47 (24)	11 (22)	58 (23)
	No Job	2 (1.0)	0 (0)	2 (1.0)
Tribe	Bamileke	182 (91)	47 (94)	229 (92)
	Bulu	5 (3)	3 (6)	8 (3)
	Akum	4 (2)	0 (0)	4 (2)
	Yambassa	2 (1)	0 (0)	2 (1)
	Bamoun	5 (3)	0 (0)	5 (2)
	Bassa	2 (1)	0 (0)	2 (1)

Table 2: Mean glycemic and electrolyte parameters in patients versus controls.

Subjects	Mean ± standard deviation				
	HbA1c (%)	Glycaemia (g/L)	Sodium (meq/L)	Potassium (meq/L)	Calcium (mg/dL)
Patients	6.06±1.63	1.80±0.91	154.31±6.58	5.24±1.55	9.11±2.30
Controls	4.35±0.42	0.99±0.33	151.60±18.86	5.16±1.79	9.21±1.36
p-value	0.001	0.001	0.095	0.770	0.800

Table 3: Comparison of electrolyte status between patients and controls.

Parameter	Patients (n=200)		Controls (n=50)		x^2	p-value
	n	%	n	%		
Hypocalcemia	96	48	18	36	9.03	0.003
Hypercalcemia	60	30	9	18	70.42	<0.001
Hypokalemia	19	9.5	10	20	4.30	0.038
Hyperkalemia	127	64	32	64	0.00	0.948
Hypernatremia	196	98	35	70	44.66	<0.001
Hyponatremia	0	0	6	12	NT	NT

Threshold for significance: $p<0.05/5$ or $p<0.01$ (Bonferoni correction). NT = not tested

The mean duration of diabetes (interquartile range) for the patient study cohort was 5.6 (2-8) years. More than 90 percent of the study population belonged to the Bamileke tribe.

There were slightly more females (63%) than males, and 169 (68%) subjects were married. The diabetic cohort were more self-employed compared to the control group (Table 1).

Electrolyte levels in patients versus controls

Considering the entire study cohorts, mean electrolyte levels were comparable between patients and controls; although mean sodium levels tended to be higher in the patient group. The glycemic indices were higher in the patient population compared to the control group (p=0.001) (Table 2). However, when stratified according to high or low levels, diabetic patients were more hyper

or hypocalcemic and hypernatremic (p<0.01); but no significant differences were observed between the two groups with respect to potassium levels. About 98% of the diabetic cohort were hypernatremic (Table 3).

Table 4: Mean values±standard deviations of parameters in diabetic patients and versus control subjects stratified according to fasting plasma glucose levels.

Parameter	Group 1 FPG <0.8	Group 2 0.8≤ FPG <1.2	Group 3 FPG ≥1.2	Controls
FPG (g/L)	0.69±0.11	0.99±0.12	2.10±0.84	0.95±0.18
Calcium (mg/dL)	8.78±1.71	9.07±1.56	9.20±2.42	9.20±1.36
Sodium (mEq/L)	154.20±6.69	152.67±14.08	154.19± 8.01	151.55±18.85
Potassium (mEq/L)	4.87±1.21	5.69±1.86	5.17±1.49	5.16±1.79
HbA1c (%)	5.55±1.10	5.40±1.21	6.22±1.54	4.35±0.42

Table 5: p-values of comparison of parameters between diabetic patients and control subjects.

Participants	FPG	Calcium	Sodium	Potassium	HbA1c
Group 1	<0.001	0.239	0.658	0.675	<0.001
Group 2	0.289	0.636	0.722	0.363	0.001
Group 3	<0.001	0.994	0.169	0.982	<0.001

Threshold for significance: p<0.05/5 or p<0.01 (Bonferoni correction)

Table 6: Mean values±standard deviations of parameters in diabetic patients and control subjects according to glycated haemoglobin levels.

