Correlation Between Fasting Plasma Glucose and Two-Hour Plasma Glucose During Oral Glucose Tolerance Test in South Indians

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The diagnostic criteria for diabetes have been recently revised and the fasting plasma glucose (FPG) level reduced to 126 mg/dL, since the earlier cutoff of 140 mg/dL was considered to correspond to a much higher level than the 2-hour postglucose (2 h PG) value of 200 mg/dL. However, there are few data directly correlating FPG and 2 h PG during an oral glucose tolerance test (OGTT). This study reports on a retrospective analysis of 5,936 OGTTs performed at a diabetes center in South India and attempts to correlate the FPG and 2 h PG values. Using a 2 h PG of 200 mg/dL or higher as the diagnostic criterion, 46.7% of the cohort had diabetes. The corresponding values using the old FPG of 140 mg/dL or higher and the new FPG of 126 mg/dL or higher were 31.7% and 39.8%, respectively. If the FPG was further reduced to 118 mg/dL, the "diabetic yield" increased to 45.8%, ie, it approached the figures based on a 2 h PG of ≥200 mg/dL. Various regression equations were used to correlate FPG and 2 h PG values. When FPG was used as the dependent variable, the semilogarithmic regression equation provided the best fit, and using this model, the 2 h PG of 200 mg/dL corresponds to a FPG of 118 mg/dL. When the 2 h PG was used as the dependent variable, the log-log model provided the best fit, and using this model, a 2 h PG of 200 mg/dL corresponds to a FPG of 118 mg/dL. Thus, a FPG of 118 mg/dL seems to correlate with a 2 h PG of 200 mg/dL in South Indians.
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THE DIAGNOSTIC CRITERIA for diabetes mellitus have been recently modified by the American Diabetes Association (ADA) Expert Committee on the Diagnosis and Classification of Diabetes Mellitus[1] from criteria previously recommended by the National Diabetes Data Group (NDDG)[2] and World Health Organization (WHO) study group.[3] In the revised criteria, the fasting plasma glucose (FPG) level was reduced from the earlier value of ≥140 mg/dL to ≥126 mg/dL, as it was believed that the latter value corresponds better to a 2-hour postglucose (2 h PG) level of 200 mg/dL.

Few studies have examined the correlation between FPG and 2 h PG during an oral glucose tolerance test (OGTT) in a clinical setting. This report is a large retrospective analysis of OGTTs and attempts to correlate FPG and 2 h PG levels in a South Indian diabetic clinic population.

SUBJECTS AND METHODS

The present study is based on an analysis of 5,936 OGTTs performed during a 3-year period from April 1, 1994 to March 31, 1997 at the M.V. Diabetes Specialities Centre at Chennai (formerly Madras) in South India. All OGTTs were performed under standard conditions with a 75-g oral glucose load using WHO recommendations.[3] Pregnant women were not included in the analysis. Fasting and half-hourly venous plasma (EDTA) samples up to 2 hours were used for glucose determinations, which were performed within 15 minutes of sample collection. Plasma glucose levels were measured by a glucose oxidase method using kits from Boehringer (Mannheim, Germany) on a Ciba Corning Express Plus Autoanalyzer (Medfield, MA). Quality control was assessed on a daily basis, and the coefficient of variation for glucose was less than 3.0%.

Table 1. Mean Value for 2 h PG in Relation to FPG

Serial No.	FPG (mg/dL)	Mean 2 h PG (mg/dL)
1	101-105 (n = 446)	149 ± 49
2	106-110 (n = 374)	163 ± 57
3	111-115 (n = 275)	179 ± 56
4	116-120 (n = 223)	201 ± 55
5	121-125 (n = 230)	219 ± 57
6	126-130 (n = 207)	226 ± 56
7	131-135 (n = 168)	236 ± 49
8	136-140 (n = 128)	256 ± 50
9	141-145 (n = 138)	262 ± 60

Table 2. Comparison of Sensitivity and Specificity of Different FPG Levels for the Diagnosis of Diabetes

Diagnostic Criteria (FPG mg/dL)	Sensitivity (%)	Specificity (%)	Positive Predictive Value (%)	Negative Predictive Value (%)	Accuracy (%)
100	97.7	58.9	67.5	96.7	77.0
105	95.7	71.7	74.7	95.0	82.9
110	92.4	80.7	80.8	92.4	86.2
115	89.1	87.2	85.9	90.1	88.1
120	84.8	91.1	89.3	87.2	88.2
125	79.6	93.8	91.8	83.9	87.3
135	70.3	97.3	95.9	78.9	84.1
140	65.6	97.9	96.6	76.5	83.1
145	61.3	98.5	97.2	74.4	81.1

