



# Clinical Change in the Relationship with Post-Prandial Blood Glucose and Actual Carbohydrate Amount

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## Abstract

**Background:** For diabetic research, recent topic includes meal tolerance test (MTT), carbohydrate amount and post-prandial glucose.  
**Case presentation:** A Patient is 62-year-old male with type 2 diabetes (T2D). His glucose control was improved by super/standard low carbohydrate diet (LCD) from Sept 2021 to Apr 2022, with HbA1c 14.0% to 6.4%.  
**Results:** The relationship between post-prandial blood glucose (45-min) and actual carbohydrate amount in breakfast was studied. The slope of the regression curve showed gradual flatter tendency during half year.  
**Discussion:** These results suggest that post-prandial glucose would show lower level 45-min after breakfast associated with higher responsive secretion of insulin.

**Keywords:** Meal tolerance test (MTT); Type 2 diabetes (T2D); super low carbohydrate diet (LCD); Post-prandial blood glucose; Regression curve

## Introduction

Diabetes has been crucial disease across the world, and in discussion for long years. It seems to have several subgroups or etiological mechanism from several points of view [1]. Diabetes is one of the non-communicable diseases (NCDs) and shows complicated interrelationships with dyslipidemia, atherosclerotic cardiovascular disease (ASCVD), hypertension and other diseases [2]. In the light of prevalence and incidence of diabetes, International Diabetes Federation (IDF) has announced successively epidemiological reports [3]. According to several statistics, diagnosed DM and also undiagnosed DM (UDM) in adults have increased in rapid stages [4]. Regarding standardization of diabetes, American Diabetes Association (ADA) has proposed the latest guideline in Jan 2022, which has

been accepted for medical staffs and patients worldwide as recommended Medical Care in Diabetes-2022 [5].

Concerning diabetic nutritional therapy, calorie restriction (CR) was formerly rather usual treatment method. After that, low carbohydrate diet (LCD) has become an adequate way for patients with diabetes and obesity. LCD was applied to lots of cases with successful clinical efficacy by Doctors of Atkins and Bernstein [6]. Dietary Intervention Randomized Controlled Trial (DIRECT) Group has revealed clinical effect of LCD [7]. Successively, comparative studies of LCD and CR have reported from several investigators [8]. On the other hand, authors and collaborators have firstly started LCD in Japan, and continued clinical practice and research in the fields of LCD, CR, and related issues [9]. Furthermore, we have established Japan LCD Promotion Association (JLCDPA) and developed LCD medically and

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socially [10]. In order to inform LCD to many people, three useful LCD ways were presented [11]. These methods are super LCD, standard LCD and petite LCD, which include carbohydrate content ratio as 12%, 26% and 40%, respectively [12].

For carbohydrate intake and post-prandial elevated blood glucose, authors have reported meal tolerance test (MTT) [13]. We have also proposed novel method of Carbo-70 using breakfast with 70g of carbohydrate [14]. In addition, we have reported a diabetic case with measurement of carbohydrate amount in the meal [15]. Among our continuous diabetic practice and research, we have investigated detail relationship with post-prandial blood glucose and intake of carbohydrate amount. In this article, general progress and some perspective would be described.

### Case Presentation

#### Present history

The patient is 62-year male with type 2 diabetes (T2D). About 5 years ago, his body weight was increased and then he was diagnosed as T2D. After that, he has indicated to continue diabetic nutritional therapy that is standard low carbohydrate diet (LCD) for his daily life. His general condition was stable for a few years with HbA1c 6.0% - 6.3%. However, his diabetic control was exacerbated in Sept 2021 associated with diabetic symptoms and elevated HbA1c. Several causes for the exacerbation exist such as irregular meal, exercise and life style. Consequently, he was advised to check actual carbohydrate amount in the meal and post-prandial blood glucose.

