A low-carbohydrate diet improves metabolic control in a type 1 diabetic child without side effects

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Introduction and objectives

Despite intensive insulin treatment of type 1 diabetes (T1DM), metabolic control remains suboptimal, especially in children. To optimize postprandial glycaemia, some families decrease the amount of carbohydrates contained in a meal. While "low-carbohydrate diets" may improve metabolic control in some selected populations, controversies remain around the risk of hypoglycemia and ketoacidosis and the impact of such diets on growth and development of children.

Research design and methods

We report the case of a child whose whole family started a low-carbohydrate diet when it was seven years old, in an attempt to induce weight reduction for the parents. The child adhered to this diet and subsequently developed T1DM at the age of eight years. It continued the same diet after diagnosis.

Results

HbA1c was 13.8% (127.3 mmol/mol) at the time of T1DM diagnosis and decreased to 7.3% (56.3mmol/mol) three months later. During subsequent follow-up, it ranged from 5.9% (41 mmol/mol) to 6.4% (46.6 mmol/mol). Time in range was > 90% most of the time (**figure 1**).

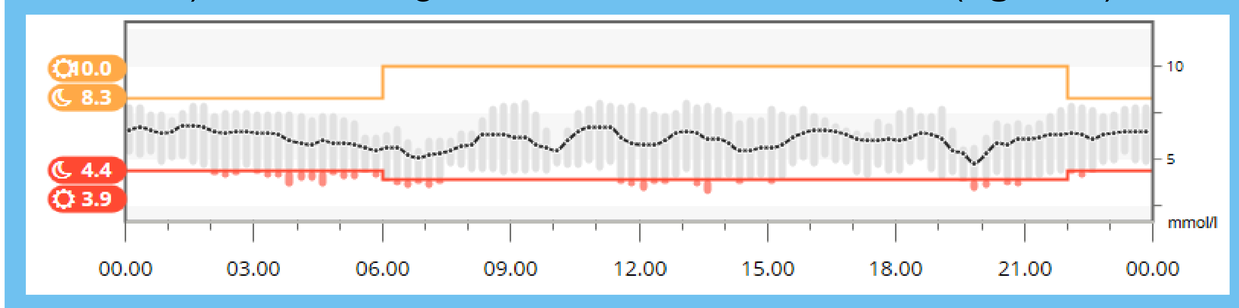

Figure 1: Representative CGM data over a period of 16 days

The diet of the child consisted of a mean of 33g carbohydrates per day (12% of the daily caloric intake) and numerous supplements such as omega-3 fatty acids, vitamins A, B1, B2, B6, B12, C, D, E and K, as well as folic acid were taken on a daily basis (**table 1**). Almost every meal or snack the child ate was homemade, including "low-carbohydrate" desserts and bread, made of almonds, linseed and Chia seeds.

Measurement	Reference values	
Vitamin A	1.00 – 2.10 µmol/l	1.16
Vitamin D (25-OH)	75 – 250 nmol/l	130
Vitamin E	7.0 – 20.9 µmol/l	31.9
Vitamin B6	8.7 – 27.2 µg/l	47.3
Vitamin B12	180 – 900 ng/l	> 1500
Vitamin C	2.0 – 14.0 mg/l	12.8
Folic acid	3 – 20 µg/l	> 24.1
Calcium (ionized)	1.12 – 1.32 mmol/l	1.16
Magnesium	0.7 – 1.1	0.9
Phosphates	1.4 – 1.8 mmol/l	1.4
Ferritin	30 – 300 µg/l	39
Zink	11 – 18 µmol/l	15.4
Selenium	0.88 – 1.54 µmol/l	1.23
Cholesterol	< 5.0 mmol/l	5.0
LDL-Cholesterol	< 2.6 mmol/l	2.6
HDL-Cholesterol	> 1.0 mmol/l	2.4
Triglycerides	< 1.7 mmol/l	0.4

Table 2: Laboratory measurements of selected metabolites

Nutrient	From meals	From supplements	Total/d	Recommended daily intake (1)	Percentage recommended intake
Vit. A (µg)	1566.9	1500.0	3066.9	900.0	**341 %**
Vit. D (µg)	4.4	58.0	62.4	20.0	**310 %**
Vit. E (mg-eq.)	7.6	109.5	117.1	11.0	**1065 %**
Vit. K (µg)	54.9	97.5	152.4	40.0	**381 %**
Vit. B1 (mg)	0.9	5.0	5.9	0.9	**656 %**
Vit. B2 (mg)	1.0	5.35	6.35	1.0	**635 %**
Vit. B6 (mg)	0.9	5.5	6.4	1.0	**640 %**
Vit. B12 (µg)	4.9	128	132.9	2.0	**6645 %**
Vit. C (mg)	96.0	462.0	558.0	65.0	**858 %**
Folic acid (µg)	180.5	420.5	601.0	240.0	**250 %**
Calcium (mg)	638.0	1225.0	1863.0	1100.0	**169 %**
Magnesium (mg)	127.4	453.0	580.4	250.0	**232 %**
Phosphorus (mg)	975.8	53.5	1029.3	1250.0	**82 %**
Iron (mg)	6.1	0.0	6.1	15.0	**41 %**
Zink (mg)	6.9	19.5	26.4	7.0	**377 %**
Selenium (µg)	0.0	78.5	78.5	45.0	**174 %**
Copper (mg)	0.6	2.1	2.7	1.0 - 1.5	**180 - 270 %**
Carbohydrates (g)	33.5 (12%		33.5	292.0	**11%**
Fat (g)	69.0 (52%)		69.0	71.0	**97%**
Proteins (g)	102.3 (36%		102.3	35.0	**292%**
Calories (kcal)	1185		1185	2000	**59 %**

Table 1: Estimated daily intake of (micro)nutrients and calories

Hypoglycemic events were rare and the insulin needs ranged from 0.11 to 0.24U/kg/day, despite low fasting c-peptide values of 40pmol/l (265-1390pmol/l). Despite these low insulin needs, ketone measurements were normal. After two years of carbohydrate restriction, weight gain and linear growth remained normal despite a suboptimal caloric intake (59% of recommended values), and no episode of ketoacidosis was observed.
Laboratory investigations showed total and LDL-cholesterol levels at the upper limit of normal. No micronutrient deficiencies were seen (**table 2**). On the contrary, some values were above normal limits, probably due to intake of supplements above recommended values.

Conclusions

According to the International Society for Paediatric and Adolescent Diabetes (ISPAD), it is recommended that 50 – 55% of energy be derived from carbohydrates for children with T1DM to avoid potential adverse outcomes such as abnormal growth, increased risk of hypoglycemia, increased risk of ketoacidosis, dyslipidemia, vitamin deficiencies and psychological side effects. There is currently no evidence to support this approach in children with T1DM but it is essential to accompany families who choose carbohydrate restriction in order to keep in touch with them on a long term and thus to be able to carefully monitor side effect of their dietary regimen. This case report shows that, despite a highly sophisticated diet, an appropriate intake of calories, lipids, cholesterol, proteins, dietary fibres and micronutrients is difficult to achieve, thus potentially affecting long-term health due to dyslipidemia, lack or excess of micronutrients, inappropriate energy intake and potential alteration of the gut microbiome.

(1) According to the recommended values by the Swiss, German and Autrian Societies for Nutrition

58ESPE P3-084
Diabetes and insulin
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Poster presented at: ESPE 2019 VIENNA
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