Cut-Off Fasting Plasma Glucose Level To Determine Impaired Glucose Metabolism In Obesity

S Guldiken, A Tugrul, G Ekuklu, E Arikan, B Altun, M Kara

Citation

S Guldiken, A Tugrul, G Ekuklu, E Arikan, B Altun, M Kara. *Cut-Off Fasting Plasma Glucose Level To Determine Impaired Glucose Metabolism In Obesity*. The Internet Journal of Internal Medicine. 2002 Volume 4 Number 1.

Abstract

Objective: Our aim was to find out which fasting glucose level should be the cut-off point for impaired glucose metabolism in obese patients.

Subjects: 257 patients (195 females, 62 males) whose body mass indexes (BMI) were above 30kg/m² participated in this study. After all cases had underwent a 75gr oral glucose tolerance test (OGTT) the patients were divided into four groups according to their fasting plasma glucose values (group 1:80-89mg/dl (4.4-4.9mmol/l), group 2:90-99mg/dl (5.0-5.5mmol/l), group 3:100-109mg/dl (5.6-6.0mmol/l), group 4 :110-125mg/dl (6.1-6.9mmol/l)). According to OGTT results we defined patients as cases who were normal, who had impaired fasting glucose, and who had impaired glucose metabolism (diabetes mellitus and impaired glucose tolerance).

Results: No difference was found between age, gender, BMI, systolic and diastolic blood pressure, and lipid profiles of the groups. The number of patients who were diagnosed as impaired glucose metabolism increased apparently in the third group (%50.7) (p<0.05). Mean fasting plasma glucose level of the third group was 104,16±2,73mg/dl (5.78±0,15mmol/l). Although there was no statistically difference between the groups, mean homeostasis model assessment (HOMA) values were above 4 in the third and fourth groups, in the patients who had impaired fasting glucose and impaired glucose metabolism.

Conclusion: We think that it is necessary to apply a OGTT to obese patients whose fasting plasma glucose levels are above 104 mg/dl in order to reduce the mortality and morbidity of the cardiovascular diseases.

INTRODUCTION

Obesity plays an important role in the pathogenesis of diabetes mellitus (DM). Central pattern of body fat distribution, increase of intra-abdominal and visceral fat ratio and of BMI are associated with the metabolic syndrome which includes hyperinsulinemia, abnormal glucose tolerance, hypertension, dyslipidemia, and cardiovascular disease ([1]). Meanwhile obesity itself has a high mortality and morbidity rate ([2]). While coronary heart disease tends to increase in non-diabetic obeses ([3]), cardiovascular mortality is higher in obese diabetics when compared to non-obese diabetics ([4]).

OGTT is frequently used in epidemiological studies which aim to assess risk factors of cardiovascular diseases. Plasma glucose level in the second hour of OGTT was found to be a strong indicator for cardiovascular diseases in the studies by Hoorn ([5]), Honolulu Heart ([6]), Chicago Heart ([7]) and recently DECODE study ([8]). Especially in large population surveys OGTT (which is used to diagnose diabetes and also to determine the possible cardiovascular risk) increases the costs of the study. Thus, the studies have aimed to find the fasting glucose level in which having an impaired glucose metabolism risk is more frequent ([9],[10],[11],[12]). In our study, the aim was to find out which fasting glucose level should be the cut-off point for impaired glucose metabolism in obese patients.

METHODS

257 (195 females, 62 males) patients who have applied to Endocrinology Department of Medical Faculty of Trakya University because of obesity were randomised to the study. Their diabetes history was unknown. Their physical examinations were done. Systolic (SBP) -diastolic (DBP) blood pressures and anthropometric data [weight, height, waist, and hip circumstance, waist-to-hip ratio, and BMI

(kg/m²)] were measured for all individuals. Venous blood samples were obtained from the patients after at least 9 hours of fasting for the assessment of glucose, insulin, cholesterol, triglyceride, and high-density lipoprotein (HDL) levels. All patients were made to drink 75gr glucose for OGTT. Then venous blood samples were obtained again to measure the 2 nd h glucose level.

Glucose oxidase method (Beckman Coulter LX20) was carried out to measure glucose, spectrophotometric method (Beckman Coulter LX20) was used to measure triglyceride, cholesterol and HDL. Low-density cholesterol (LDL) level was calculated according to Friedewalds' formula [LDL = Cholesterol-(triglyceride/5+HDL)] ($_{13}$). Insulin was measured by chemiluminescens method (Immulate DPC).

