International Journal of Research in Medical Sciences
Anago EAA et al. Int J Res Med Sci. 2016 Dec;4(12):5430-5435
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012

DOI: http://dx.doi.org/10.18203/2320-6012.ijrms20164223

Original Research Article

Electrolyte disturbances in diabetic patients in Cotonou, Benin

Eugenie A. A. Anago*, Thierry C. M. Medehouenou, Casimir D. Akpovi, Henri Tchehouenou

Laboratory of Research in Applied Biology (LARBA), Ecole Polytechnique d'Abomey-Calavi, University of Abomey-Calavi, B.P. 2009 Cotonou, Benin

Received: 19 October 2016
Accepted: 15 November 2016

***Correspondence:**
Dr. Eugenie A. A. Anago,
E-mail: anagocina@yahoo.com

ABSTRACT

Background: As globally observed in low income countries, the incidence of diabetes rise rapidly in Benin. Electrolytes imbalance contribute to complications observed in diabetes. The aim of this study was to estimate electrolytes disturbances in diabetic patients in Cotonou, Benin.
Methods: A total of 260 participants were included in the study: 150 diabetic patients and for the control group110 age and sex matched non diabetic subjects. Glucose, Ca2+, Mg2+, K+, Na+ and Cl- were determined in fasting blood samples. The proportions of subjects with abnormal values in the diabetic population and in the control group were compared using Chi-square test. The diabetic population was divided in three groups in regard of the fasting plasma glucose (FPG) level. For each group, the mean values of the parameters were compared to those of the control group using the Student't-test.The significance level was set to 5%.
Results: Near half of the diabetic patients suffered from hyperkalemia (48%). Hypocalcemia was observed in 41.3% of the diabetic patients and hypercalcemia was found in 23.3%. Hypomagnesemia and hyponatremia affected more than 40% of the diabetic subjects. The mean values of serum potassium were significantly elevated in all three groups of diabetic patients compared to the control group.
Conclusions: This study showed that electrolyte imbalances affect the diabetic patients in Cotonou.

Keywords: Diabetes, Electrolytes, Hyperglycaemia, Hypocalcemia, Hyperkalemia

INTRODUCTION

The number of persons affected by diabetes continues to increase worldwide. Estimates suggest that 438 million individuals will be affected in 2030.[1] Essentially, emerging and developing countries will experience this large increase. Higher rate of mortality and morbidity are observed in low-income countries due to their weak health systems and limited infrastructures. More than 80% of the mortality due to diabetes is registered in those countries.[2] In Benin, the prevalence of diabetes raised from 3.3% in 2002 to 4.6% in 2012.[3,4]

Diabetes syndrome is associated with multiple tissue alterations such as hypertension, retinopathy, cardiomyopathy and neuropathy in various degrees.[5,6] It is known that diabetes is associated with serum electrolytes disturbances. Electrolyte disorders are mainly observed in hospitalized patients but also community subjects are frequently affected.[7,8] The diabetic ketoacidosis and hyperosmolar hyperglycemic state, the two serious acute metabolic complications, are involved in the osmotic diuresis in diabetes. Although these two disorders often occur together, diabetic ketoacidosis is typically related to type1 diabetes and hyperosmolar hyperglycemic state is typically associated with type2 diabetes. Osmotic diuresis leads to loss of water, sodium, potassium, and other electrolytes.[9] Several studies have determined the prevalence of diabetes in sub-Saharian Africa and data about complication of

diabetes were available.[10,11] The electrolytes disturbances should be taken in account in the surveillance of diabetes. Currently in our country, the fasting blood glucose test is the main one done for the diabetes management. The patient lipid profile is sometimes added to this test. In the present study, we measure glycemia, calcemia, magnesemia, kaliemia, natremia and chloremia in known diabetic and non-diabetic patients living in Cotonou, Benin

METHODS

Study participants

This prospective study was conducted from April to July 2015. The participants were 150 diabetic patients attending the Diabetes Center at Akpakpa in Cotonou (Benin) and 110 age- and sex-matched controls recruited among patients attending the Laboratory of *Hôpital de Menontin* in Cotonou for blood analysis. Patients who reported the use of insulin, oral antidiabetic medication or who knew about their disease were considered as diabetics and excluded from the control group.

