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Research letter

A low-carbohydrate high-fat diet initiated promptly after diagnosis provides clinical remission in three patients with type 1 diabetes

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Q2 There has been growing interest in low-carbohydrate high-fat (LCHF) diets in recent years because it has been associated with positive outcomes in several diseases, including diabetes. In type 1 diabetes (T1D), observational studies and three randomized trials involving a limited number of patients have suggested that an LCHF diet might improve glycaemic control, glycaemic variability and time spent in hypoglycaemia [1]. However, this type of diet has been criticized because intakes of saturated fats usually increase, raising concerns about cardiovascular risk [1]. Nevertheless, studies of the LCHF diet in T1D have not confirmed any negative effects on lipid parameters, and one study reported finding no changes in inflammatory markers [1]. At present, few studies have evaluated the long-term effects of an LCHF diet on T1D outcomes in larger populations, and evidence to support the use of this type of diet without risk, especially for cardiovascular outcomes, is lacking.

The mean duration of T1D was at least 12 years in all of the studies published so far on this topic. Here, we report on three patients recently diagnosed with T1D who started LCHF diets shortly after receiving the diagnosis and experienced clinical remission, defined as the withdrawal of insulin therapy for at least 3 months. These patients' characteristics have been collected retrospectively and are summarized in Table 1.

Case 1

Patient A was diagnosed with T1D in January 2015 at the age of 36 years. He had no medical history and was a non-smoker. He reported polyuria/polydipsia and weight loss (6 kg) during the month prior to diagnosis. At diagnosis, his plasma glucose was 289 mg/dL and he was positive for glutamic acid decarboxylase (GAD) autoantibodies. He commenced multiple daily injections of insulin. One month after diagnosis, he took the initiative to start an LCHF diet with an average daily intake of 50 g of carbohydrates. He was able to stop insulin completely 15 days later, and has not used insulin since March 2015. His plasma C-peptide was 0.33 nmol/L in March 2015 and 0.46 nmol/L in January 2019. Lipid parameters were within recommended ranges before and after beginning the LCHF diet. In the 4 years since his diagnosis, he has had no diabetes-related complications. Before the diagnosis, he had started exercising two to three times a week for about 1–2 h each time.

Case 2

Patient B was diagnosed with T1D in November 2017 at the age of 40 years. He had no medical history and was a non-smoker. He reported polyuria/polydipsia and weight loss (3 kg) before the diagnosis. At diagnosis, his plasma glucose was 305 mg/dL, and GAD and islet antigen 2 (IA2) autoantibodies were positive. He started treatment with multiple daily injections of insulin. Two months after the diagnosis, he took the initiative to follow an LCHF diet with an average daily intake of 50 g of carbohydrate. He stopped insulin therapy at the beginning of the diet and has not used insulin since, except for one infectious episode. Plasma C-peptide was not measured at the time of diagnosis, but was 0.3 nmol/L at 1 year after beginning the LCHF diet. Lipid parameters were not measured either before or at the time of diagnosis. However, 3 months after initiating the LCHF diet, his plasma low-density lipoprotein cholesterol (LDL-C) was 164 mg/dL. At 1 year after the diagnosis, he had no diabetes-related complications. He had started exercising two times a week for about 1–2 h before the diagnosis.

Case 3

Patient C was diagnosed with T1D in May 2015 at the age of 38 years. He had no medical history and was a non-smoker. He presented with polyuria/polydipsia and weight loss (2 kg), and had complained of blurred vision during the previous month. At the time of diagnosis, his plasma glucose was 340 mg/dL, and GAD and IA2 autoantibodies were positive. Multiple daily injections of insulin were started and, 9 months later, an LCHF diet was implemented including an average intake of 20–30 g/day of carbohydrates. Two weeks after commencing this diet, he was able to stop the insulin therapy. Plasma C-peptide measured 2 years after starting the LCHF diet was 0.5 nmol/L. However, after not using insulin for 18 months, in December 2017, he had to resume insulin therapy to maintain capillary glycaemia at 80–100 mg/dL. Plasma LDL-C and high-density lipoprotein cholesterol (HDL-C) levels increased with implementation of the LCHF diet, while plasma triglyceride (TG) levels decreased. He reported no diabetes-related complications at 1 year after being diagnosed. After diagnosis, he started exercising once or twice a week for about 1–2 h each time.