Insulin resistance was assessed according to homeostasis model (HOMA= Fasting plasma glucose (FPG) mmol/l x insulin IU/ml / 22.5) and HOMA >4 was accepted as insulin resistance ($_{14}$).

Patients were divided into four groups according to their fasting plasma glucose levels. Patients with glucose levels 80-89 mg/dl (4.4-4.9mmol/l) were group 1, those with 90-99mg/dl (5.0-5.5mmol/l) were group 2, those with 100-109 mg/dl (5.6-6.0mmol/l) were group 3, and those with 110-125mg/dl (6.1-6.9mmol/l) were group 4.

The glucose metabolism states of all groups were defined by using their FPG and OGTT values according to the criteria which are mentioned below. FPG levels and 2 nd h plasma glucose levels of the OGTT were evaluated according to the criteria of American Diabetes Association (ADA) ($_{15}$).

1. Patiens who had glucose levels 126mg/dl (7mmol/l) in two different measuring were diagnosed as diabetic and were excluded from the study.

2. Fasting glucose level <110mg/dl (<6,1mmol/l) and 2 nd h glucose level of OGTT <140mg/dl (<7.8mmol/l) were considered as “normal glucose tolerance”.

3. Fasting glucose levels between 110mg/dl and <126mg/dl (6.1-<7.0mmol/l) and 2 nd h glucose level of OGTT <140mg/dl (<7.8mmol/l) were accepted as “impaired fasting glucose”.

4. 2 nd h glucose levels of OGTT between 140mg/dl and 199 mg/dl (7.8- 11.05mmol/l) were defined as “impaired glucose tolerance (IGT)”.

5. 2 nd h glucose levels of OGTT 200mg/dl (11.1mmol/l) were accepted as “diabetes mellitus”.

STATISTICAL ANALYSIS

Statistical analysis was performed by SPSS. Data are given as means and SDs or percentages. Differences between proportions were tested by Chi-square and Fisher fraction analysis. Differences between continuous variables were tested by an unpaired t test, non-parametric ANOVA. Differences between independent groups were tested by non-parametric t-test (Mann Whitney U). Analysis was made with help of the computer program MINITAB Version 13. (license no: wcp 1331.00197).

RESULTS

257 patients who participated in the study were divided into four groups according to the FPG levels which were mentioned above. There were 53 patients in the first group (40 females, 13 males), 43 patients (32 females, 11 males) in the second group, 65 patients (49 females, 16 males) in the third group, and 96 patients (74 females, 22 males) in the fourth group. No significant difference was found between gender, age, BMI, waist-to-hip ratio, SBP, DBP, HDL, LDL, insulin, and HOMA values of the groups (Table-I).

Figure 1

Table-I: Characteristics of the groups according to fasting plasma glucose levels.

Variables	*GROUP 1 (FPG 80-89mg/dl)*	*GROUP 2 (FPG 90-99mg/dl)*	*GROUP 3 (FPG 100-109mg/dl)*	*GROUP 4 (FPG 110-125mg/dl)*
N	53	43	65	96
Female	40	32	49	74
Male	13	11	16	22
Age (years)	50.09±12.35	46.53±15.02	52.23±11.78	52,31±12,14
BMI (kg/m²)	31,24±6.59	30.63±5.61	32.47±7.44	32.60±6.93
SBP(mmHg)	153±23.98	151.27±19.21	157.38±21.65	157.60±22.25
DBP (mmHg)	97.64±14.16	94.41±17.12	96.76±13.12	98.69±14.69
Triglyceride (mg/dl)	168.26±76.82	156.42±66.30	157.01±90.68	164.06±85.09
Cholesterol (mg/dl)	222.55±39.41	204.86±48.03	215.77±45.28	216.63±64.31
HDL (mg/dl)	51.04±33.79	45.70±18.79	50.59±11.65	48.60±11.11
LDL (mg/dl)	141.61±38.99	139.75±41.15	130.93±37.57	139.84±70.05
FPG (mg/dl)	82.07±5.07*	94.44±2.88*	104.16±2.73*	117.70±4.98*
2-h glucose (mg/dl)	112.49±30.88*	126.44±35.0	135.36±45.22	157.76±51.70*
Insulin (µIU/ml)	15.66±9.28	10.61±2.55	17,21±12,05	17,30±8,05
HOMA	3.16±1.87	2.46±0.59	4.43±3.09	4,87±2,28

*p<0.000.