Statistical Analysis

All values are expressed as the mean ± SD. Statistical analysis was performed using various regression models to compare the correlation of the FPG and 2 h PG levels. The best-fitting regression equation was used to calculate the FPG value corresponding to the 2 h PG cutoff value of 200 mg/dL. The sensitivity, specificity, positive predictive value, and negative predictive value of different FPG values for the diagnosis of diabetes were calculated.[4]

RESULTS

There were 3,888 males and 2,048 females with a mean age of 48 ± 14 years and a mean body mass index of 25.4 ± 4.3 kg/m^2. Among 5,936 individuals studied, 1,882 (31.7%) had a FPG of ≥140 mg/dL. Thus, using previous FPG criteria, 31.7% of this cohort would be diagnosed as diabetic. Using the criteria for 2 h PG of ≥200 mg/dL, 2,771 individuals (46.7%) were diagnosed as diabetic. With the new diagnostic criteria of a FPG

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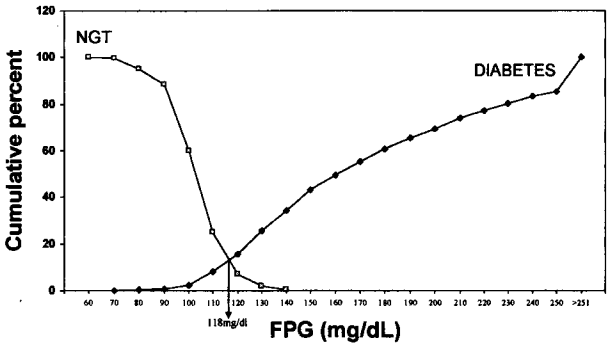

Fig 1. Cumulative distribution curves of normal glucose tolerance and diabetes mellitus. Note that the curves intersect at 118 mg/dL.

of ≥126 mg/dL, 2,363 individuals (39.8%) would be classified as diabetic. It is thus clear that in our population, reducing the FPG from 140 mg/dL to 126 mg/dL increases the "diagnostic yield" of diabetes from 31.3% to 39.8%, but this is still lower than the 46.7% diagnostic yield obtained using the 2 h PG criteria.

Of 2,771 individuals diagnosed as diabetes cases based on WHO criteria, 2,181 (78%) individuals were classified as diabetic by the ADA FPG criteria, and thus 590 (22%) individuals would remain undiagnosed. If the FPG cutoff is reduced to 118 mg/dL, 2,402 (86.7%) diabetic individuals classified by WHO criteria will also be classified as diabetics by the new FPG cutoff and only 13.3% will remain undiagnosed.

The mean 2 h PG levels corresponding to FPG levels between 101 and 145 mg/dL were determined (Table 1). A FPG between 116 and 120 mg/dL corresponds to a 2 h PG level of 201 ± 55 mg/dL.

Table 2 compares the sensitivity and specificity for a diagnosis of diabetes using different FPG cutoff values from 101 to 145 mg/dL. The sensitivity of FPG increases if the FPG cutoff value is decreased. The accuracy (defined as the sum of true positives and true negatives divided by the total number of subjects) of the test is maximal at about 120 mg/dL, whereas it tends to decrease both above and below this level.

Figure 1 shows the cumulative distribution curve for FPG in individuals with normal glucose tolerance defined as a 2 h PG level less than 140 mg and diabetes defined as a 2 h PG of ≥200 mg/dL. The FPG curves for the 2 groups intersect at 118 mg/dL. Figure 2 shows the receiver operator characteristic (ROC) curves indicating that a FPG of 118 mg/dL provides optimum sensitivity and specificity for the diagnosis of diabetes in this population.

Various regression models such as linear, quadratic, semilogarithmic, exponential, and log-log were used to study the relation between FPG and 2 h PG values. The semilog regression model performed well when FPG was used as the independent variable and 2 h PG as the dependent variable. The R^2 value was 82%, and the residual mean square and the outliers were minimal compared with other models. The regression equation using this model was 2 h PG = −1,226 + 299 ln (FPG). Using this model, a 2 h PG level of 200 mg/dL corresponds to a FPG of 118 mg/dL.

