CASE REPORT

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Unfavorable Effects of Low-carbonhydrate Diet in a Pediatric Patient with Type 1 Diabetes Mellitus

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What is already known on this topic?

Low-carbohydrate diet is used in adults who are obese or have type 2 diabetes. Its use in children is limited to resistant epilepsy.

What this study adds?

Low-carbohydrate diet is not recommended for glycemic control in children with type 1 diabetes mellitus (T1DM), as it causes growth retardation, increased blood lipid levels, and risk of cardiovascular disease. Nutritional therapy for children and adolescents with T1DM should be based on widely accepted clinical guidelines.

Abstract

A balanced and healthy diet is very important in type 1 diabetes mellitus (T1DM) in childhood. In addition to regulating blood glucose with diet, diet should also support optimal growth. Low-carbohydrate diet aims to provide daily energy from fats and was originally used for childhood epilepsy. We present a patient with T1DM who experienced unfavorable effects when on a low-carbohydrate diet.

Keywords: Low-carbohydrate diet, type 1 diabetes mellitus, nutrition therapy, childhood

Introduction

Nutritional therapy is one of the basic mainstays of type 1 diabetes mellitus (T1DM) management and should include macro- and micro-nutrients that are based on universally accepted clinical guidelines. In addition, nutritional therapy should support the normal growth and development of children while also aiding in metabolic control, and should comply with healthy eating principles and the nutritional habits of the individual (1,2). In the guidelines of the International Pediatric and Adolescent Diabetes Association it has been suggested that for energy needs 45-55% be met from carbohydrates, 30-35% from fats (< 10% saturated fat + trans fatty acids), and 15-20% from proteins (1).

The ketogenic diet (KD) is a low-carbohydrate (low-carb), protein-limited and high-fat diet that aims to provide daily energy from fats. Low-carb diets have recently been popularized in social media, by showing healthy benefits. Here, we present the clinical and laboratory findings of a patient who has been on a low-carb diet for two years after the diagnosis of T1DM and the negative effects of this nutrition model in childhood will be discussed.

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Case Report

A 6.42 year-old female patient attended our clinic because of being overweight. She had been overweight from the age of three. She was born with a birth weight of 2.950 g at term. There were no unusual features in her prenatal and natal history. Her mother had Hashimoto thyroiditis (HT), father had multiple sclerosis, and 25-year-old sister had T1DM and had been using insulin therapy for 18 years. Her height was 121 cm [0.49 standard deviation score (SDS)], body weight (BW) was 31 kg (1.78 SDS) and body mass index (BMI) was 21.17 kg/m^2 (1.87 SDS). Her blood pressure was 120/70 mmHg, thyroid gland was non-palpable, and pubertal stage was Tanner stage 1. Laboratory examinations revealed a glucose 90 mg/dL, normal liver transaminases (SGOT 34 U/L NR <47 and SGPT 24 U/L NR 0-39), cholesterol 217 mg/dL (NR 96-211), low-density lipoprotein (LDL) cholesterol 140 mg/dL (NR 38-140), high-density lipoprotein (HDL) cholesterol 57 mg/dL (NR >35), triglycerides 102 mg/dL (NR 35-110), a thyroid stimulating hormone (TSH) of 3.67 µIU/mL (NR 0.6-5.5), and a free thyroxine (fT4) of 1.26 ng/dL (NR 0.8-1.9). No fatty liver was detected in the abdominal ultrasonography (USG). The patient, who was overweight, was followed-up by making recommendations for a healthy diet with appropriate calories for her age and exercise.

