Research Article

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Correlation of fasting and post meal plasma glucose level to increased HbA1c levels in type-2 diabetes mellitus

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ABSTRACT

Background: Various observational studies and clinical trials have demonstrated that intensive glycemic control prevents the development and progression of long term diabetic micro-vascular complications and may reduce macrovascular complications. However, there is insufficient data to determine the contribution of fasting and post meal plasma glucose to increase the percentage of HbA1_C level. Therefore, it is desirable to know whether fasting or post-prandial plasma glucose level alone or in combination will be necessary in adjusting the therapy to achieve optimal HbA1_C levels in type-2 diabetes mellitus. The present study was aimed to correlate fasting and post meal plasma glucose level to HbA1_C level in type-2 diabetes mellitus.

Methods: 50 diagnosed uncomplicated patients of type-2 diabetes mellitus under treatment in diabetic clinic of Acharya Vinoba Bhave Rural Hospital (AVBRH) were enrolled for the study. We have used Pearson's correlation coefficient to find the statistical significance.

Results: Both fasting as well as post-meal glucose levels were correlated with $HbA1_C$ but higher correlation was seen between fasting plasma glucose and $HbA1_C$.

Conclusion: Our study revealed that fasting plasma glucose value appreciably contributes $HbA1_C$ as compared to post-meal glucose values.

Keywords: Diabetes mellitus, Fasting plasma glucose, Post meal plasma glucose, Glycosylated hemoglobin

INTRODUCTION

Incidence of diabetes mellitus has been increasing in urban and rural areas of India and it will be one of the major cause of death in India in 21st century. Various observational studies and clinical trials have demonstrated that intensive glycemic control prevents the development and progression of long term diabetic micro-vascular complications and may reduce macrovascular complications.

Diabetes is caused by an absolute or functional lack of insulin, which leads to increased glucose levels outside

the cell. High concentrations of glucose can increase the glycation of common proteins such as hemoglobin, forming Hemoglobin $A_{\rm IC}$ (HbA1_c). However, it is important to note that HbA1c is neither considered dysfunctional nor harmful. 3

Nevertheless, the concentration of $HbA1_C$ predicts diabetes complications because it reflects more harmful glycation sequel of diabetes, such as retinopathy and nephropathy, which are understood to be due to harmful advanced glycation end products. Hemoglobin A_{1C} is known to correlate with blood glucose levels over the

lifetime of the red blood cell, which is approximately 120 days.⁴

 HbA_{1C} expressed as a percentage of total blood hemoglobin concentration gives a good retrospective assessment of the mean plasma glucose concentration during the preceding 6-8 weeks while the recent glycemic level has the highest influence and the preceding 30 days contribute only upto 50%. $^{5-7}$

A cut-off value of 6.5% HbA_{1C} classifies diabetic subjects with a specificity of 98.7%. Normal level of HbA_{1C} is 4-5.9%. There are however insufficient data to determine the contribution of fasting and post meal plasma glucose to the percentage of HbA_{1C} level. Hence it is desirable to know whether fasting or post prandial plasma glucose level alone or in combination will be necessary in adjusting the therapy to achieve optimal HbA_{1C} levels in type-2 diabetes mellitus. 10

Hence, the present study was planned to correlate fasting and post meal plasma glucose level to increased HbA_{1C} level in type-2 diabetes mellitus patients.

Aim

The present study was aimed to correlate fasting and post-prandial plasma glucose with HbA_{1C} in type-2 diabetes mellitus.

Objectives

- 1. To find out whether fasting or post prandial plasma glucose level alone or in combination will be necessary in adjusting the therapy to achieve optimal HbA_{1C} levels in type-2 diabetes mellitus.
- HbA_{IC} being a costly test, whether strict monitoring and control of FPG or PPG can help the clinicians to have an economical alternative test, compared to HbA_{IC} for glycemic control of their uncomplicated diabetic patients.

