

A child with type 1 diabetes mellitus (T1DM) successfully treated with the Paleolithic ketogenic diet: A 19-month insulin freedom

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SUMMARY

Type 1 diabetes mellitus (T1DM) is a chronic disease resulting from autoimmune destruction of insulin secreting beta cells of the pancreas. Worldwide the number of new T1DM cases is on a continuous rise despite extensive research efforts during the past decades. Patients with T1DM require lifelong insulin replacement. Currently T1DM patients are put on a high carbohydrate/low fat diet, a practice which has recently been criticized by several investigators. Here we report our second case of T1DM successfully treated with the paleolithic ketogenic diet, an animal meat-fat based diet, which is the opposite of the standard diabetes diet in several respects. The 9-year-old child initially followed the traditional diabetes diet with insulin replacement. After six weeks the child switched to the paleolithic ketogenic diet under our close control. He was able to discontinue insulin while maintaining normoglycemia. Stimulated C peptide level was in the normal range at 14 months after diet onset. Currently he is on the diet and is without insulin for 19 months which is well beyond the "honeymoon" period. While on the paleolithic ketogenic diet subsequent laboratory work ups were normal and no side effects emerged. Following the dietary shift his eczema disappeared, the number of upper respiratory infections greatly reduced and improved physical fitness was noted. We assume that in new-onset cases of T1DM adopting the paleolithic ketogenic diet may be feasible and effective in managing this condition. It seems that the autoimmune process may halt when strictly adhering to the diet.



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CASE REPORT

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ABSTRACT

Introduction: Currently, type 1 diabetes mellitus (T1DM) is treated with insulin and a high carbohydrate diet. In literature, there are studies indicating that low carbohydrate diets may be beneficial in reducing hypoglycemic episodes as well as the need for insulin. Previously, we reported a case of a 19-year-old T1DM patient who was successfully treated with a modified version of the ketogenic diet we refer to as the Paleolithic ketogenic diet. **Case Report:** A nine-year-old child with T1DM who initially was on an insulin regime with high carbohydrate diet then was put on the Paleolithic ketogenic diet. Following dietary shift glucose levels normalized and he was able to discontinue insulin. No hypoglycemic episodes occurred on the diet and several other benefits were achieved including improved physical fitness, reduction of upper respiratory tract infections and eczema. Currently, he is on the diet for 19 months. **Conclusion:** Adopting the Paleolithic ketogenic diet ensured normoglycemia without the use of

external insulin. The diet was sustainable on the long-term. Neither complications nor side effects emerged on the diet.

Keywords: C peptide, Ketogenic diet, Ketosis, Low carbohydrate diet, Paleolithic diet, Paleolithic ketogenic diet, Type 1 diabetes mellitus

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INTRODUCTION

Currently, treatment of type 1 diabetes mellitus (T1DM) relies on insulin replacement together with a high-carbohydrate diet [1]. Two group studies, however, showed that putting patients on a low-carbohydrate diet results in decreased need for insulin, lowers the number of hypoglycemic episodes and can be maintained on the long-term without side-effects [2, 3]. The classical ketogenic diet is an established and effective treatment in epilepsy [4]. We are aware of four case studies in literature where epilepsy co-occurring with T1DM was treated with the classical ketogenic diet [5–8]. Recently, we have published a case of a 19-year-old patient with T1DM who was successfully managed with a modified version of the ketogenic diet we refer to as the Paleolithic ketogenic diet [9]. In that case insulin could be discontinued, glucose levels normalized and the level of C-peptide increased more than three-fold within two months. Herein, we report a case of a child with T1DM who was successfully

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treated with the Paleolithic ketogenic diet. The child has a follow-up of 19 months.

CASE REPORT

Medical history

The nine-year-old child had a three-month history of polyuria, polydipsia, polyphagia, fatigue and weight loss. His abdomen was bloated. He had frequent upper respiratory tract infections, epistaxis and eczema on his hands as well as asthma. A laboratory workup on 01 January 2014 showed glucose level of 692 mg/dl and glucose in the urine. A laboratory test on 07 January 2014 showed mild positivity of anti GAD (glutamic acid decarboxylase) antibodies (1280 IU/ml). He was placed on an insulin regime (21 IU daily) with six meals containing 210 g carbohydrate. He was on the conventional insulin therapy for six weeks. Although he strongly adhered to the prescribed diabetes diet his glucose levels fluctuated largely and his complaints (fatigue, eczema, bloated abdomen) persisted too. Therefore, parents of the child sought for alternative treatment options.