Parameter	Group A HbA1c <6.5%	Group B HbA1c ≥6.5%	Controls
FPG	1.64±0.81	2.11±0.99	0.95±0.18
Calcium	9.32±2.40	8.67±2.03	9.20±1.36
Sodium	155.34±6.92	151.93±5.14	151.59±18.86
Potassium	5.18±1.52	5.36 ± 1.64	5.16±1.79
Hb1Ac	5.19±0.65	7.73±1.24	4.35±0.42

Table 7: p-values of comparison of parameters between diabetic patients and control subjects.

HbA1c	FPG	Calcium	Sodium	Potassium	HbA1c
<6.5%	<0.001	0.754	0.049	0.939	<0.001
≥6.5%	<0.001	0.109	0.888	0.529	<0.001

Threshold for significance: p<0.05/5 or p<0.01 (Bonferoni correction)

Table 8: Electrolyte status according to fasting plasma glucose levels.

Parameters	Blood glucose level for diabetic patients (n=200)			p-value
	Hyperglycemia (n=146)	Hypoglycemia (n=15)	Normoglycemia (n=39)	
Hyperkalemia, n (%)	90 (71)	8 (6.3)	29 (23)	<0.001
Hypokalemia, n (%)	12 (63)	2 (11)	5 (26)	0.002
Normokalemia, n (%)	44 (81)	5 (9.3)	5 (9.3)	<0.001
Hypercalcemia, n (%)	45 (75)	4 (6.7)	11 (18)	<0.001
Hypocalcemia, n (%)	71 (74)	8 (8.3)	17 (18)	<0.001
Normocalcemia, n (%)	30 (68)	3 (6.8)	11 (25)	<0.001
Hypernatremia, n (%)	142 (72)	15 (7.7)	39 (20)	<0.001
Hyponatremia, n (%)	0	0	0	NT
Normonatremia, n (%)	4 (100)	0	0	NT

Threshold for significance: p<0.05/7 or p<0.007 (Bonferoni correction). NT = not teste

Serum electrolyte levels with respect to the glycaemic indices in patients versus

Controls

When the diabetic patient population was stratified according to fasting plasma glucose levels, the glycemic indices in all three groups were significantly higher in patients compared to controls, but for Group 2 patients who did not differ from controls according to mean glycemia levels. The mean levels of the electrolytes did not differ between any of the patient subgroups and the control cohort (Tables 4 and 5). When the patient group was stratified according to HbA1c levels, mean glycemia levels were higher in patients compared to the control group, but the mean levels of the electrolytes did not differ between any of the patient subgroups and the control cohort; however, sodium levels tended to be higher in patients with HbA1c levels less than 6.5% compared to the control group (p=0.049) (Tables 6 and 7). With respect to blood glucose levels, electrolyte disturbances were almost exclusively observed in diabetes patients with hyperglycemia (Table 8). Considering this hyperglycemic subgroup of patients, 71% had hyperkalemia, 75% had hypercalcemia and 72% had hypernatremia. Low levels of these electrolytes (hypokalemia, hypocalcemia) were also more observed in the hyperglycemic patient cohort. No diabetic patient had hyponatremia (Table 8).

DISCUSSION

This findings have demonstrated that electrolyte imbalance observed in type 2 diabetes patients from the West Region of Cameroon is closely related to their blood glucose levels. Electrolyte imbalances are common in patients with diabetes and may be the result of an altered distribution of electrolytes related to hyperglycemia induced osmotic fluid shifts or of total-body deficits brought about by osmotic diuresis.[10,15] Such disturbances also result from renal diseases and medication through diuretics and calcium channel blockers. It can contribute to the complications observed in diabetes such as kidney disease and failure.