A significant difference was found between mean fasting plasma glucose levels of the groups. Mean 2 nd h plasma glucose level was highest in the fourth group, lowest in the first group (p<0.000). No significant difference was found between the mean plasma glucose values of second and third groups (p>0.05). Mean systolic blood pressures, although they were not statistically significant, were higher in the 3 rd

and 4 th groups when compared to 1 th group and 2 nd groups. Although there was no significant difference between the groups, mean HOMA values were above 4 in the 3 rd and 4 th groups.

When all of the groups were evaluated by using the definitions that they had been given after they had gotten OGTT, 104 (%40.4) cases were found out to be normal, 40 (%15.5) cases had impaired fasting glucose, 85 (%33.0) cases had impaired glucose tolerance, and 28 (%10.9) cases were diabetic. When impaired glucose tolerance and DM were evaluated together as impaired glucose metabolism, there were 113 (%43.9) cases in total (Table-II).

Figure 2

Table-II: Distribution of cases into group according to results of OGTT.

According to OGTT;	*GROUP 1*	*GROUP 2*	*GROUP 3*	*GROUP 4*	*p**
Normal	43 (%81.1)	29 (%67.4)	32 (%49.2)		
Impaired fasting glucose				40 (%41.7)	NS**
Impaired glucose tolerance	8 (%15.1)	12 (%27.9)	28 (%43.0)	37 (%38.5)	NS
Diabetes Mellitus	2 (%3.8)	2 (%4.7)	5 (%7.69)	19 (19.8)	NS
Total	53	43	65	96	
Impaired glucose metabolism	10 (%18.9)	14 (%32.6)	33 (%50.7)*	56 (%58.3)*	<0.05

* Chi-square **Non-significant

The percentage of impaired glucose metabolism did not show significant difference between the 1 th group and 2 nd group, but its frequency increased significantly in 3 rd and 4 th groups in which FPG values were above 100mg/dl (5.55mmol/l) (p=0.004).

Characteristics of the groups which have been defined as normal, impaired fasting glucose and impaired glucose tolerance and DM according to OGTT are shown in the Table-III.

Figure 3

Table-III: Characteristics of the groups designed according to the results of OGTT.

	Normal group (n=104)	*Impiared fasting glucose group (n=40)*	*Impaired glucose Metabolism group (n=113)*	*p**
Female	80	30	85	
Male	24	10	28	
Age(years)	48,0±13,34*	46.65±13.26*	54.99±10.76*	<0.05
BMI (kg/m²)	31,17±6.46	34.03±6.79	32.00±7.00	NS**
SBP (mmHg)	151.16±20.76*	149.37±18.05*	161.85±23.04*	<0.05
DBP (mmHg)	95.77±14.54	98.50±15.45	98.18±14.5	NS
Fasting plasma glucose (mg/dl)	92.13±9.98*	116.60±4.6*	108.21±12,71*	<0.05
2-h plasma glucose (mg/dl)	103.76±22.4*	114.07±15.1*	176.76±41.19*	<0.05
Triglyceride (mg/dl)	150.58±69.10	152.62±78.33	175.43±91,82	NS
Cholesterol (mg/dl)	213.81±43.18	201.10±32.27	222.94±64.19	NS
HDL (mg/dl)	52.45±24.93	47.57±1.86	46.74±11.48	NS
LDL (mg/dl)	137.95±39.58	123.65±27.89	142.13±68.11	NS
Insülin (µIU/ml)	13.28±7.21	17.49±8.53	17.30±10.77	NS
HOMA	3.07±1.46	4.97±2.47	4.39±2.88	NS

*ANOVA **Non-significant

Patients were older in the impaired glucose metabolism group (p<0.001). Systolic blood pressure values were higher in the impaired glucose metabolism group (p<0.001). Higher mean 2 nd h plasma glucose level was found in the impaired glucose metabolism group (p<0.001). There was no significant difference between gender, BMI, diastolic blood pressure, triglyceride, cholesterol, HDL, LDL, HOMA values of the groups. Although they were not statistically significant, the mean HOMA values were above 4 in the groups of impaired glucose metabolism and impaired fasting glucose.