The study was conducted in accordance with the ethical standards of the University of Abomey-Calavi, and informed consent was obtained from each participant at the beginning of the study.

Biochemical analysis

Two blood sample tubes were collected from each participant after an overnight fast. The tubes were stored at 4°C until the centrifugation was performed (10 minutes, 1500 g). Plasma from fluoride tube was used for glucose test and serum was used for the other parameters. The blood glucose level was measured using a colorimetric method with glucose oxidase associated with peroxidase reaction. The calcemia is determined with arsenazo III, a complexometric dye method. The blood magnesium level was performed using the calmagit complexometric method. The kits purchased for the analysis were from Elitech (Puteaux, France) and the tests were performed manually using a Biolabo spectrophotometer (Maizy, France).

Kalemia, chloremia and natremia were determined with an ion electrode Smartlyte electrolyte analyzer from Diamond Diagnostics (Paris, France). The kits were procured by the same manufacturer.

Definitions

According to the guidelines of the WHO, diabetes was defined as fasting plasma glucose level greater than 1.2 g/L or on diabetic medication.[5] We stratified the diabetic population into three categories. Group I with fasting plasma glucose level greater than 2g/L, group II with fasting plasma glucose level between 1.2 g/L and 2 g/l. In the group III, the glucose level was less than 1.2 g/L.

Normal serum electrolyte reference ranges were as follows: 88-102 mg/L for calcemia, 16-25 mg/L for magnesemia, 136-145 meq/L for natremia, 3.5-4.5 meq/L for kalemia and 98-107 meq/L for chloremia.

Statistical analysis

Data were analyzed with MS Excel (2007). The results were expressed as proportion of subjects with abnormal values in the diabetic population and in the control group. Differences in proportion were evaluated using the Chi-square test. Following the stratification of diabetic patients in regard of the plasma glucose level in three groups, means and standard deviations were calculated. For each group, mean values of electrolytes were compared to those of the control group using the Student's t-test. The significance level was set to 5%.

RESULTS

Age and sex distribution

Among the 150 diabetic patients involved in this study, 110 (73.3%) were aged between 40 to 65 years. In the control group, 17 (15.4%) of 110 subjects were under 40 years while 80 (72.8%) were between 40 to 65 years old (Table 1). Overall, 60% of the participants were female.

Table 1: Age and sex distribution of the study population.

Age range (years)	Diabetic patients	Control group
< 40	22 (14.7%)	17 (15.4%)
40-65	110 (73.3%)	80 (72.8%)
> 65	18 (12%)	13 (11.8%)

Plasma glucose and serum electrolyte levels in participants

The mean value of blood glucose is higher in diabetic subjects when compared with the control group (2.07 versus 0.96g/L).

The proportions of hypocalcemia and hypercalcemia were higher in the diabetic patients in comparison to the control subjects (Figure 2). Hypocalcemia affected up to 16.4% in control subjects and 41.3% in diabetic patients. The proportion of hypercalcemia was 10% in the control group against 23.3% in diabetic patients.

Hypomagnesemia was most frequently encountered in diabetic patients than in the control subjects with respectively 43.3% versus 9.1% (Figure 1).

The Figure 2 depicted that 45.3% of diabetic patients against 11.8% of control subjects had hyponatremia. The proportions were respectively 35.3% and 5.3% for hypochloremia. A high proportion of the diabetic patients

(48%) showed hyperkalemia against 19.1% in the control group (Figure 2).

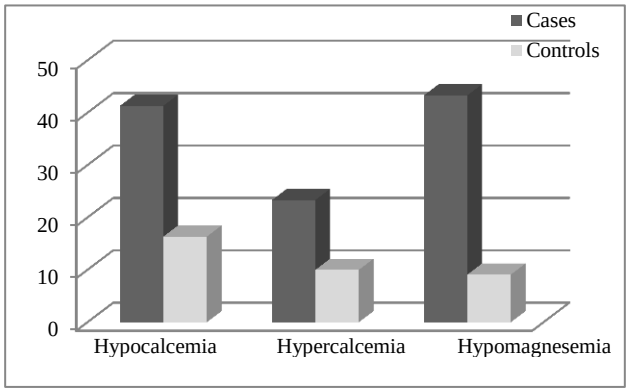

Figure 1: Proportions of hypocalcemia, hypercalcemia and hypomagnesemia in cases and control subjects.