In this study, hypernatremia was almost exclusively found in the hyperglycemic patient subgroup. It is well known that DM is a cause of dysnatremias via several underlying mechanisms. The serum concentration of serum sodium is variable in patients with uncontrolled DM, reflecting the balance between the hyperglycemia-induced water movement out of the cells that lowers [Na^+], and the glucosuria-induced osmotic diuresis, which tends to raise [Na^+]. As glucose is an osmotically active substance, hyperglycemia increases serum osmolality, resulting in movement of water out of the cells and subsequently a reduction of serum sodium levels by dilution.[16] However, hypotonic renal losses (loss of water in excess of sodium and potassium) due to osmotic diuresis can lead to hypernatremia if this water loss is not sufficiently replaced.[17] This results support that of Liamis et al, in which one third of the cases with hypernatremia were observed in poorly controlled DM.[15] As hypernatremia is linked to the induction of severe cellular dehydration of the central nervous system cells and endocrine dysfunction (insulin-mediated glucose metabolism and glucagon-dependent glucose, gonadotropin release), diabetic patients of the West Region of Cameroon may be exposed to complications associated with hypernatremia.[16]

A disturbance in potassium levels was observed in this study cohort. According to Anago et al, only patients with elevated blood glucose levels had higher potassium level whereas this increase was observed in all the three patient subgroups in this study; notwithstanding, being distinctly higher in the hyperglycemic subgroup compared to the other two groups.[10] This condition can be caused by potassium wasting which results from the increased delivery of sodium to the distal nephron coupled with increased mineralocorticoid activity.[17] Diabetes-associated hyperkalemia has multiple causes such as reduced glomerular filtration, redistribution of potassium from intracellular to extracellular compartment and alterations in the Na^+/K^+ ATPase that maintained the transmembrane gradients of sodium and potassium.[10] Previous studies by Wang in China revealed significantly higher proportion of hyperkalemia and hypokalemia among the diabetics, contrary to this records of a similar proportion between patients and controls but for a tendency of higher hypokalemia in the patient cohort.[17,18] Typical healthy diabetic diet may often be rich in K^+. However, the development of overt hyperkalemia is most common in patients with other risk factors that further impair the efficiency of potassium excretion, such as renal insufficiency, volume depletion, or the use of medications that interfere with potassium handling.[14,16]

As reported by ANAGO, calcium disorders in diabetic patients included both hypocalcemia and hypercalcemia.[10] Current study confirms this record, with further emphasis of higher proportions of hypercalcemia (75%) and hypocalcemia (74%) in the group with hyperglycemia. Studies have shown that under conditions of renal failure, hyperphosphatemic condition or hypomagnesemia may induce hypocalcemia.[18,9] Other risks factors of hypocalcemia include vitamin D deficiency or the administration of diuretics drug. The prevalence of hypocalcemia (47.5%) among the diabetic patients in this study is similar to data from Anago et al, who reported a prevalence of 41.3% in diabetes patients from Cotonou.[10]

Considering the 146 patients with hyperglycaemia, the duration of diabetes was about 0-5 years for about 100 (68%) of the cases. As indicated by IDF, type 2 diabetes has a long asymptomatic pre-clinical phase which frequently goes undetected.[7] In addition, as the majority of patients in this study were house keepers, the poor finance condition might have prevented early diagnosis

or proper management of their diabetes predisposing them to electrolyte disturbances.

CONCLUSION

Electrolyte disturbance is common in type 2 diabetes patients receiving care in health facilities of the West Region of Cameroon. The proportion of disturbance is observed to be higher in patients with hyperglycemia compared to those with normal or hypoglycemic levels. Hypercalcemia and Hypocalcemia were recorded in more than 30% of the patient cohort. Almost all the diabetes patients suffered from hypernatremia. This study confirms the need to include the determination of electrolytes in diabetes patient care. Based on this findings, authors may suggest that proper management of blood glucose levels would improve on the electrolyte status of type 2 diabetic patients.

ACKNOWLEDGEMENTS

Authors would like to thank Dr. Ngueugoue Francois, head of diabetology service at the Bafoussam Regional Hospital; Mrs. Makamta Jeanne Marie, CEO of CERPRO LABO and Mrs Makoungnie Ngankam Chimaine, CEO BIOTEST for assisting with the logistic.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee of the Faculty of Health Sciences, University of Douala - Cameroon (N° 1642 CEI-Udo/06/2018/T of 7 June 2018).