Paleolithic ketogenic diet

We first met the child and his parents on 13 February 2014. We advised the Paleolithic ketogenic diet consisting of only animal meat, fat, offal and eggs with a fat:protein ratio of about 2:1. Following our advice the child consumed meat, fat and offal only from cattle and pork. He did not consume vegetables and fruits at all. Artificial sweeteners and vegetable oils were excluded. He was allowed to consume small amounts of honey. The diet was introduced gradually within five days. During this time insulin was adjusted according to fingerstick glucose measurements. From the sixth day (from 18 February 2014), the child was on a full Paleolithic ketogenic diet. C-peptide measurement was performed on 13 February 2014 which showed 1.1 ng/ml (normal range: 0.9–7.1 ng/ml). Given that on the Paleolithic ketogenic diet glucose levels were normal both before and after meals insulin was discontinued. The child was advised to eat when hungry. Typically, he had three meals a day. Ketosis was regularly checked by urinary ketone strips which showed sustained ketosis. Food records together with fingerstick glucose were tracked daily. This latter showed normal levels both preprandially and postprandially. For statistical calculations and visualization purposes we selected fingerstick glucose measurements for the meal closest the noon (Figure 1). Glucose levels were significantly lower during the Paleolithic ketogenic diet as compared to the six weeks of the insulin regime both preprandially (Paleolithic ketogenic diet mean: 75.7 mg/dl; insulin regime mean: 146 mg/dl) and postprandially (Paleolithic ketogenic diet mean: 93.7 mg/dl; insulin regime mean: 198.2 mg/dl). Glucose levels showed higher

fluctuations during the insulin regime as also shown by larger standard deviation of glucose values on the insulin regime (SD=72 mg/dl) as compared to the Paleolithic ketogenic diet (SD=15.5 mg/dl). Hypoglycemic episodes which were frequent on the standard insulin regime completely disappeared while on the Paleolithic ketogenic diet. Currently, the child is on the Paleolithic ketogenic diet for 19 months without interruption (Figure 1).

Laboratory workup

Laboratory workups were carried out six times (Table 1). While on the Paleolithic ketogenic diet glucose levels on laboratory tests were between 86 and 130 mg/dl whereas his HgA1c levels were between 5.2 and 5.6%. Cholesterol and LDL cholesterol were slightly elevated. Uric acid was normal. Triglyceride measurements were normal except for elevations on 19 January 2014 and 03 February 2015 which were associated with parent reports of increased food intake. Other laboratory blood parameters were normal. Urinary ketones were positive on each laboratory test. C-peptide measurements indicated 0.7 ng/ml on 15 September 2014 and 0.5 ng/ml on 09 February 2015. Thus measured C-peptide levels seemed to decrease over time. The decrease of C-peptide levels following diagnosis onset is a well-known phenomenon in T1DM and is attributed to the progression of the autoimmune destruction of insulin secreting beta cells [10]. In our case, however, the very low carbohydrate intake might also have resulted in decreased levels of C-peptide. In order to get clues for distinguishing between the two possibilities we measured C-peptide twice two days apart at the same time of the day (in the morning). The first measurement was carried out in fasting (thus after a skipped breakfast) while the second one was carried out following having a usual breakfast. In other words, in the second case we measured a stimulated C-peptide, however, stimulation was done without carbohydrates only using his regular Paleolithic ketogenic diet. Fasting C-peptide on 27 April 2015 was 0.5 ng/ml while 1.2 ng/ml on 29 April 2015 following stimulation (Figure 2). Given that no data are

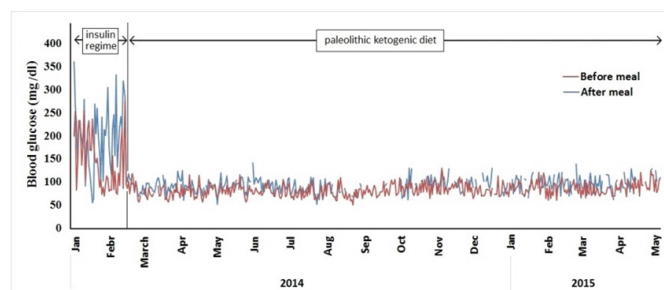


Figure 1: Blood glucose levels while on the standard diabetes diet containing 210 g carbohydrate with insulin therapy (21 IU daily) and while on the Paleolithic ketogenic diet without insulin. For visualization purposes out of the measurements we selected the meal closest to noon. Note normal glucose levels and the absence of large fluctuation in glucose levels following the shift towards the Paleolithic ketogenic diet.

available on C-peptide levels on a low carbohydrate diet in healthy subjects we additionally had two healthy normal controls (females, aged 39 and 42 years, respectively) who had been following the Paleolithic ketogenic diet to measure their fasting C-peptide levels. The two subjects were instructed to consume no carbohydrate for three days prior to blood test. These subjects had a C-peptide level of 1 and 1.3 ng/ml thus levels which also fall around the lower limit of the normal range.