Here, we report for the first time on three patients with T1D who experienced clinical remission after starting an LCHF diet. Clinical remission was temporary for one patient, but is still in effect for the two others after 1 and 4 years, respectively.

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Table 1
Characteristics of three patients diagnosed with type 1 diabetes before and after implementation of a low-carbohydrate high-fat (LCHF) diet.

Patient A

	Before diagnosis	At diagnosis	Beginning of LCHF diet	1 year after diagnosis	2 years after diagnosis	3 years after diagnosis	4 years after diagnosis
Weight (kg)	82	76	1 month after diagnosis	80	82	81	80
Body mass index (kg/m^2)	24.2	22.4		23.6	24.2	23.9	23.6
Glycaemia (mg/dL)	95	289					
HbA_{1c} (%)		8.9		5.1	5.2	5.4	5.5
C-peptide (nmol/L)		0.33		0.33	0.3	0.21	0.46
GAD autoantibody (IU/mL)[a]		> 500					
Total cholesterol (mg/dL)	153			148	129	131	132
LDL cholesterol (mg/dL)	104			60	46	53	51
HDL cholesterol (mg/dL)	43			54	47	47	47
Triglycerides (mg/dL)	89			82	73	73	75
Creatinine (μmol/L)		82.3		80.5	71	80	74
Microalbuminuria (mg/L)				< 3	< 3	< 3	9.4
Insulin dose (IU/kg/day)			0.25	0	0	0	0
Symptomatic hypoglycaemia (*n*/year)				0	0	1	0

Patient B

	Before diagnosis	At diagnosis	After 2 months	Beginning of LCHF diet	After 5 months	After 1 year	After 15 months
Weight (kg)	89	86	88	2 months after diagnosis	86	87	
Body mass index (kg/m^2)	26	25.1	25.7		25.1	25.4	
Glycaemia (mg/dL)		305					
HbA_{1c} (%)		13.8	8.2		5.7	5.7	5.6
C-peptide (nmol/L)							0.3
GAD autoantibodies (IU/mL)[b]		13.3					
IA2 autoantibodies (IU/mL)[b]		17.1					
Total cholesterol (mg/dL)					259		
LDL cholesterol (mg/dL)					164		
HDL cholesterol (mg/dL)					81		
Triglycerides (mg/dL)					77		
Creatinine (μmol/L)		90					100
Microalbuminuria (mg/L)					8		
Insulin dose (IU/kg/day)			0.19	0	0	0	0
Symptomatic hypoglycaemia (*n*/year)					0	1	0

Patient C

	Before diagnosis	At diagnosis	After 6 months	Beginning of LCHF diet	After 1 year	After 2 years	After 3 years	After 4 years
Weight (kg)	98	96	98	9 months after diagnosis	95	93	93	95
Body mass index (kg/m^2)	26.6	26	26.6		25.7	25.2	25.2	25.7
Glycaemia (mg/dL)	101	3.4						
HbA_{1c} (%)		11.5	6.3		5.7	5.7	5.2	4.6
C-peptide (nmol/L)		0.17				0.5	0.23	0.19
GAD autoantibodies (IU/mL)[a]		> 250						
IA2 autoantibodies (IU/mL)[a]		289.6						
Total cholesterol (mg/dL)			245			332	292	301
LDL cholesterol (mg/dL)		158	164		204	242	215	209
HDL cholesterol (mg/dL)		47	53		59	76	67	79
Triglycerides (mg/dL)		114	143		119	70	52	67
Creatinine (μmol/L)		66	74			75	80	
Microalbuminuria (mg/L)		< 3	< 3		< 3	< 3	< 3	
Insulin dose (IU/kg/day)		0.58	0.16	0.16	0	0	0.17	0.17
Symptomatic hypoglycaemia (*n*/year)					0	0	0	2

GAD: glutamic acid decarboxylase; IA2: islet antigen 2; LDL/HDL: low-density/high-density lipoprotein
[a] Normal range < 10.
[b] Normal range < 1.