METHODS

Study type

Observational study.

Study design

Fifty diagnosed patients of type-2 diabetes mellitus under treatment in diabetic clinic of Acharya Vinoba Bhave Rural Hospital (AVBRH) were enrolled for the study.

Study sample

Total 3 ml of blood (fasting) and 1 ml of blood (post meal) 2 hours after the meal was collected after informed and written consent from diagnosed patients of type-2

diabetes mellitus under treatment in diabetic clinic of Acharya Vinoba Bhave Rural Hospital (AVBRH).

Following investigations were carried out on autoanalyzer (Rx Daytona, random access analyzer).

Table 1: Investigations on auto-analyzer.

Test	Bulb	Method
Fasting plasma glucose (FPG)	Fluoride	GOD-POD method ¹¹
Post-meal plasma glucose (PPG)	Fluoride	GOD-POD method ¹¹
Glycosylated hemoglobin (HbA _{1C})	EDTA	Immunoturbidemetric method ¹²

Quality control

Clinical biochemistry laboratory at AVBRH routinely observes external as well as internal quality control.

Statistical analysis

Mean, standard deviation and coefficient of correlation was done by SPSS17.0 statistical software.

Inclusion criteria

Diagnosed, uncomplicated patients of type-2 diabetes mellitus undergoing antidiabetic treatment.

Exclusion criteria

Diabetic patients suffering from other chronic diseases.

RESULTS

Fifty uncomplicated patients of type 2 diabetes mellitus (NIDDM) who were on antidiabetic drugs were enrolled for the study. Mean and Standard Deviation of Fasting and Post- meal plasma glucose level and glycated Hb are found to be higher, mean of fasting plasma glucose level (165.30 mg/dl), post-meal glucose level (258.44 mg/dl), and glycated Hb (8.47%) was found to be increased which is being shown in Table 2.

Table 2: Mean and standard deviation of fasting and post-meal plasma glucose levels and glycated hemoglobin (HbA_{1C}).

N=50	Mean ± SD
FPG	$165.30 \pm 41.97 \text{ mg/dl}$
PPG	$258.44 \pm 70.70 \text{ mg/dl}$
HbA _{1C}	$8.47 \pm 2.92\%$

Glycated hemoglobin levels in 20% of patients were <6.5% while 80% had values >6.5% (Table 3). Highly positive correlation was found between FPG and PPG with glycated Hb (Figure 1 and Figure 2). Moreover,

correlation coefficient of fasting plasma glucose level was found highly significantly positive with HbA_{1C} (Figure 1). Also FPG and PPG are highly significantly positively correlated with each other as shown in Table 4.

Table 3: Distribution of diabetic patients based on $HbA_{\rm IC}$ levels.

HbA _{1C} level	Number	Percentage (%)
Normal (<6.5%)	10	20
High (>6.5%)	40	80

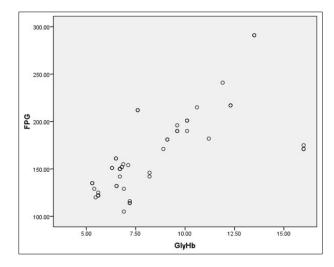


Figure 1: Showing correlation between fasting plasma glucose level and HbA_{1C} (r = 0.685).

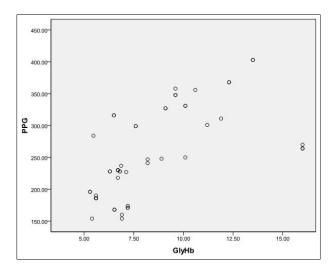


Figure 2: Showing correlation between post-meal plasma glucose level and HbA_{1C} (r = 0.623).

Table 4: Showing correlation coefficient of fasting and Post- meal plasma glucose levels with each other.