In the first year of her follow-up, when she was 7.33 years old, she attended with complaints of increased appetite and not gaining weight. Her height was 127 cm (0.74 SDS), BW was 34 kg (1.98 SDS) and BMI was 21.08 kg/m^2 (1.94 SDS), blood pressure was 110/70 mmHg, pubertal stage was Tanner stage 1 and other system examinations were normal. Her blood sugar was 280 mg/dL (NR <100 mg/dL), hemoglobin A1c (HbA1c) 7.8%, and c-peptide 0.925 ng/mL (NR 1.1-4.4). The patient had positive diabetes autoantibodies with islet antibody 67.05 U/mL (<1), anti-GAD 41.45 U/mL (<1) and was diagnosed with T1DM and an intensive insulin regimen (1 U/kg/day; 60% insulin lispro, 40% insulin glargin) was started. A diabetic diet was recommended to her providing 1711 kcal, made up of 53% carbohydrates, 19% protein, and 28% fat (5.8% saturated fatty acids, 3.5% polyunsaturated fatty acids, 16.4% monounsaturated fatty acids). Diabetes education was given to the family and the patient and she was discharged.

The patient, who continued her follow-up in a private endocrinology clinic for a while, was found to have a TSH of 27.4 µIU/mL (0.6-5.5) and fT4 1.42 ng/dL (0.8-1.9) during this period and sodium levothyroxine (LT4) treatment was started for supposed HT. Thyroid antibodies were positive. She then left the pediatric endocrinology clinic and was followed in a private clinic. In this private clinic, the patient was given a low-carb diet consisting of 1342 kcal, 23% carbohydrates, 23% protein, 54% fat (15.8% saturated fatty acids, 11.8% polyunsaturated fatty acids, and 22.8% monounsaturated fatty acids). She was fed with a low-carb diet for two years, and the LT4 treatment was discontinued.

After two years on a low-carb diet, the patient re-attended our department when she was 9.25 years old because her blood sugar was high while she was taking the low-carb diet. At that time, height was 131.7 cm (-0.35 SDS), BW was 26.35 kg (-0.71 SDS), BMI was 15.19 kg/m^2 (-0.69 SDS), goiter stage 1b, puberty Tanner stage 1 and other system examinations were normal. The growth rate during feeding with the KD was 4.7 cm over two years. The patient's complete blood count, serum electrolytes, and kidney function tests were normal. However, liver function tests and lipid profile were SGOT 111 U/L (<47), SGPT 168 U/L (0-39), cholesterol 1029 mg/dL, LDL cholesterol 826 mg/dL, HDL cholesterol 136.2 mg/dL, and triglycerides 334 mg/dL. Thyroid function tests were TSH 10.275 µIU/mL and fT4 1.18 ng/dL. Her HbA1c was 7.78% and c-peptide was 0.41 ng/mL. Stage 1 hepatosteatosis was detected on abdominal USG. Carotid color Doppler USG and echocardiographic examinations were normal. No diabetic retinopathy was detected in the eye examination. The patient was started on intensive insulin regimen (multiple daily injection treatment, 1 U/kg/day; 60% insulin lispro and 40% insulin glargine treatment) and 2 mcg/kg/day LT4 therapy. Her nutrition therapy was revised again to 1908 kcal, provided by 56% carbohydrates, 18% protein, and 26% fat (5.5% saturated fatty acids, 3.4% polyunsaturated fatty acids, and 15% monounsaturated fatty acids). Atorvastatin treatment was started with the recommendation of the metabolism department until the blood lipid parameters decreased to acceptable levels, and ursodeoxycholic acid and vitamin E treatments were started with the recommendation of the gastroenterology department for elevated transaminases. Structured diabetes and diet education was given to the patient and her family again. The mother was reluctant to adhere to the healthy eating plan. In the follow-up, it was observed that there was an improvement in growth rate (5.04 cm/year), liver function tests returned to normal, and cholesterol levels decreased. The follow-up data of the patient is given in Table 1. Dietary contents at diagnosis and follow-up are given in Table 2.

