



# Clinical Efficacy of Low Carbohydrate Diet (LCD) For Detail Analysis of Daily Meal and Blood Glucose

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## Abstract

**Background:** Regarding nutritional therapy for obesity and diabetes, low carbohydrate diet (LCD) has been effective.

**Case presentation:** The case is 61-year-old male with obesity and type 2 diabetes mellitus (T2DM). He has been an athlete for long, and exercised much in hot climate during Mar-Sept, 2021. He often drank much amount of oral rehydration solution (ORS) and sports drink solution (SDS). In late Sept, he felt strong fatigue, weight loss, thirsty, and visited a clinic. He was diagnosed to have severe T2DM with HbA1c 14.0%.

**Results:** He started to take super-LCD and to take pictures of all meals every day. He can continue them perfectly and HbA1c decreased to 10.7% in October and 7.8% in November. He has checked pre-prandial and post-prandial blood glucose, ranging almost 120-200 mg/dL due to LCD continuation. Daily carbohydrate intake amounts were checked, which were 87g, 137g, 81g and 136g.

**Discussion and Conclusion:** His intake of ORS and SDS seemed to be adequate judging from their difference. The clinical course was successful, that was probably due to satisfactory lifestyle, continuing LCD and recording diet method, accumulating picture data of all meal, calculating carbohydrate and calorie intake every day. This case become a significant reference.

**Keywords:** Low carbohydrate diet (LCD); Type 2 diabetes mellitus (T2DM); Oral rehydration solution (ORS); Sports drink solution (SDS); Daily carbohydrate intake; Recording diet

## Introduction

Diabetes mellitus (DM) has been gradually increasing for long years worldwide, reaching to the degree of pandemic. It includes apparent DM and also undiagnosed diabetes mellitus (UDM). International Diabetes Federation (IDF) has continued various management for DM and presented the estimates of UDM [1]. From worldwide data, approximately one in two adult population (20 to 79 years) with diabetes were unaware of their diabetes status, which was 239.7 million and 44.7%. Combined of clinical DM and UDM, the prevalence was reported to be 9.3% in 2019, and will be up to 10.2% and 10.9% in 2030 and 2045,

respectively [2]. Obesity is usually the basis of diabetes and metabolic syndrome [3]. Therefore, it is necessary to take appropriate measures against obesity from an early stage. Proper diet and exercise are fundamentally essential for these responses [4]. For nutritional therapy for obesity and diabetes, low carbohydrate diet (LCD) has been effective. Before LCD, calorie restriction (CR) was standard diet method by the calculation of total calorie a day. However, several researchers in western countries reported clinical efficacy of LCD from historical point of view [5]. After that, detail comparison of three meals with LCD, CR and Mediterranean diet was reported [6]. Recently, LCD has been estimated to become first approach for the

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management of diabetes and obesity [7]. Similar to European countries, LCD in Japan was initiated by authors and collaborators [8]. For practical application of LCD for everyone, three types of LCD were presented, which are super LCD, standard LCD and petite LCD. They are easy to understand to continue for daily diet therapy, where carbohydrate content by calorie ratio is 12%, 26% and 40%, respectively [9]. Successively, we have continued the development of LCD in the light of medical and social aspects by establishment of Japan Low Carbohydrate Diet Promotion Association (JLCDPA) [10]. We have treated thousands of obesity patients for LCD, in which 25% of the patients achieved reduction more than 10% of former body weight [11]. Authors and collaborators continued practice and research of diabetes and LCD for years [12]. Furthermore, clinical research of insulin secretion for meal tolerance test (MTT) was conducted [13]. During our medical practice, 61-year-old male with obesity and type 2 diabetes mellitus (T2DM) was treated for LCD. The case showed remarkable improvement of diabetic status by strict LCD meal with complete recording data. His clinical course with some perspectives will be described in this article.

## Case Presentation

### History of present illness (HPI)

The case is a 61-year-old man with obesity and type 2 diabetes mellitus (T2DM). When he was a child, he started to play baseball. He became an excellent pitcher and he could throw fast ball about 150 km/hr. During senior high school, he was known widely and had the possibility to be selected to the draft selection of Nippon Professional Baseball (NPB) Organization. However, he had to throw too much games, and then he hurt his shoulder and elbow. He had to resign entering NPB. After that, he has worked in the administration section of the hospital. With his diligence and trust from others, he became the general manager of the hospital and developed his career in the medicinal practice. Furthermore, he contributed much in the baseball and softball sports fields. He won in several baseball tournament, including all-Japan national sports festival as a player, coach and manager. He also continues teaching other coaches in senior baseball teams and developing research of sports medicine in Research association of baseball Tokushima (RABT).

Concerning his health status, he was healthy until 30's. During his 40's, his weight increased from 78kg to more than 100kg. He was diagnosed as obesity and T2DM in his late 50's. Then, he was advised to continue LCD, resulting in 10kg weight reduction until 2020. When he played many softball games in Mar-Sept, 2021, he drank much amount of oral rehydration solution (ORS) and sports drink solution (SDS). He felt strong fatigue and weight loss in late Sept, and his HbA1c was proved to be 14.0%.