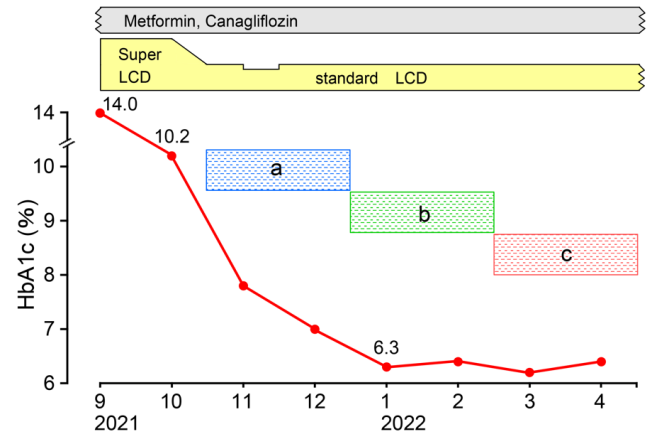
#### Several exams

His physical examination revealed unremarkable findings, which include consciousness, vital signs, chest, and abdomen. Neurological examination was intact. As to his physique, his stature, body weight and body mass index (BMI) showed 181cm, 88kg and 26.9 kg/m<sup>2</sup>, respectively. The results of the biochemical test showed that Hb 16.2 g/dL, WBC 86 x 10<sup>2</sup> /μL, Plt 21.1 x 10<sup>4</sup> /μL, LDL 142 mg/dL, HDL 65 mg/dL, Triglyceride 100 mg/dL, AST 22 IU/L, ALT 28 IU/L, LDH 141 IU/L, GGT 25 IU/L, Cr 0.8 mg/dL, eGFR 89 mL/min/1.73m<sup>2</sup>, BUN 17 mg/dL, UA 3.9 mg/dL, CRP 0.02 mg/dL. For other basal examinations, ECG showed within normal limits, and chest X-ray was negative. Pulse wave velocity (PWV) examination revealed normal results. The ankle brachial index (ABI) was 1.19/1.19 (0.91-1.40) and cardio-ankle vascular index (CAVI) was 9.3/9.2 (7.8-9.4) (right/left).

#### Clinical course

He was advised to continue super LCD for early period and standard LCD for consecutive period (Figure 1). It means that carbohydrate amount is set for 12% and 26% for calorie-ratio calculation, respectively. For medication of oral hypoglycaemic

agents (OHAs), he was indicated to continue metformin 500mg and Canagliflozin 100mg. His HbA1c was decreased from 14.0% to 6.4% from Sept 2021 to April 2022. During this period, the relationship of post-prandial blood glucose (45-min) and actual carbohydrate intake was studied.



**Figure 1:** Clinical progress of glucose variability and medication three consecutive periods are indicated for post-prandial study. They are a: Oct-Dec 2021, b: Jan-Feb 2022, c: Mar-May 2022.

### Results

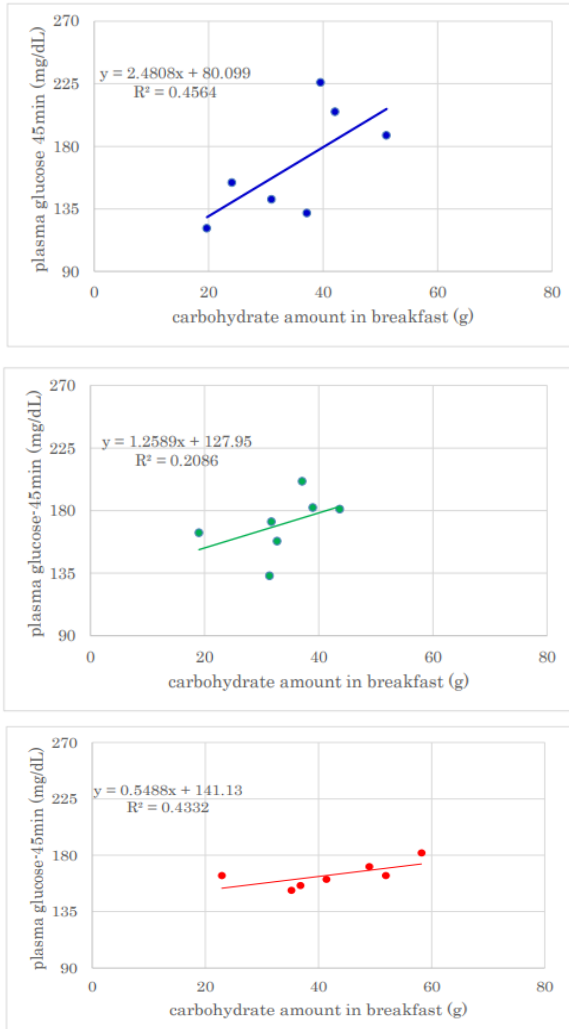
Current case has checked the relationship of post-prandial blood glucose and carbohydrate amount. In fact, he measured the blood glucose 45-min after breakfast one a week, and also calculated detail carbohydrate amount including in each breakfast. Among them, 4 different breakfast is shown associated with actual picture, carbohydrate amount and post-prandial blood glucose (Figure 2).

breakfast	Ingredient	each Carbo (gram)	total Carbo (gram)	blood glucose 45-min (mg/dL)	Month Date
A	raisin bread	57.0	58.2	182	March 7 2022
	bacon/spinach	0.2			
	tomato	0.0			
	coffee	1.0			
B	melon bread	49.7	51.9	164	March 21 2022
	Wiener sausage	0.1			
	tomato/cucumber	0.1			
	coffee	1.0			
C	plain bread	30.4	35.2	152	April 7 2022
	yogurt	3.6			
	bacon/spinach	0.2			
	coffee	1.0			
D	rice ball	35.0	36.8	156	May 2 2022
	fried egg	0.2			
	meat/sausage	0.6			
	coffee	1.0			

