

Useful meal tolerance test (MTT) for carbohydrate amount and post-prandial blood glucose

Abstract

Background: Low carbohydrate diet (LCD) has been effective for type 2 diabetes mellitus (T2DM), because of less post-prandial increase of blood glucose.

Case presentation: The case is 62-year-old male with T2DM, who had experience of LCD a few years ago. He developed diabetic exacerbation as HbA1c 10.7% in autumn 2021.

Results: He began super-LCD with 12% of carbohydrate in calorie ratio, and recorded the pictures of detail food intake every day and 45-minute post-prandial blood glucose for long. His HbA1c decreased to 7.1% for 9 weeks. For breakfast, carbohydrate amount varies from 19.7 g to 51.1g, and 45-min post-prandial blood glucose distribute 121mg/dL to 226mg/dL. The relationship between carbohydrate amount in breakfast and 45-min post-prandial blood glucose was investigated. As a result, significant correlation was observed between them ($R^2=0.46$, $p<0.05$). Regression curve revealed $y=2.5897x+73.226$, in which the slope of the straight line is 2.6.

Discussion and Conclusion: Obtained data may suggest that carbohydrate 1g can increase post-prandial glucose 2.6mg/dL. As to the standard fact of carbohydrate metabolism in the textbook, 3.0mg/dL glucose increase per carbohydrate 1g has been observed. Restricted carbohydrate intake would be beneficial for improving glucose variability in T2DM.

Keywords: low carbohydrate diet (LCD), type 2 diabetes mellitus (T2DM), post-prandial blood glucose, regression curve, meal tolerance test (MTT)

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Introduction

As crucial non-communicable disease (NCD), diabetes mellitus has been treated across the world for years. Standard guideline for diabetes has been proposed by International Diabetes Federation (IDF), American Diabetes Association (ADA) and other associations. ADA announced the Standards of Medical Care in Diabetes-2022 on Jan 1, 2022.¹ The adequate information and education may contribute the prevention of increasing diabetes in developed countries and developing countries.² The fundamental principle for diabetic therapy would be nutritional treatment. To continue stable eating patterns associated with appropriate macronutrient distribution and less carbohydrate intake would be recommended.³

Authors and colleagues have continued diabetic clinical practice and research for long.⁴ Our fields of research include continuous glucose monitoring (CGM), antidiabetic therapy, clinical treatment using Glucagon-Like Peptide 1 receptor agonist (GLP-1RA), low carbohydrate diet (LCD), meal tolerance test (MTT) and so on.^{5,6} Among them, MTT would be useful for the investigation of the relationship between intaking of carbohydrate amount and post-prandial elevation of blood glucose.⁷ We have formerly proposed MTT using breakfast with 70g carbohydrate and reported enough elevation of blood glucose, insulin (IRI) and C-peptide for patients with type 2 diabetes mellitus (T2DM).⁸ It would be beneficial for speculating actual responses of insulin and blood glucose by simple method.⁹

Among various types of diabetes, we have experienced an impressive patient with T2DM. The case is a 62-year old men who has continued strict LCD associated with investigation for analysis of carbohydrate amount in the meal and daily measuring blood glucose.^{10,11} From such situation, relationship of carbohydrate and glucose variability was studied. General progress, detail data and perspectives are described in this article.

Case presentation

History and physicals

The patient is a 62-year-old man who has T2DM for 3-4years. When he was 40years old, he became gradually obese. He was pointed out to have T2DM when he was late 50's. After that, he started to continue LCD meal for long, and then his body weight decreased from 100kg to 93kg. His HbA1c has persisted around 6.2-6.5% during 2020-2021. During summer 2021, he enjoyed his sports opportunities and always drank sports drink solution (SDS) every day. Then, he felt thirsty and polyuria in autumn 2021, and visited diabetic clinic. It was pointed out that he has severe level of diabetic status associated with 10.7% of HbA1c.