N=50	FPG	PPG
FPG	1	
PPG	0.879^{**}	1

DISCUSSION

India leads the world with largest number of diabetic subjects, earning the dubious distinction of being termed the "diabetes capital of the world". According to the Diabetes Atlas 2006 published by the International Diabetes Federation, the number of people with diabetes in India currently around 40.9 million is expected to rise to 69.9 million by 2025 unless urgent preventive steps are taken.¹³

Brig Waqar Azim (2011), estimated through his work that PPG has a stronger correlation with HbA_{1C} as compared to the FPG so a strict monitoring and control of PPG can help the clinicians to have an economical alternative test, compared to HbA1c for glycemic control of their uncomplicated diabetic patients.¹⁴

India being a developing country having large number of poor people, everybody cannot frequently afford for a bit costly test like HbA_{IC}, hence the knowledge of correlation of fasting plasma glucose and post meal plasma glucose with glycated hemoglobin will be helpful in the management of type-2 diabetes mellitus to achieve optimal glycemic control.

In this study, we correlated HbA_{1C} with fasting as well as post meal plasma glucose in type-2 diabetic patients. Both fasting and post-meal plasma glucose levels were found to be positively correlated with HbA_{1C} (Figure 1 and Figure 2). Moreover fasting plasma glucose level was found to be highly positively correlated with HbA_{1C} (r = 0.685). This is in accordance with Bonora E (2001),¹⁵ M. Saiedullah, S. Begum et al. (2011),¹⁶ Louis Monnier (2003).¹⁷

This result is also in accordance with Matthew Riddle et al., 18 who concluded that with oral therapies alone at baseline, participants with HbA $_{\rm IC}$ <8.0% had 76% contribution from basal hyperglycemia and after intensifying therapy with insulin the HbA $_{\rm IC}$ reduced and there was change in this relationship. All 50 patients in present study were on oral therapies and their

mean HbA_{1C} (8.47%) correlated more significantly with fasting plasma glucose as compared to post meal plasma glucose.

Monnier L, Colette C (2006), ¹⁹ reviewed previous studies of diurnal glycemic profiles and concluded that relative contribution of postprandial plasma glucose to HbA_{1C} was high (70%) in patients with fairly good control of diabetes (HbA_{1C} <7.3%) and decreased progressively (30%) with worsening diabetes (HbA_{1C} >10.2%) whereas the contribution of fasting plasma glucose showed a gradual increase with increasing levels of HbA_{1C} .

Our results are not in accordance with Masram et al., ²⁰ Waqar Azim et al., ¹⁸ Rosediani M²¹ who revealed that

PPG has a stronger correlation with HbA_{IC} as compared to the FPG.

Bonora et al.¹⁵ evaluated the extent of plasma glucose excursions with meals, the relations between plasma glucose levels at different times of the day, i.e. before and 2-3 hour after breakfast, lunch and dinner, and the relations between the latter and HbA_{1C} in non–insulintreated type 2 diabetic subjects and concluded that although HbA_{1C} is more related to pre-prandial than postprandial plasma blood glucose levels monitoring of glucose control and evaluation of the efficacy of treatment cannot be restricted to fasting glucose and or HbA_{1C}. Indeed, both fasting glucose and HbA_{1C} are poor indicators of glucose levels at other times of the day, especially those occurring in the postprandial state.

A systematic review on "Guidelines for management of post meal glucose" recommends that although control of fasting hyperglycaemia is necessary, it is usually insufficient to obtain optimal glycaemic control. Post meal hyperglycemia is associated with increased risk of retinopathy, increased carotid intima thickness, oxidative stress, inflammation and endothelial dysfunction. Hence targeting both post-meal and fasting plasma glucose is an important strategy for achieving optimal glycaemic control.²²