DISCUSSION

Obesity is one of the components in insulin resistance syndrome. Like hyperinsulinemia, hypertension, dyslipidemia, and impaired glucose metabolism, it plays an important role in the development of cardiovascular diseases ([16]). Obesity is a risk factor for DM and hypertension ([1,3]). Therefore, early discovery of other risk factors that contribute to cardiovascular disease is important in obese patients.

In our study, we examined the OGTT results of groups whose BMI's were above 30 kg/m². The separation the groups had been made by regarding the FPG values. The other characteristics of the groups like gender, lipid profile, and insulin levels were not significantly different than each other. This examination led us to the significantly higher impaired glucose metabolism frequencies in 3 rd and 4 th groups in which FPG were above 100mg/dl (5.55 mmol/l) (Table-II). In a previous public study in which OGTT was applied to non-obese participants, cut-off levels of FPG were suggested as 100.8mg/dl (5.6 mmol/l) for DM and 90mg/dl (5.0mmol/l) for impaired glucose tolerance ([9]). Rodriguez et al. ([11]) reported that 110mg/dl (6.1mmol/l) was the FPG value by which the most of the diagnosis of DM could be made after having OGTT. Tai et al. ([17]) found the microvascular complications in 90.7 % of patients who were diagnosed DM with OGTT and whose fasting plasma glucose levels were between 108-126mg/dl (6.0-7.0mmol/l). In our study, the mean FPG value of the 3 rd group in which the frequency of impaired glucose metabolism increased significantly was 104.16±2.73 mg/dl (5.78±0.15mmol/l).

The prevalence of hypertension is higher in patients with DM and IGT ([18]). We also found that the systolic blood pressures of patients who had impaired glucose metabolism were higher than those of the other groups (Table-III). This result points out that obesity is an important risk factor for the development of DM and hypertension and for both

diseases have probably common risk factors. Therefore it is appropriate to investigate impaired glucose metabolism in hypertensive patients.

A recent study showed that obesity, age, family history and sedentary lifestyle are risk factors for DM and IGT ([19]). In our study, the age of the patients with impaired glucose metabolism was greater than that of the normal group. It is advised that patients should be investigated in more detail for cardiovascular disease and its risk factors after fifth decade of age.

Although there is no statistically significant difference between the groups, HOMA values are higher especially in the 3 rd and 4 th groups. Also, HOMA value is above 4 in the groups which are diagnosed to have impaired fasting glucose and impaired glucose metabolism. Thus, as we mentioned before, insulin resistance is found in the pathogenesis of the insulin resistance syndrome whose components are obesity, hypertension, dyslipidemia, and impaired glucose metabolism.

In conclusion, obesity, hypertension, impairments of glucose metabolism, dyslipidemia are very important risk factors for cardiovascular diseases. Therefore, early diagnosis is extremely important. It is appropriate to look for the other risk factors in patients who have any one of these risk factors.

We think that it is necessary to apply OGTT to obese and hypertensive patients whose fasting plasma glucose levels is above 104mg/dl (5.78mmol/l) in order to both to prevent the high rates of mortality and morbidity and also to reduce the expensive cost.

CORRESPONDENCE TO

Sibel Guldiken Mimarsinan Evleri Fatih Mah. B3 Blok D4 Kutlutas 22030 Edirne /Turkey E-Mail: Sibel71@Hotmail.Com Fax Tel. No: 00 90 0284 2124222