The case showed normal consciousness, conversation and behaviors associated with normal vitals for P 64/min, blood pressure 128/80mmHg and normal respiration, temperature and SpO₂. His height and weight were 180cm and 88kg. His body mass index (BMI) was 27.2kg/m², and showed normal lung, heart, abdomen with unremarkable neurological test. The results of laboratory examinations were unremarkable, in which main data were LDL-C 148 mg/dL, HDL-C 67mg/dL, TG 90mg/dL, AST 19 U/L, ALT 17 U/L, r-GTP 17 U/L, BUN 17mg/dL, Cr 0.8mg/dL, uric acid 3.9mg/dL, Hb 17.6g/dL, RBC 569 x 10⁶ /μL, WBC8300 /μL, Plt 20.5 x 10⁴ /μL.

Clinical progress

The case had the experience to continue LCD every day before, then he began super-LCD again from autumn 2021. Super-LCD means the restriction of carbohydrate meal as possible associated with approximately 12% carbohydrate content by calorie ratio.¹² He could control daily meal with less carbohydrate, and take pictures of meals for long period. He has been working in the administration department of large hospital, and then he can check post-prandial blood glucose

when he had continued LCD meal for long. His post-prandial blood glucose was proved to be mostly increased after 45 minutes after breakfast.¹³ Consequently, he checked 45-min postprandial blood glucose.

Results

The case has checked the picture of actual breakfast and also 45-min post-prandial blood glucose after breakfast. Among them, four representative data are shown in Table 1, which clarified the detail carbohydrate amount in the foodstuff and blood glucose levels. In Table 1, carbohydrate amount in breakfast varies from 32.0 g to 51.1g, and 45-min post-prandial blood glucose distribute 132mg/dL to 205mg/dL. His lifestyle is stable and morning situation is always same around the breakfast.

Table 1 Carbohydrate amount and post-prandial blood glucose in breakfast

breakfast	Ingredient	each Carbo (gram)	total Carbo (gram)	Glucose-45min (mg/dL)
A	white rice 75g	24.0	42.1	205
	glucomannan 75g	13.0		
	salmon	0.1		
	miso soup, etc.	5.0		
B	plain bread 30g	30.4	37.4	132
	chiken meat	6.0		
	salad	0.2		
	coffee	0.8		
C	Melon-flavored bread	49.7	51.1	188
	egg	0.1		
	bacon	0.3		
	salad	0.2		
D	plain bread 30g	30.4	32.0	142
	slice cheese	0.4		
	two pieces of ham	0.2		
	salad	0.2		
	coffee	0.8		

The relationship between carbohydrate amount in breakfast and 45-min post-prandial blood glucose was shown in Figure 1. The ranges are from 19.7 g to 51.1g in carbohydrate amount and from 121mg/dL to 226mg/dL in post-prandial blood glucose. Significant correlation was observed between them ($R^2=0.46$, $p<0.05$). Regression curve revealed $y = 2.5897x + 73.226$, in which the slope of the straight line is 2.6.

Discussion

In latest standard diabetic guideline by ADA, there is a general comment with evidence level B.³ Reduced intake of overall carbohydrate for diabetic patient has showed the most evidence of improving glucose variability. It may be applied in various type of eating way which meets each preference and need of each person. There is another comment with evidence level A, where patients with diabetes or increased risk should minimize consuming of foods with added sugar. Such foods may have the possibility to change more healthy and higher nutrient food choice.³

Regarding the treatment for diabetes, the fundamental principle has been proposed for long. Reducing caloric intake and increasing physical activity will be focused to lifestyle intervention for the first-line treatment for T2DM.¹⁴ However, LCD has been prevalent and evaluated to be clinically effective for several aspects.¹⁵ They include to improve daily glucose variability, to reduce glucose-lowering agents for T2DM patients and to reduce body weight.¹⁶