Plasma C-peptide was detectable at diagnosis for two of the patients, which is in line with data showing that many patients with T1D still have substantial insulin secretion at the time of diagnosis [2]. In our three patients, the introduction of an LCHF diet was associated with preservation of β-cell function, as all maintained high levels of plasma C-peptide for many months after initiating the diet. In a study of 3929 patients with T1D, C-peptide levels were higher in those aged > 18 years and were 0.30 nmol/L at 1 year after diagnosis, which is lower than in our three patients [3]. Levels of plasma C-peptide remained unchanged after implementation of the diet in two of our patients (data not available for the third patient), which extended to 4 years in patient A. As HbA_{1c} decreased after LCHF implementation in all three patients, it is unlikely they were experiencing a spontaneous prolonged partial remission (a so-called 'honeymoon' period). These results are novel because no data on the progression of C-peptide with an LCHF diet in patients with T1D are available in the literature. In any case, preservation of residual β-cell function is

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highly desirable as it may lead to decreases in both the short- and long-term complications of T1D [4], and the LCHF diet could be a way to preserve β-cell function.

Our three older male patients all presented with factors associated with preservation of β-cell function. This is in line with data indicating that female gender, younger age and the onset of ketoacidosis are associated with poorer preservation of β-cell function [5].

The LCHF diet was implemented promptly after T1D diagnosis. Such swift implementation after diagnosis is likely to play a major role in the preservation of β-cell function and in the ability to manage without insulin therapy, as in the case of patient A, who is still in clinical remission 4 years after diagnosis. Indeed, in all three patients, glycaemic control was optimal under the LCHF diet (which is in line with the available data [1]), and HbA_{1c} improved after starting the diet. In addition, there is proof of a significant inverse relationship between C-peptide and HbA_{1c} at 6 and 12 months after diagnosis [6], and hyperglycaemia can impair insulin secretion and irreversibly damage β cells. Thus, the quick and effective control of glycaemia obtained with the LCHF diet is likely to play a major role in the preservation of β-cell function.

Only one patient reported hypoglycaemia while following the diet, which is consistent with the literature [1]. However, none of our patients experienced any weight gain with the LCHF diet, and the available data mostly show that the LCHF diet has no adverse impact on lipid parameters [1]. Patient A had baseline lipid parameters within the recommended range, and these parameters were not modified by the LCHF diet. Patient C had the lowest carbohydrate intake, but his LDL-C level was above the recommended range at baseline (164 mg/dL) and increased during the LCHF diet, although TG levels decreased with the LCHF diet. A meta-analysis of overweight and obese individuals with and without diabetes found significant decreases in TG levels and significant increases in LDL-C levels when comparing an LC diet with an LF diet [7]. The fact that patient C was overweight might explain the effect of the LCHF diet on his lipid parameters. In the case of patient B, lipid parameters were not available before the start of the LCHF diet. His LDL-C plasma level was above the recommended range during the LCHF diet, while HDL-C and TG levels were within normal ranges.

However, there are no long-term studies to allow us to conclude that the LCHF diet is effective for glycaemic control and prevention of diabetes-related complications over the long term. There is also insufficient evidence to support the use of this type of diet without increasing certain risks, especially those pertaining to cardiovascular outcomes. On the other hand, short-term studies involving a limited number of patients are encouraging. Nevertheless, not all patients with T1D are able to adhere to such a restrictive diet, and the data available in the literature thus far suggest avoiding the LCHF diet in children with T1D [1].

Yet, patients with T1D are increasingly turning to the LCHF diet as a way to manage their condition. For this reason, studies are urgently needed to determine whether the diet can safely control glycaemia and minimize hypoglycaemia variability and risk. Our present results confirm that glycaemic control is optimal in patients with T1D who adhere to the LCHF diet. More important, we have shown that three patients with T1D experienced clinical remission after starting the LCHF diet.

In conclusion, we report here, for the first time, the cases of three T1D patients who experienced clinical remission after commencing an LCHF diet soon after their diagnosis. Implementation of such a diet resulted in optimal glycaemic control while the frequency of hypoglycaemia was low, although the effect on lipid parameters was variable. In any case, the LCHF diet, if introduced promptly, could preserve β-cell function in patients with residual insulin secretion at diagnosis. Thus, an LCHF diet appears to be a feasible therapeutic option in self-motivated adults with T1D, provided that their lipid parameters are carefully controlled, and early introduction of the LCHF diet may well lead to clinical remission of T1D.

Disclosure of interest

The authors declare that they have no competing interest.

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