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RESEARCH ARTICLE

ASSOCIATION OF PLASMA GLUCOSE LEVELS WITH ESTIMATED AVERAGE GLUCOSE LEVELS IN DIABETIC PATIENTS

Dipsha Kriplani[1]*, Akshay Kriplani[2] and Arvind Bhake[3]

Department of Pathology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Science, Sawangi (M), Wardha, Maharashtra, India

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ABSTRACT

Background: The aim of the study was to measure the fasting plasma glucose levels and the glycosylated hemoglobin levels of type 2 diabetic patients and to calculate the estimated average glucose (eAG) levels to establish a correlation between the fasting glucose levels and the estimated average glucose levels. **Methods:** Fasting blood glucose (FPG) levels was measured by glucose oxidase - peroxidase method and glycosylated hemoglobin level was measured by Latex agglutination inhibition assay. Estimated average glucose (eAG) levels expressed in mg/dl were calculated by Nathan's regression equation: eAG= 28.7 x HbA1c - 46.7. Pearson correlation coefficient (r) was used to establish a correlation between FPG & eAG and a value of r=0.92 was considered strong enough to establish a correlation between HbA1c and estimated average glucose (eAG). **Result:** Pearson's correlation coefficient was found to be strong enough to justify a correlation between the values of HbA1c and estimated average glucose (eAG). **Conclusion:** Since estimated average glucose values correlate with the values of glycosylated hemoglobin and are reported in terms of mg/dl, reporting it along with HbA1c assists the clinicians to have a better understanding of the status of glycemic control of the patient

INTRODUCTION

Diabetes mellitus is a metabolic disorder of multiple etiology characterized by chronic hyperglycaemia with disturbance in carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action or both.[1] Long term effects of diabetes are responsible for the macro and microvascular complications. [2] The criteria for diagnosis of diabetes are: presence of symptoms of diabetes along with random blood sugar concentration ≥ 200 mg/dl (11.1mmol/L) or fasting plasma glucose ≥ 126mg/dl (7mmol/L) or levels of glycosylated hemoglobin ≥ 6.5% or Oral Glucose Tolerance Test ≥ 200 mg/dl (11.1mmol/L).[3] Levels of glycosylated hemoglobin are increased in diabetic patients.[4] Its rate of formation is dependent on the blood glucose concentration and is expressed in % of total blood haemoglobin concentration.[5] It gives a retrospective assessment of the mean plasma glucose concentration during the preceding 8-12 weeks.[6-8] The American Diabetes Association Standards of Medical Care in Diabetes, 2010 has established glycosylated hemoglobin as a dependable method of assessing glycemic control.[9] The higher the percentage of circulating HbA1C, the poorer the mean diabetic control. HbA1c levels should be checked at least two times per year to reduce the risk of microvascular complications.[10] Clinicians use HbA1c test results to guide treatment decisions, and it has thus become a cornerstone for assessing diabetes care. [11]

Estimated average glucose (eAG) level is calculated by Nathan's regression equation which was recommended by the American Diabetes Association (ADA), 2010. It states that:
eAG = 28.7 x HbA1c - 46.7

The values are expressed in mg/dl.[12] The correlation between A1C levels and eAG levels based on data from international A1C- derived Average Glucose (ADAG) trial using is as follows:

HbA1C (%)	eAG (mg/dL)
6	126
6.5	140
7	154
7.5	169
8	183
8.5	197
9	212
9.5	226
10	240

The goal for proper glycemic control should be to maintain eAG < 140 mg/dl.[12] Using Nathan's regression equation, the estimated average glucose levels were calculated and its

Corresponding author:* **Dipsha Kriplani
Department of Pathology, Jawaharlal Nehru Medical College, Datta Meghe Institute of Medical Science, Sawangi (M), Wardha, Maharashtra, India

correlation with the fasting plasma sugar level was investigated in the present study.

MATERIALS AND METHODS

This is an analytical, laboratory experimental study conducted on 60 type 2 diabetic patients in the department of Pathology in Jawaharlal Nehru Medical College and Central Laboratory of Acharya Vinobha Bhave Rural Hospital, Sawangi (Meghe), Wardha. Institutional Ethical Committee clearance was taken and consent was obtained from the participant. Diabetic patients with hemoglobin < 12gm% were excluded from the study. Fasting blood glucose (FPG) levels was measured by glucose oxidase - peroxidase method. Glycosylated hemoglobin level was measured by Latex agglutination inhibition assay. Estimated average glucose (eAG) levels were calculated by Nathan's regression equation: eAG= 28.7 x HbA1c - 46.7. As per American Diabetes Association, diabetes was defined by levels of fasting plasma glucose ≥ 126mg/dl.[13] According to the fasting blood glucose levels, samples divided into 3 groups: Group A comprised of patients with FPG between 100- 125 mg/dl, Group B with patients having FPG between 126 -200 mg/dl and Group C with patients having FPG > 200 mg/dl.