## Physical and Other Examination

As to physical status, his consciousness, speech and behaviour were normal. Vitals were pulse rate 56/min, BP 136/82 with normal temperature and respiration. His physique was 181 cm, 87kg, 26.6 kg/m<sup>2</sup> in BMI and 88 cm in abdominal circumference. For reference, his former physique during 50's was 104kg, 31.7 kg/m<sup>2</sup> and 110cm when he was 50-56 years old. His physical examination showed unremarkable in the lung, heart, abdomen and neurological findings. The results of several examinations in Sept, 2021 were as follows: Hb 16.2 g/dL, RBC 508 x 10<sup>6</sup> /μL, WBC 8600 /μL, Plt 21.1 x 10<sup>4</sup> /μL, BUN 14 mg/dL, Cr 0.7 mg/dL, uric acid 3.0 mg/dL, TG 100 mg/dL, HDL-C 65 mg/dL, LDL-C 142 mg/dL, TP 7.3 g/dL, Alb 4.3 g/dL, AST 22 U/L, ALT 28 U/L, GGT 25 U/L, ALP 193 U/L (100-340), LDH 141 U/L (120-240), CRP 0.02 mg/dL, Concerning diabetes, HbA1c 14.0%, post-prandial blood glucose 292 mg/dL. Other examinations were as follows: Chest X-P was unremarkable, and electrocardiogram (ECG) revealed within normal limits. The examination of pulse wave velocity (PWV) showed that ankle brachial index (ABI) 1.19/1.19, cardio-ankle vascular index (CAVI) 9.3/9.2 in right/left, respectively.

## Clinical Course and Results

His severe diabetic status was found in later September, 2021. At once, he was to begin LCD meals for three meals a day. He could continue LCD every day and the actual meals are recorded by camera. Furthermore, he could check the values of blood glucose frequently, which were regularly connected to pre-prandial and post-prandial timing. The results of fasting, and 45 min postprandial data of lunch and supper are summarized (Table 1).

The values of pre-prandial and post-prandial glucose were well controlled between about 120-200 mg/dL, which was due to limited intake of carbohydrate. Furthermore, his daily meals are recorded every day. The actual meals on Oct 20, Nov 5, Nov 12 and Nov 19 are observed (Figure 1).

Taken food included meat, salad, soup, Japanese style pot, bread, noodle, and so on. They showed less carbohydrate intake amount per day, which were 87g, 137g, 81g and 136g, respectively. For one of 4 days in Figure 1, the detail content of the meal on Oct 2 are as follows: i) breakfast: low-carbohydrate chocolate bread 1.7g, cream stew-style soup 12g, coffee 1g, ii) lunch: lunch box including mackerel dishes 6.5g, roast beef 7.7g, salad 1g, miso soup 13g, iii) supper: omelette 27.7g, salad 1g, boiled seaweed 7.6g, iv) snack: fruit citrus 7.4g. For total calculation, carbohydrate amount is 87g/day, and total calories is 1589 kcal/day. By continuing LCD, his HbA1c levels were acutely decreased. During Sept-Nov, 2021, HbA1c values were 14.0%, 10.3% and 7.8%, respectively.



Figure 1: Actual meal for LCD with carbohydrate amount.

## Discussion

In current case, some characteristic points are observed in the following: i) he has been an athlete working in the hospital, who has rather enough knowledge for general medicine and sports medicine, ii) he was treated obesity and T2DM by LCD about a year ago, iii) drinking much amount of oral rehydration solution (ORS) and sports drink solution (SDS) can become a trigger for exacerbation of diabetic control, iv) continuation of LCD and recording every meal was effective for clinical improvement. Their perspectives are described in order.

Firstly, the case has been a baseball player so far, and was not obese until 40 years old. During 40s and 50s, he came to have obesity and T2DM. He tried some kinds of nutritional and exercise approaches for weight reduction, including calorie restriction (CR) and resistance muscle training. However, they were not effective or successful [14].

Table 1: The results of fasting, and 45 min postprandial data of lunch and supper are summarized.

| Month | Date | breakfast-0min | breakfast-45min | supper-45min  | carbohydrate | calorie    | actual  |
|-------|------|----------------|-----------------|---------------|--------------|------------|---------|
|       |      | blood glucose  | blood glucose   | blood glucose | amount       | energy     | meal    |
|       |      | (mg/dL)        | (mg/dL)         | (mg/dL)       | (g/day)      | (kcal/day) | (Fig 1) |
| Oct   | 4    |                | 121             |               | 66           | 1882       |         |
|       | 6    | 148            |                 |               | 50           | 1787       |         |
|       | 8    |                |                 | 130           | 140          | 1573       |         |
|       | 11   |                | 205             |               | 101          | 1313       |         |
|       | 13   | 111            |                 |               | 104          | 2387       |         |
|       | 15   |                |                 | 220           | 91           | 1490       |         |
|       | 18   |                | 226             |               | 83           | 1348       |         |
|       | 20   | 118            |                 |               | 87           | 1589       | Fig 1a  |
|       | 22   |                |                 | 133           | 99           | 1970       |         |
| Nov   | 1    |                | 132             |               | 176          | 1400       |         |
|       | 3    | 132            |                 |               | 130          | 1633       |         |
|       | 5    |                |                 | 166           | 137          | 1663       | Fig.1b  |
|       | 8    |                | 188             |               | 110          | 1970       |         |
|       | 10   | 121            |                 |               | 150          | 1679       |         |
|       | 12   |                |                 | 150           | 81           | 1494       | Fig 1c  |
|       | 15   |                | 154             |               | 132          | 2032       |         |
|       | 17   | 123            |                 |               | 103          | 2294       |         |
|       | 19   |                |                 | 145           | 136          | 1182       | Fig 1d  |
|       | 22   |                | 143             |               | 166          | 1839       |         |