In present study although FPG is more correlated with HbA_{1C} than PPG, but both are significantly correlated with HbA_{1C} . This suggests that correcting both will help to achieve a good glycemic control. Thus, if one aims at controlling plasma glucose not only in the fasting state but throughout the day to achieve better long-term metabolic control (HbA_{1C}) and minimize the risk of chronic diabetic complications, glucose monitoring cannot be limited to fasting or pre-prandial glucose monitoring but correcting glucose levels all throughout the day will result in a greater reduction of HbA_{1C} , as in the DCCT²³ or the Kumamoto Study.²⁴

Implications of study

The above study will be helpful in -

- Correlating fasting glucose level or post meal glucose level alone or in combination with HbA_{1C} in order to achieve optimal HbA_{1C} level for therapy of diabetes mellitus.
- Early detection of hyperglycemia and achieving good glycemic control in type-2 diabetes mellitus patients in order to prevent the complications of disease, morbidity and mortality.

Study limitations

The present study was carried out in a small sample size. Plasma glucose and HbA_{1C} determinations were carried on a single day whereas several glucose determinations

over a period of several weeks can be better correlated to HbA_{1C} than a single or a few glucose determinations on a single day.

CONCLUSION

Fasting plasma glucose and post meal plasma glucose both are significantly positively correlated with HbA_{1C} and fasting plasma glucose is highly significantly and positively correlated with HbA_{1C} than PPG. Thus correcting either fasting plasma glucose or post meal plasma glucose or both will help to achieve a good glycemic control in uncomplicated patients of type 2 diabetes mellitus. Estimating fasting plasma glucose test could be an economical alternative test to HbA_{1C} for glycemic control of uncomplicated diabetic patients.

Early detection of hyperglycemia & good glycemic control can prevent complications & further decreases morbidity and mortality.

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Abbreviations

HbA_{IC}: Glycosylated hemoglobin, FPG: Fasting plasma glucose, PPG: Post-meal plasma glucose, GOD-POD: Glucose oxidase peroxidase, NIDDM: Non-insulin dependent diabetes mellitus.

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REFERENCES

- Manjunatha Gaud BK, Bhavna Nayal, Sarsina Devi O, Sathisha TG, Sweta Shivashanker, Devaki RN. Relationship of calculated HbA_{1C} with fasting plasma glucose. Int J Appl Biol Pharmacol Technol. 2011;2(2):58-61.
- Sherita Golden, Todd Brown, Hsin-Chieh Yeh, Nisa Maruthur, Padmini Ranasinghe, Zack Berger, et al. Use of HbA_{1C} and microalbuiminuria in monitoring of diabetes mellitus. Evidence Report/Technology Assessment No. 842003; 84 (04-E001), 2012.
- 3. Castilho EM, Glass ML, Manco JC. The effects of 2,3-diphosphoglycerate, adenosine triphosphate, and glycosylated hemoglobin on the hemoglobin-oxygen affinity of diabetic patients. Braz J Med Biol Res. 2003;36(6):731-7.
- Nathan DM, Singer DE, Hurxthal K, Goodson JD. The clinical information value of the glycosylated hemoglobin assay. N Engl J Med. 1984;310(6):341-