The data was collected, interpreted & analyzed statistically. Pearson correlation coefficient (r) was used to establish a correlation between FPG & eAG. The American Diabetes Association and American Association of Clinical Chemists have determined that the correlation (r=0.92) is strong enough to justify reporting both an HbA1c result and an estimated average glucose (eAG) result.[12]

RESULTS

Table 1 Number of patients in group wise distribution

	Fasting sugar level (mg/dl)	Number	%
Group A	100-125	3	5
Group B	126-200	35	58.33
Group C	>200	22	36.66
Total		60	100

Maximum number of study subjects were seen to have fasting sugar levels in the range of 126-200mg//dl.

Table 2 Age wise distribution of the diabetic patients

		Age (years)					Total
Fasting blood sugar (mg/dl)		**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	
Group A	**100-125**	33.3%	33.3%	-	33.3%		3
Group B	**126-200**	17.1%	22.8%	20%	31.4%	8.6%	35
Group C	**>200**	18.18%	13.63%	27.27%	36.36%	4.5%	22

Maximum number of diabetic patients were seen to lie in the age range of 61 to 70 years.

Table 3 Mean fasting plasma glucose levels in group wise distribution

Fasting blood sugar (mg/dl)		Mean fasting plasma glucose level
Group A	100-125	120.7
Group B	126-200	155
Group C	>200	264.13
Total		193.54

Table 3 shows the mean fasting plasma glucose levels in the three groups. The mean of fasting plasma glucose levels in the range of 126 to 200mg/dl was 155 and the mean of fasting plasma glucose levels above 200mg/dl was 264.13.

Table 4 Mean glycosylated hemoglobin levels in group wise distribution

Fasting blood sugar (mg/dl)		Mean glycosylated hemoglobin
Group A	**100-125**	6.92
Group B	**126-200**	10.02
Group C	**>200**	11.89
Total		8.46

Table 4 shows the mean values of glycosylated hemoglobin in the various groups based on the levels of fasting blood sugar levels. A linear correlation is seen between the levels of fasting blood sugar and the levels of glycosylated hemoglobin.

Table 5 Mean estimated average glucose levels in group wise distribution

Fasting blood sugar (mg/dl)		Estimated average glucose level
Group A	**100-125**	151.9
Group B	**126-200**	240.87
Group C	**>200**	294.54
Total		196.1

Table 5 shows the values of estimated average glucose levels in the various groups based on the levels of fasting blood sugar levels which were calculated using the Nathan's regression equation. Like the values of glycosylated hemoglobin, the estimated average glucose levels also show a linear correlation with the fasting blood sugar levels.

Table 6 Correlation between fasting plasma glucose levels and estimated average glucose levels

Fasting blood sugar (mg/dl)		FPG v/s eAG
Group A	**100-125**	r= 0.89
Group B	**126-200**	r= 0.781
Group C	**>200**	r= 0.622
Entire group		r= 0.56

Table 6 shows the correlation between fasting plasma glucose levels and estimated average glucose levels which was calculated by using the Pearson correlation coefficient (r). A significant positive correlation was seen in all the groups based on fasting blood sugar levels.

DISCUSSION

Fasting plasma glucose levels indicate the glucose values of the patient at that time. The values depend on a number of factors and vary from day- to – day, with the previous day's diet, exercise etc. The measurement of HbA1c is used to determine the average level of glycaemic control over the previous 8- 12 weeks. It is a gold standard measurement of chronic glycaemia. The American Diabetic Association, the European Association for the Study of Diabetes (EASD) & The International Diabetes Federation (IDF) sponsored an International study to define a mathematical relationship between HbA1c and the eAG level which states that 28.7x HbA1c - 46.7= eAG. Using the formula in this study, the eAG levels of our study group were calculated. It was observed that the eAG levels positively correlate with the FPG levels.

Since eAG values are derived from HbA1c values and are expressed in mg/dl which is the same unit used to express FPG levels, it is more convenient and accurate to use eAG values to assess the glycemic control of the patients and to plan further management. Thus, this formula can assist health care providers and their patients for regular self-monitoring.

CONCLUSION

Reporting the estimated average glucose level together with the HbA1c level is believed to assist patients to understand the importance of keeping blood glucose levels within acceptable limits

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