REFERENCES

1. Ozougwu JC, Obimba KC, Belonwu CD, Unakalamba CB. The pathogenesis and pathophysiology of type 1 and type 2 diabetes mellitus. J Physiol Pathophysiol. 2013 Sep;4(4):46-57.
2. Roglic G, editor. Global report on diabetes. World Health Organization; 2016:1-88.
3. Patschan D, Müller GA. Acute kidney injury in diabetes mellitus. Int J Nephrol. 2016;2016.
4. Jingi AM, Nansseu JR, Noubiap JJ. Primary care physicians' practice regarding diabetes mellitus diagnosis, evaluation and management in the West region of Cameroon. BMC Endocr Disord. 2015 Dec;15(1):18.
5. Hall V, Thomsen RW, Henriksen O, Lohse N. Diabetes in Sub Saharan Africa 1999-2011: epidemiology and public health implications. A systematic review. BMC Pub Health. 2011 Dec;11(1):564.
6. WHO. Diabetes country profiles Cameroon, 2016. Available at: http://www.who.int/diabetes/country-profiles/cmr_en.pdf?ua=1. Accessed 11 May 2017.
7. IDF Clinical Guidelines Task Force. Global Guideline for Type 2 Diabetes: recommendations for standard, comprehensive, and minimal care. Diabetic Medi. 2006 Jun;23(6):579-93.
8. Unachukwu MN, Engwa GA, Nwalo FN, Attama TJ, Abonyi C, Akaniro-Ejim EN, et al. Influence of Type 2 Diabetes on Serum Electrolytes and Renal Function Indices in Patients. J Clini Diagn Res. 2018 Jun 20;12(6):13-6.
9. Hasona NA, Elasbali A. Evaluation of electrolytes imbalance and dyslipidemia in diabetic patients. Medi Scie. 2016 Jun;4(2):7.
10. Anago EA, Medehouenou TC, Akpovi CD, Tchehouenou H. Electrolyte disturbances in diabetic patients in Cotonou, Benin. Int J Res Medi Scie. 2016 Dec;4(12):5430-5.
11. Chinenye S, Uloko AE, Ogbera AO, Ofoegbu EN, Fasanmade OA, Fasanmade AA, et al. Profile of Nigerians with diabetes mellitus–Diabcare Nigeria study group (2008): Results of a multicenter study. Indian journal of endocrinology and metabolism. 2012 Jul;16(4):558-64.
12. Type AP. Diabetes Policy Group. Type 2 diabetes practical targets and treatments. Health Commun Austr. 2002;11.
13. Reinehr T. Type 2 diabetes mellitus in children and adolescents. World J Diabetes. 2013 Dec 15;4(6):270-81.
14. Burtis CA, Ashwood ER, Bruns DE. Tietz textbook of clinical chemistry and molecular diagnostics-e-book. Elsevier Health Scie. 2012 Oct 14.
15. Liamis G, Liberopoulos E, Barkas F, Elisaf M. Diabetes mellitus and electrolyte disorders. World J Clini Cases: WJCC. 2014 Oct 16;2(10):488-96.
16. Palmer BF, Clegg DJ. Electrolyte and Acid-Base Disturbances in Diabetes Mellitus. New Engl J Medi. 2015 Dec 17;373(25):2482.
17. Wang S, Hou X, Liu Y, Lu H, Wei L, Bao Y, et al. Serum electrolyte levels in relation to macrovascular complications in Chinese patients with diabetes mellitus. Cardiovasc Diabetol. 2013 Dec;12(1):146.
18. Ahn C, Kang JH, Jeung EB. Calcium homeostasis in diabetes mellitus. J Veterin Scie. 2017 Sep 1;18(3):261-6.

Cite this article as: Sayouba JPD, Asanghanwa M, Njouendou AJ, Kamga HL, Assob JCN. Electrolyte imbalance in type 2 diabetes: a case study from the West region of Cameroon. Int J Res Med Sci 2020;8:2017-22.