Research Article

Association between Glycemic Control Parameters in Sudanese Diabetic Patients

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Abstract

Introduction: Glycated Hemoglobin (HbA1c) and Fasting Blood Glucose (FBG) measurements provide useful information about glycemic control status in diabetic patients. Estimated Average blood Glucose (eAG) is often calculated to translate HbA1c result into terms that closely represent a daily reading of Fasting Blood Glucose (FBG). **Objective:** This study was carried out to evaluate the glycemic control status and the association between FBG and eAG in diabetic patients. **Methods:** This retrospective cohort study was conducted on FBG, HbA1c tests results of 687 diabetic patients (324 males and 363 females) who were attending the diabetic care center in Khartoum state. HbA1c level >7% represents the cutoff for poor glycemic control as well, fasting blood glucose levels of (<130 mg/dl, 130-180 mg/dl, and >180 mg/dl) were used to categorize the patients into three subgroups of glycemic status (A, B and C) respectively. (eAG) was calculated by using the regression equation: eAG (mg/dL)=28.7 × HbA1c (NGSP, %)-46.7. **Results:** The rate of poor glycemic control was found to be 76.9%, 80.6% for males, and 73.6% for females. A positive significant correlation was observed between FBG and eAG within the study groups (p<0.001) while for the subgroups the association was found significantly different only in the more poor glycemic control group C (p=0.369, p<0.001). **Conclusion:** Calculation of estimated average blood glucose with fasting blood glucose help patients and clinicians in assessment of glycemic control status.

Keywords: HbA1c; eAG; Diabetes; Glycemic control; Sudanese; FBG; Hyperglycemia

Introduction

Diabetes mellitus is a metabolic disorder associated with a defect of normal glucose metabolism resulting in hyperglycemic status. [1] Often chronic hyperglycemia adequate to cause secondary pathophysiological changes in various organ systems may impose a tremendous burden on the lives and well-being of individuals, families, and societies worldwide. [2,3] The fluctuation of blood glucose concentration in blood arises from poor glycemic control associated with diabetes complications which comprise a major health problem in Sudan. [4] Thus diabetes mellitus management needs accurate monitoring of blood glucose control to assess the efficiency of a particular therapy and glycated end product. [5] Glycated Haemoglobin (HbA1c) and fructosamine levels in the blood are the two main important laboratory investigations used in medicine as a diagnostic tool for the evaluation of the degree of glycemic control during the two to three past months in diabetic patients. [6] HbA1c provides a reliable measure of chronic glycaemia, so clinicians use HbA1c test results to guide treatment decisions because there is a direct quantitative relationship between HbA1c level and the risk of diabetes micro vascular complications. So, the test has become the cornerstone for assessing diabetes care, and the diabetic patient must have to check their HbA1c levels at least two times per year. [7] Yet, translation of HbA1c levels into Estimated Average Glucose (eAG) can help individuals with diabetes to correlate these levels with the daily monitoring of glucose levels. The HbA1c percentage of diabetic patients can be converted to the units of measure seen by the patient on glucose meters (mg/dL) for daily self-monitoring by calculating estimated average glucose. [7,8] Different studies provide various equations that investigated the relationship between the mean blood glucose level and the level of HbA1c, but the American Diabetes Association (ADA) recommended the use of Nathan's regression equation. [5] The linear regression formula ("28.7 × A1c-46.7") is often used to calculate the eAG from A1c and thus, every one percent increase in HbA1c is equal to an increase of 29 mg/dL in eAG. [8] This study aims to find out the association between fasting blood glucose and estimated average glucose and determine their relation to the glycemic control status of diabetic patients.

Materials and Methods

Information disclosure

This retrospective cohort study was conducted in diabetic care center in Khartoum state. A laboratory data of 687 (324 females and 363 males) diabetic patients (May-August 2019) included in this study. The study was approved by the clinical chemistry department scientific committee, college of medical laboratory sciences.