In order to distinguish among several clinical trials for LCD, the carbohydrate ratio by the percentage of total energy intake was

investigated.¹⁷ As a result, carbohydrate intake of <10% is VLCKD (a very low-carbohydrate ketogenic diet), 10-25% is LCD (a low carbohydrate diet), 26-45% is a moderate carbohydrate diet, and >45% is a high-carbohydrate diet.^{18,19} As the greater carbohydrate is restricted, the greater glucose-lowering efficacy is found in T2DM.²⁰ However, it is not clarified yet whether strong restriction may lead to reduction of cardiovascular risk factors including blood pressure, hyperlipidemia and body composition.¹⁹

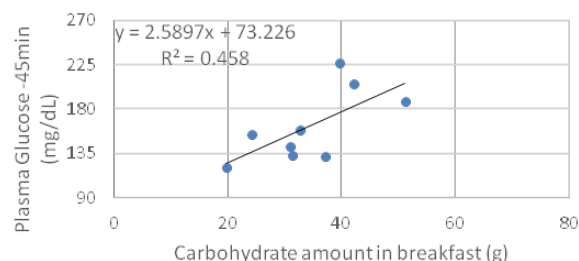
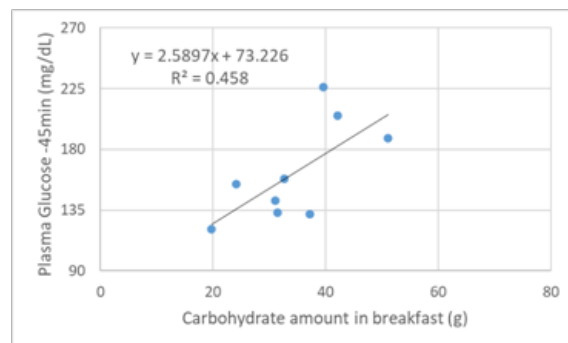


Figure 1 Relationship between carbohydrate amount and post-prandial glucose.

From lots of meta-analyses and reviews, greater glucose-lowering efficacies by LCD were found compared with control diets. These results may be influenced by various factors other than LCD alone.²¹ Then, clinical effects by LCD may be underestimated in some reports with certain protocols.²² However, our previous study showed clinical efficacy of LCD for 2700 cases with obesity, in which average weight reduction was 6.6% associated with middle 50% (25%-75%) of 2.6%-9.8% as 4.3kg weight reduction.²³

In the current case, detail data of carbohydrate and post-prandial blood glucose were investigated (Table 1). Furthermore, both parameters showed positive correlation (Figure 1). As to the regression curve, the slope of the straight line is 2.6. This means that 1g of carbohydrate may increase about 3mg/dL of blood glucose. Authors and co-researchers have given lectures of LCD to various subjects, patients and associations so far. In the standard textbook of biochemistry, intake of carbohydrate increases blood glucose values.²⁴ Among them, we have taught that 1g of carbohydrate can increase 3mg/dL of blood glucose in the case of T2DM.²⁵ Similarly, 5mg/dL and 1mg/dL of blood glucose will be increased in the case of T1DM patient and normal healthy subject, respectively.²⁶ Consequently, obtained results of 2.6mg/dL per 1g of carbohydrate would be almost near data of 3mg/dL per 1g of carbohydrate. Further detail study with lots of data collection will be expected.

Conclusion

In summary, this report presented a diabetic male with LCD treatment. Detail records and relationship of carbohydrate amount and

post-prandial blood glucose was investigated. Restricted carbohydrate intake would be beneficial for improving glucose variability. Current meaningful case will hopefully become a reference for clinical research development in diabetic medicine.

Ethical considerations

This study was conducted by the adequate ethical principles, which is the Declaration of Helsinki. Further, several comments were cited from the Ethical Guidelines for Research for Human beings and conduction of the Good Clinical Practice (GCP). Authors and colleagues were given written informed consent from the case in the current investigation. Moreover, we established the ethical hospital committee for the clinical research including medical, pharmacological and legal specialties. Related professionals have discussed enough and made confirmation that this study be adequate and proper by all members.

Conflicts of interest

The authors declare no conflicts of interest.

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