References

1. Boyko EJ, Fujimoto WY, Loonitti DL, Newell Morris L. Visceral adiposity and risk of type 2 diabetes mellitus: a prospective study among Japanese Americans. Diabetes Care 2000; 23: 465-471.
2. Calle EE, Thun MJ, Petrelli JM, Rodriguez C, Heath CW. Body mass index and mortality in a prospective cohort of US adults. N Eng J Med 1999; 341: 1097-1105.
3. Abbasi F, Jr Brown BW, Lamendola C, McLaughlin T, Reaven GM. Relationship between obesity, insulin resistance, and coronary heart disease risk. J Am Coll Cardiol 2002; 40: 937-943.
4. Leibson CL, Willamson DF, Melton J, Palumbo PJ, Smith SA, Ransom JE, Schilling PL, Narayan KMV. Temporal trends in body mass index among adults with diabetes. Diabetes Care 2001; 24: 1584-1589.
5. Vegt F, Dekker JM, Ruhe HG, Stehouwer CDA, Nijpels GBLM, Heine RJ. Hyperglycaemia is associated with all-cause and cardiovascular mortality in the Hoorn population: the Hoorn Study, Diabetologia 1999; 42: 926-931.
6. Donahue RP, Abbott RD, Reed DM, Yano K. Post-challenge glucose concentration and coronary heart disease in men of Japanese ancestry. Honolulu Heart Program. Diabetes 1987; 36: 689-692.
7. Lowe LP, Liu K, Greenland P, Metzger BE, Dyer, Stamler J. Diabetes, asymptomatic hyperglycemia, and 22 year mortality in black and white men. The Chicago Heart Association Detection Project In Industry Study. Diabetes Care 1997; 20 : 163-169.
8. The DECODE study group on behalf of the European Diabetes Epidemiology Group, Glucose tolerance and mortality: comparison of WHO and American Diabetes Association diagnostic criteria. Lancet 1999; 354: 617-621.
9. Bortheiry AL, Malerbi DA, Franco LJ. The ROC curve in the evaluation of fasting capillary blood glucose as a screening test for diabetes and IGT. Diabetes Care 1994; 17: 1269-1272.
10. Clements JP, French LR, Boen JR, Sprafka JM, Hedlund B, Goetz FC. A reassessment of fasting plasma glucose concentrations in population screening for diabetes mellitus in a community of northern European ancestry: The Wadena City Health Study Acta Diabetol 1994; 31: 187-192.
11. Rodriguez Moran M, Guerrero- Romero F. Fasting plasma glucose diagnostic criterion, proposed by the American Diabetes Association has low sensitivity for diagnosis of diabetes in Mexican population. J Diabetes Complication 2001; 15: 171-173.
12. Shaw JE, Zimmet PZ, Hodge AM, Courten M, Dowse GK, Chitson P, et al. Impaired fasting glucose: how low should it go? Diabetes Care 2000; 23 : 34-39.
13. Kane JP, Mallary MJ. Disorders of lipoprotein metabolism. In: Greenspan FS, Strewler GJ (eds). Basic & Clinical Endocrinology. Appleton Lange:NewYork 1997, pp 680-709.
14. Matthews DR, Hosker JP, Rudenski AS, Naylor BA, Treacher DF, Turner RC. Homeostasis model assessment : insulin resistance and cell function from fasting plasma glucose and insulin concentrations in man. Diabetologia 1985; 28: 412-419.
15. The Expert Committee on the diagnosis and classification of diabetes mellitus. Report of the Expert Committee on the diagnosis and classification of diabetes mellitus. Diabetes Care Suppl, 2002; 25/1: 5-20.
16. Groop L, Orho-Melander M. The dysmetabolic syndrome. J Intern Med 2001; 250: 105-120.
17. Tai ES, Lim SC, Tan BY. Screening for diabetes mellitus. A two step approach in individuals with impaired fasting glucose improves detection of those at risk of complication. Diabet Med 2000; 17: 771-775.
18. Pablos-Velasco P, Martinez-Martin FJ, Perez FR, Uriste LM, Roblen RG. Prevalence, awareness, treatment and control of hypertension in Canarian population. Relationship with glucose tolerance categories. The Guia Study. J Hypertens 2002; 20: 1965-1971.
19. Jorgensen ME, Bjeregaard P, Borch-Johsen K, Backer V, Becker U, Jorgensen T, Mulvad G. Diabetes and impaired glucose tolerance among the inuit population of greenland. Diabetes Care 2002; 25: 1766-1771.

Author Information

S. Guldiken, MD
Endocrinology Department, Trakya University Medical Faculty

A. Tugrul, MD
Endocrinology Department, Trakya University Medical Faculty

G. Ekuklu, MD
Public Health Department, Trakya University Medical Faculty

E. Arikan, MD
Endocrinology Department, Trakya University Medical Faculty

B. Altun, MD
Endocrinology Department, Trakya University Medical Faculty

M. Kara, MD
Endocrinology Department, Trakya University Medical Faculty