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Study design, population and baseline characteristics

The study group was selected from diabetic patients that had hemoglobin levels between 12 and 16 g/dl. Glycaemic control status was defined according to the HbA1c target of <7% as recommended by the American Diabetes Association and accordingly, HbA1c level of >7.0% was defined as 'poor glycaemic control'. The estimated glucose levels (mg/dl) were calculated using the following formula: (28.7 × HbA1c-46.7). [8]

According to the patients' fasting blood glucose levels, we divided the study group into three groups: group A: FPG, <130 mg/dL; group B: FPG=130-180 mg/dL; and group C: FPG.>180 mg/dL.

Statistical analysis

All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, version 20.0 for Windows, IBM). Data were expressed as the means ± Standard Error of the Mean (SEM). A p-value of 0.05 was accepted as significant.

The normality of the variables was evaluated by using the Kolmogorov-Smirnov test. The Chi-square test performed to compare proportions between patients with good and poor glycemic control, to compare levels of FPG and eAG the Wilcoxon signed-rank test applied, and the Mann-Whitney U test used to compare between the variables of males and females. Spearman correlation coefficient (r) was used to illustrate the relationship between FPG and eAG levels.

Results and Discussion

Different studies investigated the relationship between the mean blood glucose level and the level of HbA1c and various equations have been obtained. [4,5] Nathan's regression equation, which translated HbA1c into eAG level and determines its relationship to the Fasting Plasma Glucose (FPG) level has been recommended by the American Diabetes Association (ADA) to be used as comparative with FBG to help in monitoring glycemic control. [5,6] The present study results [Table 1] showed that 76.9% of the study group had poor glycemic control. This percentage was found to be similar and comparable to the poor glycemic percentages reported by different studies conducted in Eastern Sudan (71.9%). [4] Khartoum and Atbara (83.8%). [9] Community-based study in different cities in Sudan (85%) [10] and in Bangladesh about 82% participants were found to be had inadequate glycaemic control (HbA1c ≥ 7%). [11]

As well, results [Table 1] showed that the calculated eAG means were found to be a higher and statistically significant difference (p<0.001) than FBG means within the entire group, good glycemic control, and poor glycemic control groups with strong positive correlation. These findings were found to be is consistent with previous studies conducted by Bozkaya et al. [5]

The eAG levels were found higher than the FBG levels because of fasting state and because the eAG level is reflective of all plasma glucose levels over the previous 2 months-3 months. Consequently, calculation of eAG will help patients better understand the importance of keeping their blood glucose levels within acceptable limits and may rescue them from invasive approaches for glucose homeostasis [5] because due to the low level of FBG, patients may change diet, which could negatively impact their or her metabolic control. Different studies reported that dietary non-compliance, lack of physical exercise, poor storage and usage of drugs, poor quality of drugs, poor prescription of drugs are the main factors that contributed to the main diabetic complications such as cardiovascular disease, nephropathy, and retinopathy have been associated with longer duration of poor diabetes control. [12,13]

For the subgroups, the study results [Table 2] showed that calculated eAG levels were found to be higher and statistically significant than FBG in groups A and B (p<0.001)rather than in group C in which the eAG level was found less than FBG with no statistical difference (p=0.645). Moreover, a significant positive strong correlation coefficient showed in group C (p<0.001). These findings demonstrate that the association

Table 1: The statistics of glycemic control parameters within groups.

Groups	Entire group		Good glycemic control HbA1C <7%		Poor glycemic control HbA1C>7%	
N (%)	687(100%)		159 (23.1%)		528 (76.9%)	
Parameters	**Mean ± SEM**	**P-value**	**Mean ± SEM**	**P-value**	**Mean ± SEM**	**P-value**
FBG (mg/dl)	193.4 ± 3.6	<0.001	128.6 ± 4.3	<0.001	212.9 ± 4.1	<0.001
eAG (mg/dl)	225.0 ± 3.1		141.0 ± 3.8		250.3 ± 3.1	
HbA1c (%)	9.5 ± 0.10		6.5 ± 0.13		10.3 ± 0.10	
FBG *vs.* eAG	r=0.594 (p<0.001)		r=0.754 (p<0.001)		r=0.467 (p<0.001)	

P-value at (p<0.05).