Continuous subcutaneous glucose monitoring

We additionally performed continuous subcutaneous glucose monitoring (Medtronic, Guardian Real-Time

Continuous Glucose Monitoring System) for six days between 22 and 28 April 2015. The system provides an average tissue glucose measurement every five minutes. Sensor daily overlay is shown in Figure 2. On average glucose level was of 101 mg/dl. Glucose levels did not substantially change following having meals: during the 60 minutes before meals glucose level was 97 mg/dl on average while during the 60 minutes following meals it was of 94 mg/dl on average (Figure 3).

Changes in clinical and physical features

Shortly, after diet onset the child reported increased physical and mental fitness. His eczema disappeared within a few weeks. While on the paleolithic ketogenic

Table 1: Laboratory parameters between January 2014 and April 2015. Laboratory parameters on 01 January 2014 correspond the time of diagnosis (thus he was on a normal diet and not yet had insulin). Laboratory parameters on 07 January 2014 correspond to the insulin regime with 21 IU of insulin and 210 grams carbohydrate daily. Laboratory parameters on 03 April 2014 and thereafter correspond to the Paleolithic ketogenic diet without insulin. Note the low glucose levels as well as normal laboratory parameters on the paleolithic ketogenic diet.

	01 Jan. 2014	07 Jan. 2014	03 Apr. 2014	19 Jun. 2014	19 Sep. 2014	27 Nov. 2014	03 Feb. 2015	24 Apr. 2015	
	Diagnosis	Insuline regime	PK diet	PK diet	PK diet	PK diet	PK diet	PK diet	
WBC	6.8	7.9	5	5.4	5.3	8.1	4.8	5.3	G/l
RBC	4.6		5	4.6	4.5	4.3	4.5	4.2	T/l
Hgb	14.1	12.6	15.1	14	13.8	13.3	13.5	12.9	G/dl
Hct	43	38.7	43	40	39	39	39	38	%
CRP	0.2		0.4	0.4	0.7	0.5	0.1	0.2	mg/l
GGT	9		9.3	12.5	11.3	12	12.4	8.9	U/l
GOT	21		24.1	24.4	25.8	20.1	18.1	21.8	U/l
GPT	18		19.4	17.4	13.3	12	10.4	10.5	U/l
Sodium	133	141	141	136.4	135.8	141.3	140.2	136	mEq/l
Potassium	4.3	4.28	4.5	4.5	4.3	4.5	4.3	4.3	mEq/l
Calcium			9.88	10.16	9.8	9.76	9.56	9.16	mg/dl
Magnesium			2.09	2	2.12	1.95	2.02	2.02	mg/dl
Iron			104	88	60	68	82	88	µg/dl
Carbamid	10.6		19	23.2	13.7	15.1	14.3	11.2	mg/dl
Creatinine	0.35		0.67	0.48	0.45	0.8	60	0.46	mg/dl
T. protein	6.7		7.1	6.9	7.1	7.3	6.7	6.6	g/dl
Glucose	692	110	86	114	101	130	128	106	mg/dl
HgA1c		14.5		5.2	5.2	5.6	5.6	5.6	%
Cholesterol		207	189	293	201	197	243	224	mg/dl
HDL cholesterol			70	83	69	71	59	69	mg/dl
LDL cholesterol					125	93	136	129	mg/dl
Triglyceride		66		209	45	173	239	124	mg/dl
Uric acid			6.41	5.72	5.45	6.44	7.2	5.55	mg/dl
Urinary ketone	positive	negative	positive	positive	positive	positive	positive	positive	

Abbreviations: WBC white blood cell count, RBC red blood cell count, Hgb hemoglobin, Hct hematocrit, CRP C-reactive protein, GOT glutamate-oxaloacetate transaminase, GPT glutamate-pyruvate transaminase, GGT gamma-glutamyl transferase, T. protein total protein, HbA1c glycated hemoglobin, HDL high density lipoprotein, LDL low density lipoprotein, PK diet Paleolithic ketogenic diet

diet he reported no epistaxis and a great reduction in his upper respiratory infections and associated symptoms. For the change in his physical appearance, including the disappearance of his bloated abdomen and developmental achievements (Figure 4). At the time of diagnosis he weighted 24 kg and his height was 134 cm (BMI=13.37). Currently, (19 months after diet onset) he weights 28.4 kg and his height is 140 cm (BMI=14.49).

Informed consent

Parents of the child gave written informed consent for the publication of this case.