For all analyzed parameters a higher rate of abnormal values were found among the diabetic population. As summarized in Table 2, the proportions of hypocalcemia, hypercalcemia, hyperkalemia, hypomagnesemia, hyponatremia and hypochloremia were significantly predominant in diabetic patients.

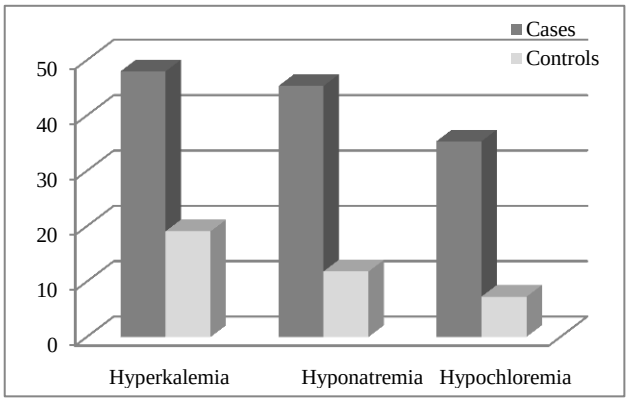

Figure 2: Proportions of hyperkalemia, hyponatremia and hypochloremia in cases and control subjects.

Table 2: Proportions of subjects with electrolyte disturbances in diabetic patients and control group.

Parameter	Diabetic patients (n= 150)		Control group (n= 110)		χ2	p-value
	n	%	n	%		
Hypocalcemia	62	41.3	18	16.4	17.42	<0.0001*
Hypercalcemia	35	23.3	11	10	6.86	0.0009*
Hypomagnesemia	65	43.3	10	9,1	34.61	<0.0001*
Hypermagnesemia	21	14	12	10,9	0.30	0.58
Hypokalemia	13	8.7	7	6,3	0.65	0.21
Hyperkalemia	72	48	21	19,1	21.84	<0.0001*
Hypernatremia	68	45.3	13	11.8	31.69	<0.0001*
Hypernatremia	26	17.3	15	13.6	0.40	0.52
Hypochloremia	53	35.3	8	7.27	26.3	<0.0001*
Hyperchloremia	21	14	12	10,9	0.30	0. 58

Significant p-values are marked with the sign *

Mean values of blood electrolytes levels

For the further analysis of the data, mean and standard deviation were calculated for each parameter (Table 3). The comparison of the defined three groups of diabetic patients with the control subjects revealed a significant lower level of magnesium in group I (17.60 versus 20.96 mg/L) and group II (19.60 versus 20.96 mg/L).

As shown in Table 4, kalemia was significantly increased in all groups of diabetic patients (group I, 4.70 meq/L; group II, 4.56 meq/L; group III, 4.82meq/L) when compared with control subjects (4.29 meq/L). The mean level of chloremia showed no significant difference between diabetic patients and control subjects.

Table 3: Mean values and standard deviations of parameters in diabetic patients and control subjects.

	Group I <1.2g/L	Group II 1.2 -2g/L	Group III >2g/L	Control subjects
FPG	1.09±0.08	1.58±0.23	2.96±0.89	0.96±0.18
Ca2+	90.92±10.57	91.98±11.80	94.01±11.34	92.58±8.30
Mg2+	17.60±6.25	19.60±5.38	20.25±6.35	20.96±3.23
K+	4.70±0.94	4.56±0.71	4.82±0.88	4.29±0.46

Table 4: Comparison of parameters between the three groups of diabetic patients and the control group (p-values).

	Ca2+	Mg2+	K+	Na+	Cl-
Control and group I (FPG <1.2g/L)	0.77	0.00031*	0.0021*	0.302	0.77
Control and group II (FPG 1.2 – 2g/L)	0.69	0.039*	0.0025*	0.018*	0.072
Control and group III (FPG >2g/L)	0.35	0.34	<0.0001*	0.72	0.46

Significant p-values are marked with the sign *

DISCUSSION

Patients with diabetes frequently develop electrolyte disturbances due to hyperglycemia induced osmotic imbalance. Such disturbances also result from renal diseases and medication through diuretics and calcium channel blockers.[8,12] This study showed that the majority of the diabetic patients had electrolyte disturbances when compared with the control subjects.