**Figure 2:** Breakfast content with carbohydrate amount and post-prandial blood glucose.

It includes 4 different staple food of bread and rice. They include raisin bread, melon bread, plain bread and rice ball, associated

with carbohydrate amount as 57.0g, 49.7g, 30.4g and 35.0g, respectively. Post-prandial blood glucose 45-min showed 182mg/dL, 164mg/dL, 152mg/dL and 156 mg/dL, respectively. This case has continued this research for several months. The results were divided into three periods, which were a) Oct-Dec 2021, b) Jan-Feb 2022 and c) Mar-May 2022. For three different periods, the correlation with post-prandial glucose and carbohydrate amount was investigated (Figure 3a-c). Among these figures, the degree of slope of the regression curve of a,b,c) is getting lower in order, which were 2.48, 1.26 and 0.55, respectively. Thus, the slope of c) became flatter than that of a).



**Figure 3:** Correlation between carbohydrate intake and post-prandial blood glucose.

3a: Breakfast data once a week during Oct-Dec 2021.

3b: Breakfast data once a week during Jan-Feb 2022.

3c: Breakfast data once a week during Mar-May 2022.

## Discussion

In this report, super LCD and standard LCD were provided to the patient, and his general diabetic condition was improved. This

case showed clinical efficacy of LCD (Figure 1). In recent decade, diabetic diet therapy has been in focus, where LCD has been more prevalent [16]. LCD is recognized for lowering blood glucose and body weight [17]. In addition to LCD, authors have continued to report several diabetic matters with anti-diabetes agents [18]. These include MTT, continuous blood glucose monitoring (CGM) and glucagon-like peptide 1 receptor agonist (GLP-1RA) and others [19,20].

For his diabetic variability, blood glucose was measured and monitored 45 minutes after breakfast. Simultaneously, carbohydrate amount in the breakfast was calculated and the relationship between them was analysed (Figure 2). Several MTT reports were found, in which beta-cell function was studied using a standardized liquid diet [21]. Similar to MTT, oral glucose tolerance test (OGTT) has been widely used [22]. We proposed a method using 70g of carbohydrate food similar to 75g of glucose [23]. In fact, we proposed a breakfast loading test using Japanese style breakfast with carbohydrate 70g [24]. This method was used to examine the changes in blood glucose, insulin, and c-peptide responses [25].

In this case, the difference in blood glucose increase with respect to carbohydrate intake was examined for three consecutive periods (Figure 3a-c). The results showed that the slope of the regression curve of 3c) became flatter than that of 3a). This result supposed that insulin secretion responsive to glucose loading may be increased. When insert  $x=50$  (gram of carbohydrate amount), the result of  $y$  becomes, 204, 191, 168 mg/dL, respectively. In contrast, by inserting  $x=20$  to Figure 3b and 3c,  $y$  will become 153 and 152 mg/dL, respectively, which is almost same. From this estimated calculation, it may be supposed that LCD continuation would bring improved insulin secretion for >30-50g of carbohydrate. It is rather usual that healthy person and diabetic patients have breakfast with carbohydrate amount about 40-80g per meal. The case has continued standard LCD for several months, and then the pancreas may be in rest for a while leading to improved insulin response. Consequently, continuing LCD may have beneficial effects of increasing insulin secretion and also improving the ability of self-remedy situation by oneself.

This case has investigated the relationship between post-prandial blood glucose and carbohydrate amount in the breakfast. Carbohydrate is usually included in staple food, such as bread, rice and noodles [26]. According to the textbook of Harper's biochemistry, it has been reported that 1g of carbohydrate taken per os will increase blood glucose 1mg for healthy subjects, 3mg for T2D patient and 5mg/dL T1D patient [27].

Some limitations are present in this case report. The relationship with post-prandial glucose and carbohydrate intake would be important, which is the theme of this presentation. However, such results do not necessarily show the precise glucose value like computer or the electric experiments. The reason includes the

ingestion and absorption of glucose in the intestine. Further studies will be required for MTT research. In summary, this article presented the combined research of LCD and MTT in diabetic patient. The results would become at least some meaningful reference for diabetic detail research in the future.

### Ethical Considerations

Current investigation was conducted along the Declaration of Helsinki that was previously revised in 2013 for the WMA Fortaleza General Assembly. In addition, several commentaries were added by the ethical guidelines for medical research. They are notified by the Ministry of Education, Culture, Sports, Science and Technology [MEXT], Japan and Ministry of Health, Labour and Welfare [MHLW], Japan. This study in detail was explained to the patient. Authors have obtained the written document agreements from the patient. Current study was discussed in the professional ethical committee. The committee involves several professionals including president, director, doctors, nurses, pharmacists, dieticians, and a professional legal specialty.

### Conflict of Interest

The authors declare no conflict of interest.

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