- 6. Tahara Y, Shima K. The response of GHb to stepwise plasma glucose change over time in diabetic patients. Diabet Care. 1993;16(9):1313-4.
- Akinloye OA, Adaramoye OA, Akinlade KS, Odetola AA, Raji AA. Relationship between fasting plasma glucose and glycated hemoglobin in adult diabetic Nigerians. Afr J Biomed Res. 2007;10:127-32.
- 6. Distiller LA, Zail SS. The Use of glycosylated haemoglobin measurements in the Control of the diabetic patient. S Afr Med J. 1979;55:335.
- 7. Alam T, Weintraub N, Weinreb J. What is the proper use of hemoglobin A_{1C} monitoring in the elderly? J Am Med Dir Assoc. 2006;7:S60-4
- Peter A, Fritsche A, Stefan N, Heni M, Häring HU, Schleicher E. Diagnostic value of hemoglobin A_{1C} for type 2 diabetes mellitus in a population at risk. Exp Clinical Endocrinol Diabet. 2011 Apr;119(4):234-7.
- Medicine net. Hemoglobin A_{1C} Test, 2014.
 Avialable at: Medicinenet.com/hemoglobin_a1c_test/article.htm
- 10. Rudiger Landgraf. Relationship of postprandial glucose to HbA_{1C} . Diabet/Metab Res Rev. 2004;20(2):S9-12.
- Carl A. Burtis, Edward R. Ashwood, Barbara Border, Norbert W. Tietz. GOD-POD method. In: Carl A. Burtis, Edward R. Ashwood, Norbert W. Tietz, eds. Fundamentals of Clinical Chemistry. 2nd ed. Toronto: W.B. Saunders; 1982: 242-251.
- 12. Little RR. Recent Progress in HbA1c testing. Diabet Care. 2000 Mar;23(3):265-6.
- 13. Mohan V, Sandeep S, Deepa R, Shah B, Varghese C. Epidemiology of type 2 diabetes: Indian scenario. Source Madras diabetes research foundation & Dr. Mohan's diabetes specialities centre. Indian J Med Res. 2007 Mar;3(125):217-30.
- 14. Azim W, Mushtaq Gill M, Azim S, Farooq W. Assessment of fasting and two-hour post-prandial glucose as an economical test for monitoring of glycemic control, compared to glycated haemoglobin. Med Channel. 2011;17(2):5-7.
- 15. Bonora E, Calcaterra F, Lombardi S, Bonfante N, Formentini G, Bonadonna RC, et al. Plasma glucose levels throughout the day and HbA_{1C} interrelationships control in type 2 diabetes: implications for treatment and monitoring of metabolic control. Diabet Care. 2001 Dec;24(12):2023-9.

- Saiedullah M, Begum S, Shermin S, Rahman MR, Khan MAH. Relationship of glycosylated hemoglobin with fasting and postprandial plasma glucose in nondiabetic, pre-diabetic and newly diagnosed diabetic subjects. Bangladesh Med J. 2011:40(1):37.
- 17. Monnier L, Lapinski H, Colette C. Contributions of fasting and post-prandial plasma glucose increments to the overall diurnal hyperglycemia of type 2 diabetic patients: variations with increasing levels of HbA_{1C}. Diabet Care. 2003 Mar;26(3):881-5.
- Riddle M1, Umpierrez G, DiGenio A, Zhou R, Rosenstock J. Contribution of basal and postprandial hyperglycemia over wide range of A_{1C} levels before and after treatment intensification in type 2 diabetes. Diabet Care. 2011 Dec;34(12):2508-14.
- 19. Monnier L, Colette C. Contributions of fasting and postprandial glucose to hemoglobin A_{1C}. Endocr Pract. 2006 Jan-Feb;12(Suppl 1):42-6.
- S. W. Masram, M. V. Bimanpalli. Assessment of contribution of fasting and post meal plasma glucose to increased HbA_{1C} in diabetes mellituscomparative study. Int J Biol Med Res. 2012;3(3):2020-4.
- 21. Rosediani M, Azidah AK, Mafauzy M. Correlation between fasting plasma glucose, post prandial glucose and glycated haemoglobin and fructosamine. Med J Malaysia. 2006 Mar;61(1):67-71.
- 22. Antonio Ceriello, Stephen Colagiuri, John Gerich, Jaakko Tuomilehto. Guideline for management of post meal glucose. Rev Nutr Metab Cardiovasc Dis. 2008;18:S17-33.
- 23. Diabetes Control and Complications Trial Research Group. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med. 1993;329(14):977-86.
- 24. Shichiri M, Kishikawa H, Ohkubo Y, Wake N. Long-term results of the Kumamoto study on optimal diabetes control in type 2 diabetic patients. Diabet Care. 2000;23(Suppl. 2):B21-9.

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