Calcemia and magnesemia

The rate of hypocalcemia was more than two fold higher and the proportion of hypercalcemia was two fold higher in the diabetic population. As to expecting, the mean values of calcemia in diabetic patients and control subjects were not significantly different (all p values >0.05) while the calculation of the mean encountered values lower and higher than the normal level.

The rate of 41.3% hypocalcemia among the diabetic patients in our study is consistent with the result of Al-Yassin et al who reported 43% of diabetic patients suffering from hypocalcemia in Diwaniya-City in Iraq.[13] Similarly to our finding, a study conducted in Nigeria showed no difference between the mean level of serum calcium in diabetic patients and control subjects.[14] However other authors observed a significant decrease in serum calcium serum level in diabetic subjects.[15,16]

Calcium disorders in diabetic patients include both hypocalcemia and hypercalcemia. Hypocalcaemia due to renal failure in diabetic patients is linked to hypomagnesemia or furosemide medication.[17,18] In the other hand, hypercalcemia observed in diabetic patients could be due to hyperparathyroidism, thiazide therapy or elevated readsorption of renal calcium.[7,19]

In this study, the percentage of hypomagnesemia cases was four fold higher in the diabetic patients than in control subjects (43.3% versus 10%). Palmer reported in a review that the incidence of hypomagnesemia in patients with type 2 diabetes varies from 13.5% to 47.7%.[19] Other authors observed a decrease in serum magnesium level in diabetic patients in China, Pakistan and India.[15,16,20] Several causes such as poor dietary intake, gastrointestinal losses, increased renal losses due to diuretic treatment and recurrent metabolic acidosis may explain the decrease of serum magnesium level in diabetic patients.[8,21]

Our findings suggested that diabetics patients who had a normal glycaemia (<1.2 g/L) and those with mildly elevated values of glucose (1.2-2 g/L) exhibited decreased mean values of magnesium whereas the diabetics with poor control of glycaemia had comparable values like the control group.

Kalemia, natremia and chloremia

When considering K+, Na+ and Cl-, our results suggested that the major disturbance was hyperkalemia which concerned almost half of the cases (48%). Comparison to the control group showed differences in the proportion of subjects affected and also in the mean level of this parameter in all the three groups of diabetic patients. Regarding the results of hyponatremia and hypochloremia, only the proportion of affected patients was higher but no significant differences were found in the mean level of the values.

Diabetes associated hyperkalemia hat multiples 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.[7, 22]

Consistent with our finding, several studies reported elevated values of serum potassium among diabetic populations. Holkar indicated in India a mean value of 5.73 ± 0.07 in ketoacidosis diabetics.[23] Shahid reported in a study conducted in Pakistan a higher level of potassium (7.41 ±1.8) in diabetic patients with stable glycemic control.[22] Our highest mean value of 4.82 ± 0.88 was found in the group with glycaemia > 2g/L. According to Sharma, only patients with elevated blood glucose had higher potassium level whereas the increase was observed in all the three groups of diabetic subjects in our study.[24]

In the development of diabetes occurred gastrointestinal and renal losses of potassium lead to hypokalemia. Hypokalemia can result also on insulin administration caused redistribution of potassium from extracellular to intercellular compartment.[7,25] This fact could explain

reports which indicated both disturbances hypokalemia and hypokalemia and others which noted only hypokalemia. The study of Wang in China revealed significantly higher proportion of hyperkalemia and hypokalemia among the diabetics in contrary to our results which showed no difference between the proportions of hypokalemia in comparison to the control population.[16] Talabani found no differences in the mean level of potassium,[26] whereas geographically closer to our country Ugwuja in Nigeria and Oyewole in Sierra-Leone reported lower mean level of potassium in diabetics than in control subjects.[14,27]

In our study, the rate of hyponatremia among diabetic patients was similarly high as that of hyperkalemia (45.33% versus 48%). Except the group with glycaemia between 1.2 and 2g/L, no differences were observed in the mean values of serum sodium level of cases and control subjects. It is known that serum sodium and potassium levels are inverse correlated.[28] Water movement out of the cell due to hyperglycemia leads to a dilution of serum sodium level.