Table 2: The statistics of glycemic control parameters within subgroups.

Subgroups	Group A FBG<130 mg/dl		Group B FBG 130-180 mg/dl		Group C FBG>180 mg/dl	
N (%)	190 (30.3%)		239 (26.2%)		253 (43.5%)	
Parameters	**Mean ± SEM**	**P-value**	**Mean ± SEM**	**P-value**	**Mean ± SEM**	**P-value**
FBG (mg/dl)	106.3 ± 1.0	<0.001	154.1 ± 1.3	<0.001	277.7 ± 4.7	0.645
eAG (mg/dl)	166.7 ± 4.1		210.5 ± 4.7		274.1 ± 4.1	
HbA1c (%)	7.4 ± 0.14		9.0 ± 0.16		11.2 ± 0.14	
FBG *vs.* eAG	r=0.062(p=0.377)		r=0.120 (p=0.110)		r=0.369 (p<0.001)	

P-value at (p< 0.05).

Table 3: Comparison of the glycemic parameter means in gender type.

Subgroups	Male	Female	
N(%)	324(47.2%)	363(52.8%)	P-value
Parameters	**Mean ± SEM**		
FBG (mg/dl)	203.6 ± 5.7	184.4 ± 4.4	0.038
eAG (mg/dl)	230.7 ± 4.6	220.0 ± 4.1	0.084
HbA1c (%)	9.7 ± 0.16	9.3 ± 0.14	0.084
FBG *vs.* eAG	0.584	0.605	<0.001

P-value at (p<0.05).

Table 4: Comparison of the glycemic control percentages in males and females.

Gender type	Male		Female		Chi squire test	
Groups	**Good control**	**Poor control**	**Good control**	**Poor control**	**χ^2**	**P-value**
Entire group	63	261(80.6%)	96	267(73.6%)	4.718	0.03
Group A	46	48(51%)	63	41(44.7%)	0.827	0.363
Group B	13	59(81.9%)	27	81(75%)	1.205	0.272
Group C	4	154(97.5%)	6	135(95.7%)	0.685	0.525

P-value at (p<0.05).

depended on the control level of glucose as the glucose control get worse, the association became stronger. The same findings reported by Bozkaya et al. [5] to address the effect of gender on the association between the glycemic parameter.

Our study results [Table 3] revealed that the eAG level was found to be higher than the FBG level in male and female groups with a strong positive correlation. Also, it was observed that the FBG level was found to be significantly higher in males than in females while there is no difference observed in eAG level between gender types. Previous studies reported that patients with good to moderate blood glucose control are not entirely successful at managing their blood glucose, as reflected by their eAG levels, and the association between the FBG and eAG levels depends on the extent of blood glucose control. [5]

Besides, the study results [Table 4] showed that (80.6%) of males had poor glycemic compared to (73.6%) in females with a significant difference (p=0.030). For the subgroup (A, B, C) the comparison results between males and females were found not statistically significant P>0.05. Different studies demonstrate the same findings [9] and show sex-based differences in the stage and severity of diabetes. [14,15] Poor awareness of diabetes and its complications is considered as the main factor that leads to an increase in the rate of poor glycemic control. Many studies suggested that diabetic patients require alternate strategies to improve glycemic control status. One of the strategies that should be considered to educate the patient on how to correlate the between fasting blood glucose as prompt evaluation of glycemic control and calculated eAG which is reflect the glycemic control for the last 2 months-3 months. [16,17]

Conclusion

Our Study concluded that the rate of poor glycaemic control was remarkably high among Sudanese diabetic patients and especially among males associated with appositive correlation between eAG and FBG. These findings suggest the reporting of estimated average glucose alongside with fasting blood glucose may help the patients and healthcare provider in better understanding of glycemic control status.

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Author's Contribution

Alneil Hamza: Data collection, analysis, interpretation and manuscript writing.

Elyasa Elfaki: Manuscript writing and editing.

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