From current episode, he came to know actual efficacy of LCD and recording diet method [15].

Secondly, he had the experience for LCD a year ago. At that time, clinical efficacy was not enough. The reason would be the degree of carbohydrate restriction. We have developed LCD movement medically and socially through Japan LCD Promotion Association (JLCDPA) [9]. There are three levels of LCD, which are super LCD, standard LCD and petite LCD, associated with

carbohydrate ratio of 12%, 26% and 40%, respectively. He applied petite LCD in autumn 2020, and super-LCD in autumn 2021 [16]. Authors and colleagues have continued LCD treatment for more than 2700 cases with diabetes, obesity and metabolic syndrome [17]. The results showed that weight reduction was 6.6% in average, and 2.6%-9.8% in the quartiles of 25%-75% associated with mean weight reduction as 4.3 kg.

Thirdly, he drank much amount of ORS and SDS during Mar-Sept 2021, and this episode may bring the exacerbation of T2DM. Actually, he drank about 1000cc of ORS in Mar-May with rather mild climate period. After that he drank about 2000-3000cc of SDS in Jun-Sept with severe hot climate period. Thus, his method of ingesting water seemed to be appropriate. The reason is the difference in the components of ORS and SDS [18]. The purpose of ORS is to treat dehydration caused by illness and diarrhea. On the other hand, the purpose of SDS is to replenish water, sugar, and minerals due to a large amount of sweating in sports [19]. However, these objectives have been often confused in our usual daily lives [20].

As to ORS, he utilized Pocari sweat (Otsuka Pharma, Japan) [21]. The content shows carbohydrate 6.2g, protein and fat 0g, energy 25kcal, NaCl 0.12g, K 20mg, Ca 2mg, Mg 0.6mg. For SDS, he used Body mainte (Otsuka Pharma, Japan) [22]. The content was carbohydrate 4.4g, protein and fat 0g, Energy 18kcal, NaCl 0.13g, K 20mg, Ca 2mg, Mg 0.6mg, as well as lactic acid bacterium B240. B240 was found from a plant, which has been used for fermented tea in Thailand [23]. From immunological point of view, B240 (*Lactobacillus pentosus* ONRICb0240) has been utilized for developing new conditioning beverage [22]. Several beneficial enhancements have been observed including blood T-helper, NK cell, IgA/IgG levels, and other immune functions [23]. Some positive efficacy would be found for elderly people, physical exercise [24-26].

Fourthly, continuation of LCD with recording data has successfully brought him clinical improvement for glucose variability. Formerly, American Diabetes Association (ADA) presented the official comment, in which only carbohydrate can directly affect blood glucose levels [27]. It is well-known that diabetic pathophysiological problems are due to elevated blood glucose, such as microvascular and macrovascular disorders [28]. Then, restriction of carbohydrate intake per os can refrain from hyperglycemia. Several evidence of LCD efficacy were reported from various studies [6,29]. Further beneficial data for LCD were found in some mega-studies [30,31]. From these reports, carbohydrate loading per os may become one of the evaluation methods. Meal Tolerance Test (MTT) is a useful way to apply certain amount of carbohydrate for breakfast. Authors have proposed MTT using 70g-Carbo breakfast [32]. MTT seems to be applied more for simple examination for glucose variability [33]. Regarding most recent reports on LCD, significant tendency can be found for short and long period [34], and for LCD and very LCD. Future comparative study for LCD seems to focus in detail differences, with expectation for beneficial diet method for diabetes and obesity [35].

In summary, this case report showed a diabetic male with obesity and T2DM. Several problems and discussion were described. There are some limitations such as detail situation of diabetes,

hydration, ORS, SDS, and actual LCD meals, which will be further investigated and follow up. We hope that this meaningful case will be useful for medical development of diabetes and research in the future.

## Ethical Considerations

Current study was performed in compliance with the adequate ethical principles. It is due to the Declaration of Helsinki. Moreover, some commentary was shown for the Ethical Guidelines for Research in the medical field for Human beings and in the conduction of the Good Clinical Practice (GCP). Authors have been provided written informed consent from the patient himself in this study. In addition, authors established the ethical committee for the clinical research including medical, pharmacological and legal specialties. We have fully discussed the detail of the study and made confirmation that this study would be proper and agreed with all members.

## Conflict of Interest

The authors declare no conflict of interest.

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