The log-log model provided the best fit when 2 h PG was used as the independent variable and FPG as the dependent variable. Using this model, the R^2 value was 81%. The regression equation using this model was ln (ln FPG) = 1.45 + 0.00055 (2 h PG). Using this regression equation, a 2 h PG level of 200 mg/dL corresponds to a FPG of 118 mg/dL.

DISCUSSION

The recent reduction of the FPG criterion to 126 mg/dL was derived from epidemiological studies in Pima Indian, Egyptian, and Pacific Islander populations and US adults.[5-8] All of these populations were more obese than our population, which is relatively lean.[9,10] Recent reports from the Diabetes Epidemiology Collaborative Analysis of Diagnostic Criteria in Europe (DECODE) study[11] have shown that the correlation of FPG with

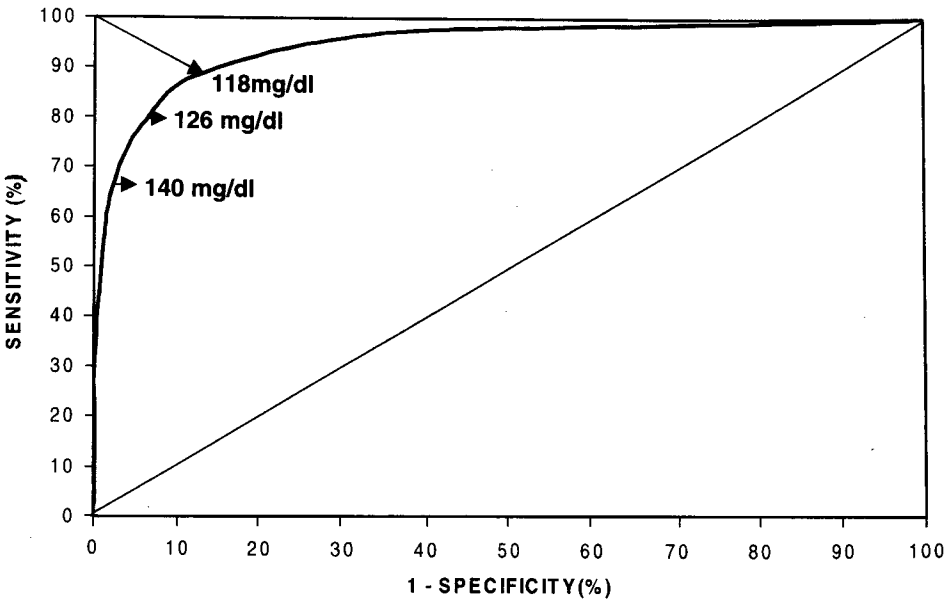

Fig 2. ROC curve for sensitivity and specificity of FPG.

2 h PG is dependent on the body mass index. It is known that obesity leads to hyperinsulinemia and insulin resistance, and hence the FPG and postload plasma glucose levels would be higher in these populations. Hence, studies from other populations, especially those with lower rates of obesity, would be of interest, particularly since the WHO consulting group on diabetes and the DECODE study group have requested such data.[11,12]

To avoid the cumbersome process of the OGTT and to simplify the test for the diagnosis of diabetes, the ADA Expert Committee has suggested the use of FPG alone for epidemiological studies. However, the Expert Committee acknowledges that with a FPG cutoff of 126 mg/dL, lower prevalence rates for diabetes would be obtained in epidemiological studies, as compared with the 2 h PG cutoff value of 200 mg/dL.[1] The benefit of reducing the FPG value in increasing the sensitivity for the diagnosis of diabetes has been confirmed in non-European populations as well, as shown by a study in a Chinese population.[13] Indeed, this is of particular relevance to populations with a high prevalence of diabetes such as the Asian Indian population.[14,15] Recent studies from Southern India[16] have shown that reducing the FPG level to 126 mg/dL increases the prevalence of diabetes from 9.0% to 10.7%, but this was still less than the figure of 11.6% obtained using a 2 h PG level of 200 mg/dL.

In the present study, only 78% of the patients diagnosed as diabetic cases by WHO criteria were also diagnosed by ADA FPG criteria. This concordance rate appears to vary according to the population studied. Thus, it was 52% in the Third National Health and Nutrition Examination Survey,[8] 62% in the Hoorn Study,[17] and 50% in the Hong Kong Chinese population study.[18] A recent analysis of epidemiological data from Europe suggests that the use of the new ADA criteria would result in changes in the prevalence of diabetes ranging from a reduction of 4% to an increase of 13%.[19] This indicates that the significance of the new ADA classification would differ according to the population studied.