Hypoglycemic drugs, diuretics and insulin tend to reduce the level of sodium.[7, 8] Several studies revealed lower sodium mean level in diabetic population.[23-27] Hyponatremia occurs frequently in diabetes but hypernatremia can also be observed in the development of the disease. Shahid reported increased sodium mean level among the diabetics group but his findings of potassium level were similar to our results and others investigations.[22]

Based on our results, 35.5% of the diabetic patients had hypochloremia, but no difference was found between the mean values of serum level by comparison with the control group.

The studies of Ugwuja and Sharma revealed that the mean level of chloride was lower in diabetics patients compared with normal subjects whereas Talabani and Oyewole reported elevated values of this parameter in diabetic population.[14, 24,26, 27]

Among the diabetic population, the observed alterations in the electrolytes levels were not correlated with the plasma glucose level. However the highest kalemia value was found in the group of glycaemia >2g/L (group III), the group with glycaemia between 1.2-2g/L (group II) exhibited a lower mean value of potassium than the group of glycaemia <1.2 g/L (group I). The group I had a lower mean value of magnesium than group II (17.60 g/L versus 19.6). The group III with plasma glucose level over 2 g/L showed no significant differences with the control group (20.3 versus 21.0).

Considering the natremia, only group II had a decreased mean value compared to the control group. Both populations group I and group III showed no differences with the control group. The fact that only one measurement of the plasma glucose was performed in our survey could be an explanation for these results. In addition, the glycaemia varies in the development of diabetes. Liamis reported that the association between diabetes and hyponatremia is independent of hyperglycaemia.[29] Pham indicated in a review that not all studies observed a correlation between glycemic control and serum magnesium level. The same author reported that magnesium replacement does not improve diabetic control.[30]

CONCLUSION

This study showed that electrolyte disorders are common among the diabetic patients who attend the diabetic center in Akpakpa, Cotonou. The proportion of hyperkalemia was higher than all other determined parameters (48%). Hyponatremia, hypomagnesemia and hypocalcemia each affected more than 40% of the diabetic patients. In addition the mean values of kalemia differed significantly between all the three groups of diabetic patients and the controls. No difference was observed between the mean values of calcemia and chloremia of diabetic subjects compared to the control subjects. This study showed the importance of serum electrolytes determination in the diabetic patient care. To analyze the association between serum electrolyte levels and the degree of hyperglycemia further investigations with a large sample is required.

ACKNOWLEDGEMENTS

Authors would like to thank Dr. Sumanth MM, Assistant Professor, Department of Community Medicine, M.M.C & R.I., Mysore for assisting with the statistical work.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

REFERENCES

1. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract. 2010;87(1):4-14.
2. Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med. 2006;3(11):e442.
3. Djrolo F, Amoussou-Guenou AD, Zannou DM, Houinato D, Ahouandogbo F, Houngbe F. Prévalence du diabète sucré au Bénin. Louvain Med. 2013;122:258-62.
4. Djrolo F, Houinato D, Gbary A, Akoha R, Djigbenoude O, Segnon J. Prévalence du diabète sucré dans la population adulte à Cotonou, Bénin. Médecine des Maladies Métaboliques. 2012;6(2):167-9.
5. Alberti KG, Zimmet PZ. Definition, diagnosis and classification of diabetes mellitus and its complications. Part 1: diagnosis and classification of