Table 1. Clinical and laboratory findings of our patient with type 1 diabetes who applied low-carb diet

	First presentation	At diagnosis of T1DM	First presentation after low-carb diet	Third month follow-up after a healthy diet plan and intensive insulin therapy	One year after a healthy diet and intensive insulin therapy
Age (years)	6.42	7.33	9.25	9.5	10.42
Height (SDS), cm	121 (0.49)	127 (0.74)	131.7 (-0.35)	132.5 (-0.45)	136.7 cm (-0.65)
Weight (SDS), kg	31 (1.78)	34 (1.98)	26.35 (-0.7)	28.25 (-0.48)	32.85 (-0.31)
Body mass index (SDS), kg/m²	21.17 (1.87)	21.08 (1.94)	15.19 (-0.69)	16.09 (0.31)	17.5 (0.04)
Puberty (Tanner stage)	1	1	1	1	2
Growth rate	-	6 cm/year	2.35 cm/year	3.2 cm/year	5.04 cm/year
HbA1c (%)	-	7.1	7.78	6.19	7.8
C-peptide (ng/mL)	-	1.1	0.41		
Cholesterol (mg/dL)	217	203	1029	348.0	351
LDL cholesterol (mg/dL)	140	125	826	249	255
HDL cholesterol (mg/dl)	57	53	136.2	88.9	80,5
Triglyceride (mg/dL)	102	125	334	50	80
SGOT (U/L)	34	33	111	52	28
SGPT (U/L)	24	22	168	53	17
Abdominal USG	Normal	-	Stage 1 hepatosteatosis	-	
TSH (µIU/mL)	3.675	2.876	10.275	1.091	1.8
fT4 (ng/dL)	1.26	1.07	1.18	1.59	1.5
Anti TPO (IU/mL)	287.6	538.1	1300	-	-
Anti Tg (IU/mL)	29.5	223.2	289.4	-	-

SDS: standard deviation score, HbA1c: hemoglobin A1c, LDL: low-density lipoprotein, HDL: high-density lipoprotein, USG: ultrasonography, TSH: thyroid stimulating hormone, fT4: free thyroxine

Table 2. Composition of the three dietary interventions

	Reference diabetic diet	Carbohyrate-restricted diet	Reference diabetic diet
Age (years)	7.33	9.25	9.5
Total energy intake (kcal)	1711	1342	1908
Carbohydrates (g)	222	75.9	260
Carbohydrates (%)	53	23	56
Fibre (g)	41.4	12.8	46.1
Protein (g)	77.0	75.1	83.2
Protein (%)	19	23	18
Fat (g)	53.6	81.1	55.6
Fat (%)	28	54	26
SFA (g)	11.2	23.6	11.7
SFA (%)	5.8	15.8	5.5
PUFA (g)	6.7	17.7	7.3
PUFA (%)	3.5	11.8	3.4
MUFA (g)	31.3	34.0	31.9
MUFA (%)	16.4	22.8	15.0
Cholesterol (mg)	252.3	319.1	291.9
Trans fatty acids (g)	0	0	0

SFA: saturated fatty acids, PUFA: polyunsaturated fatty acids, MUFA: monounsaturated fatty acids

Discussion

Low-carb diets, which have recently become one of the trendy diets, have been popularized as promoting good health in the social media, individual internet blogs, on television and in nutrition magazines. If daily energy is provided by more than 55% carbohydrate intake, it is called a high carbohydrate diet, while approximately 45% energy provision is average carbohydrate, while less than 26% intake is low-carb, and if there is less than 10% intake, it is called very low-carbdiet (3). The KD is a low-carb, protein-limited, high-fat, long-chain triglyceride-rich diet that aims to meet daily energy from fats. Protein intake is kept at the lower limit of daily requirement and carbohydrate intake is severely limited. The use of KD in the pediatric population is limited to epilepsy treatment (4). While the side effects of the KD in the acute period are vomiting and fatigue, in the chronic period, side effects such as stagnation in growth and development, impaired lipid profile, vitamin-mineral deficiencies, pancreatitis, kidney stones, arrhythmia, cardiomyopathy, and osteopenia have been reported (3,5,6,7).

The use of KD has come to the fore in individuals with diabetes, with the thought that it reduces both glycemic fluctuations and insulin need with less carbohydrates, but studies investigating its place in T1DM treatment are mostly studies with a small sample, conducted in the adult age group (5,6). Childhood diabetes differs from adult diabetes in that it has longer sleep duration, frequent infections, unpredictable physical activity and eating patterns, non-adherence to treatment in adolescence, concerns about appearance, variable metabolic status, and insulin requirement (1). Therefore, effective treatment and management of pediatric and adult T1DM will differ.