DISCUSSION

The child strictly adhered to the Paleolithic ketogenic diet as assessed by home monitoring of glucose, urinary ketones, laboratory workups and frequent feedback from the patient and his parents. They reported that maintaining the diet was relatively easy for him. Dietary adherence resulted in normalized glucose levels which allowed insulin freedom. Measurement of the stimulated C-peptide indicated normal insulin secretion.

Our experience indicate that in new-onset T1DM the Paleolithic ketogenic diet results in lowered insulin



Figure 4: The child at the time of diagnosis onset (December 2013) and currently (July 2015) on the Paleolithic ketogenic diet. Note that the bloated abdomen disappeared and the child showed a significant progression in development.

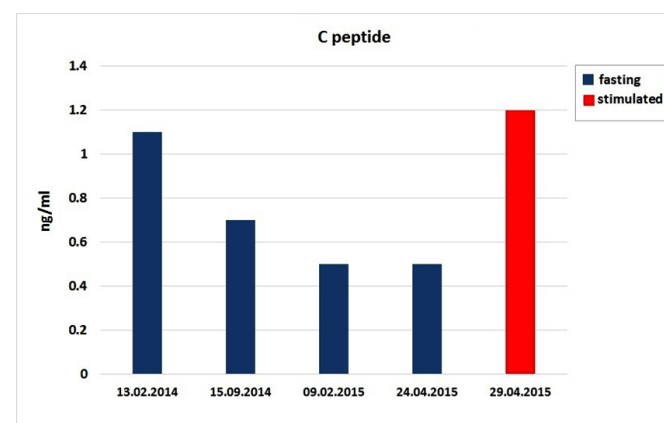


Figure 2: C-peptide levels while on the Paleolithic ketogenic diet. The first four measurements were done in fast while the fifth measurement was done postprandially (stimulated C-peptide). Note that the level of C peptide after stimulation was in the normal range (0.9–7.1 ng/ml).

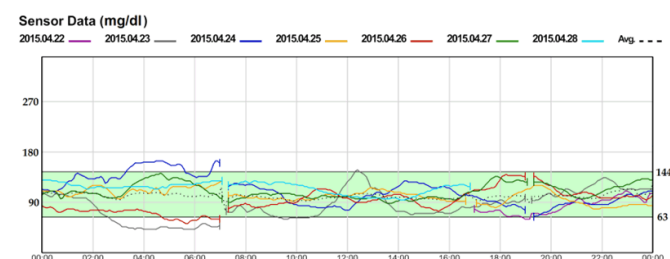


Figure 3: Continuous tissue glucose monitoring. Note that glucose levels were low and fluctuated between narrow limits on the Paleolithic ketogenic diet.

need which may be covered by the residual insulin secretion in these patients [9]. Honeymoon effect shortly after diagnosis onset is frequently described in T1DM [11]. However, normoglycemia and insulin-freedom maintained across 19 months in our patient may indicate that the patient is well beyond the honeymoon period and that the autoimmune process destructing the insulin secreting beta cells of the pancreas was halted or reversed. This may have been due to the restriction of non-Paleolithic substances, including milk and dairy, which may promote inflammation and autoimmune processes [12].

Neither side effects nor complications emerged while on the diet. Rather the Paleolithic ketogenic diet was beneficial in several respects. The child's asthma, eczema, epistaxis, bloated abdomen, frequent upper respiratory infections and fatigue disappeared. Positive effects are in line with those presented in our other patients put on the Paleolithic ketogenic diet [13–16]. Although we did not use vitamin or other supplements no deficiencies emerged.

In literature, this is the second case report of T1DM treated with the Paleolithic ketogenic diet without insulin. In both cases the Paleolithic ketogenic diet was initiated in an early period of the clinical manifestation of the disease. Although there are indications that insulin requirement may be lowered on diets low in carbohydrate [2, 3] we are not aware of any dietary intervention or other treatment modalities where insulin replacement could be discontinued in T1DM.

CONCLUSION

We opine that the Paleolithic ketogenic diet ensure normal glucose levels and can be maintained on the long-term in those patients with newly diagnosed T1DM with residual insulin secretion. It is important to emphasize, however, that in those patients with long-standing T1DM beta cells might have exhausted and therefore there may be a need for insulin replacement. In these cases, however, the Paleolithic ketogenic diet may be used as an adjunct in an attempt to likely prevent diabetic complications.

Author Contributions

Csaba Tóth – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Zsófia Clemens – Substantial contributions to conception and design, Acquisition of data, Analysis and interpretation of data, Drafting the article, Revising it critically for important intellectual content, Final approval of the version to be published

Guarantor

The corresponding author is the guarantor of submission.

Conflict of Interest

Authors declare no conflict of interest.

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