diabetes mellitus provisional report of a WHO consultation. Diabet Med. 1998;15(7):539-53.
6. Deshpande AD, Harris-Hayes M, Schootman M. Epidemiology of diabetes and diabetes-related complications. Phys Ther. 2008;88(11):1254-64.
7. Liamis G, Liberopoulos E, Barkas F, Elisaf M. Diabetes mellitus and electrolyte disorders. World J Clin Cases. 2014;2(10):488-96.
8. Palmer BF, Clegg DJ. Electrolyte and Acid-Base Disturbances in Patients with Diabetes Mellitus. N Engl J Med. 2015;373(6):548-59.
9. Kitabchi AE, Umpierrez GE, Murphy MB, Kreisberg RA. Hyperglycemic crises in adult patients with diabetes: a consensus statement from the American Diabetes Association. Diabetes Care. 2006;29(12):2739-48.
10. Hall V, Thomsen RW, Henriksen O, Lohse N. Diabetes in Sub Saharan Africa 1999-2011: epidemiology and public health implications. A systematic review. BMC Public Health. 2011;11:564.
11. Mbanya JC, Motala AA, Sobngwi E, Assah FK, Enoru ST. Diabetes in sub-Saharan Africa. Lancet. 2010;375(9733):2254-66.
12. Amenabar JJ, Garcia-Lopez F, Robles NR, Saracho R, Calero M, Gentil MA, et al. 1997 spanish nephrology association (Sociedad Espanola de nefrologia) report on dialysis and transplantation. Nephrol Dial Transplant. 1999;14(12):2841-5.
13. Al-Yassin AMH, Nimnima A, Challab ED. Calcium and diabetes mellitus type two: a prospective study done on people with type 2 diabetes in Diwaniya teaching hospital. Kufa Med Journal. 2009;12(1):468- 75.
14. Ugwuja E, Eze N. A Comparative Study of Serum Electrolytes, Total Protein, Calcium and Phosphate Among Diabetic and HIV/AIDS Patients in Abakaliki, Southeastern, Nigeria. Internet J Lab Med 2006;2(1).
15. Qazi N, Ruqaya A, Sajad H. To evaluate the levels of glycated hemoglobin, serum calcium, magnesium, phosphate, uric acid and microalbuminuria in patients with newly diagnosed type 2 diabetes mellitus. Int J Res Med Sci. 2014;2(4):1462-5.
16. 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;12:146.
17. Liamis G, Milionis HJ, Elisaf M. A review of drug-induced hypocalcemia. J Bone Miner Metab. 2009;27(6):635-42.
18. Takiishi T, Gysemans C, Bouillon R, Mathieu C. Vitamin D and diabetes. Endocrinol Metab Clin North Am. 2010;39(2):419-46.
19. Palmer BF. Metabolic complications associated with use of diuretics. Semin Nephrol. 2011;31(6):542-52.
20. Anjum A, Yousaf M, Zuber M, Ahmad HB, Zahoor AF, Khan ZI, et al. Comparative study on calcium, magnesium and cobalt in diabetic and non diabetic patients (males) in Punjab, Pakistan. Afr J Biotechnol. 2012;11(28):7258-62.
21. Siddiqui K, Bawazeer N, Joy SS. Variation in macro and trace elements in progression of type 2 diabetes. ScientificWorldJournal. 2014;2014:461591.
22. Shahid SM, Rafique R, Mahboob T. Electrolytes and sodium transport mechanism in diabetes mellitus. Pak J Pharm Sci. 2005;18(2):6-10.
23. Holkar S, Vaishnav D, Hivre M. Study of serum electrolytes levels in patients with diabetic ketoacidosis. Int J Health Sci Res. 2014;4(9):154-7.
24. Sharma A, Hirulkar NB, Ranka P. Effect of hyperglycemia on electrolytes Imbalance. Int J Pharm Biol Sci Arch. 2011;2(1):526-33.
25. Hollander-Rodriguez JC, Calvert JF, Jr. Hyperkalemia. Am Fam Physician. 2006;73(2):283-90.
26. Talabani N. Serum electrolytes and lipid profiles in non-insulin dependent diabetes mellitus patients. Asian J Med Sci. 2015;6(3):38-41.
27. Oyewole OI, Sessie S, Mansaray M, Kamara B. Changes in serum electrolytes and lipid profile in diabetes subjects in Freetown Sierra Leone. Sudan J Med Sci. 2008;3(4):309-14.
28. Saito T, Ishikawa S, Higashiyama M, Nakamura T, Rokkaku K, Hayashi H, et al. Inverse distribution of serum sodium and potassium in uncontrolled inpatients with diabetes mellitus. Endocr J. 1999;46(1):75-80.
29. Liamis G, Rodenburg EM, Hofman A, Zietse R, Stricker BH, Hoorn EJ. Electrolyte disorders in community subjects: prevalence and risk factors. Am J Med. 2013;126(3):256-63.
30. Pham PC, Pham PM, Pham SV, Miller JM, Pham PT. Hypomagnesemia in patients with type 2 diabetes. Clin J Am Soc Nephrol. 2007;2(2):366-73.

Cite this article as: Anago EAA, Medehouenou TVM, Akpovi CD, Tchehouenou H. Electrolyte disturbances in diabetic patients in Cotonou, Benin. Int J Res Med Sci 2016;4:5430-5.