In summary, this study reports on the relationship between FPG and 2 h PG based on a large number of OGTTs and suggests that in South Indians, a 2 h PG level of 200 mg/dL corresponds to a FPG of about 118 mg/dL. More studies are clearly needed to examine the significance of FPG in other non-European populations, particularly in developing countries.

REFERENCES

1. American Diabetes Association Expert Committee: Report of the Expert Committee on the Diagnosis and Classification of Diabetes Mellitus. Diabetes Care 20:1183-1197, 1997
2. National Diabetes Data Group: Classification and diagnosis of diabetes mellitus and other categories of glucose intolerance. Diabetes 28:1039-1057, 1979
3. World Health Organization: Diabetes mellitus. Report of a WHO study group. World Health Organ Tech Rep Ser No. 727:1985
4. Armitage P: Statistical Methods in Medical Research. Oxford, UK, Blackwell Scientific, 1971, p 433
5. Engelgau MM, Thompson TJ, Herman WH, et al: Comparison of fasting and 2hr glucose and HbA1c levels for diagnosing diabetes: Diagnostic criteria and performance revisited. Diabetes Care 20:785-791, 1997
6. McCance D, Hanson RL, Pettitt DL, et al: Diagnosing diabetes mellitus—Do we need new criteria? Diabetologia 40:247-255, 1997
7. Finch CF, Zimmet PZ, Alberti KGMM: Determining diabetes prevalence: A rational basis for the use of fasting plasma glucose concentrations? Diabet Med 7:603-610, 1990
8. Harris MI, Flegal KM, Cowie CC, et al: Prevalence of diabetes, impaired fasting glucose and impaired glucose tolerance in US adults. The Third National Health and Nutrition Examination Survey, 1988-1994. Diabetes Care 21:518-524, 1998
9. Ramachandran A, Snehalatha C, Shyamala P, et al: High prevalence of NIDDM and IGT in an elderly South Indian population with low rates of obesity. Diabetes Care 17:1190-1192, 1994
10. Mohan V, Ramachandran A, Viswanathan M: Tropical diabetes, in Alberti KGMM, Krall LP (eds): Diabetes Annual, vol 2. Amsterdam, The Netherlands, Elsevier Science, 1986, pp 30-38
11. The DECODE Study Group on behalf of the European Diabetes Epidemiology Group: Is fasting glucose sufficient to define diabetes? Epidemiological data from 20 European studies. Diabetologia 42:647-654, 1999
12. Alberti KGMM, Zimmet PZ: New diagnostic criteria and classification of diabetes—Again? Diabet Med 15:535-536, 1998
13. Cockram CS, Lau JTF, Chan Ay W, et al: Assessment of glucose tolerance test criteria for diagnosis of diabetes in Chinese subjects. Diabetes Care 15:988-990, 1992
14. Zimmet P, Taylor R, Ram P: The prevalence of diabetes and impaired glucose tolerance in the biracial (Melanesian and Indian) population of Fiji: A rural-urban comparison. Am J Epidemiol 118:673-688, 1983
15. Mather HM, Keen H: The Southall Diabetes Survey: Prevalence of known diabetes in Asians and Europeans. BMJ 291:1081-1084, 1985
16. Ramachandran A, Jali MV, Mohan V, et al: High prevalence of diabetes in an urban population in South India. BMJ 297:587-590, 1988
17. Vegt FD, Dekker SM, Stehouwer CDA, et al: The 1997 American Diabetes Association criteria versus the 1985 World Health Organization criteria for the diagnosis of abnormal glucose tolerance—Poor agreement in the Hoorn Study. Diabetes Care 21:1686-1690, 1998
18. Ko GTC, Chan JCN, Woo J, et al: Use of the 1997 American Diabetes Association Diagnostic Criteria for diabetes in a Hong Kong Chinese population. Diabetes Care 21:2094-2097, 1998
19. Burch-Johnson K: Will new diagnostic criteria for diabetes mellitus change phenotype of patients with diabetes? Reanalysis of European epidemiological data: DECODE Study Group on behalf of the European Diabetes Epidemiology Study Group. BMJ 317:371-375, 1998