Since nutrition with KD cannot provide enough energy in growing children, the most striking feature is the slowdown in growth rate. The present case only grew 4.7 cm in height over the two years that she used a KD, which was abnormally low for her age. After a healthy diet and multi-dose insulin therapy, the annual growth rate returned to normal. There is a misconception that less carbohydrate consumption and therefore reduced insulin requirement are better in KD nutrition, but insulin is directly and indirectly effective in cell growth and proliferation. Insulin acts by binding directly to the insulin-like growth factor-1 (IGF-1) receptor, indirectly increasing the hepatic production of IGF-1, and is in a synergistic relationship with growth hormone and other growth stimulating factors (3). Thyroid hormones are also effective in growth. Our patient's thyroid mismanagement may have contributed to the poor linear growth. As in KD, high-fat diets have also been shown to blunt pituitary growth hormone secretion. Growth arrest has been reported in the literature in patients with T1DM fed low-carb diets (2,7). It has also been shown that children with T1DM who receive intensive insulin therapy and are fed low-carb and high fat have worse glycemic control and higher HbA1c values (8,9). There are also studies showing that feeding with KD increases the risk of hypoglycemia and impairs the effectiveness of glucagon used in the treatment of hypoglycemia (10). In nutritional studies, it has been observed that as the amount of carbohydrates in the daily diet decreases, children tend to consume lower quality foods (11).

Another negative aspect of KD is that it increases blood lipids. Since the blood lipid results in our patient were above the values seen in familial homozygous hypercholesterolemia, which is the most severe form of hypercholesterolemia, and the lipid profile measured at the age of 6.42 years was close to normal, increased lipid levels may be considered as a serious complication of KD in this case. This dyslipidemia after feeding with KD have been reported previously (2,3,4,5,6,7). In a series in which six children with T1DM who followed a low-carb diet were reported, there was a case with dyslipidemia (2). The development of dyslipidemia is associated with excessive consumption of saturated fats instead of carbohydrates and, worryingly, increases the risk of cardiovascular disease (11).

Consumption of more than one type of food group and making restrictions in nutrition in childhood may also result in psychological comorbidities. This type of diet may cause social isolation and the related psychosocial burden in children. In addition, this restricted eating pattern may lead to eating disorders in the future (2).

Conclusion

In summary, in T1DM the nutrition plan should include sufficient energy and micro- and macro-nutrients to ensure the growth of the child. Nutritional therapy with KD is not recommended for glycemic control in children with T1DM, as it causes growth retardation, increased blood lipid levels, and increased risk of cardiovascular disease. Nutritional therapy for children and adolescents with T1DM should be based on universally accepted clinical guidelines.

Ethics

Informed Consent: Written informed consent was obtained from the parents of the patient.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Ceren Güleryüz, Ece Eker, Gülin Karacan Küçükali, Merve Şakar, Fatma Nur Genç, Nursel Muratoğlu Şahin, Selin Elmaoğulları, Semra Çetinkaya, Şenay Savaş Erdeve, Concept: Gülin Karacan Küçükali, Nursel Muratoğlu Şahin, Semra Çetinkaya, Şenay Savaş Erdeve, Design: Gülin Karacan Küçükali, Nursel Muratoğlu Şahin, Semra Çetinkaya, Şenay Savaş Erdeve, Data Collection or Processing: Ceren Güleryüz, Ece Eker, Merve Şakar, Fatma Nur Genç, Selin Elmaoğulları, Analysis or Interpretation: Gülin Karacan Küçükali, Fatma Nur Genç, Semra Çetinkaya, Şenay Savaş Erdeve, Literature Search: Ceren Güleryüz, Ece Eker, Gülin Karacan Küçükali, Semra Çetinkaya, Şenay Savaş Erdeve, Writing: Ceren Güleryüz, Ece Eker, Gülin Karacan Küçükali, Semra Çetinkaya, Şenay Savaş Erdeve.

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