Treatment and Remission of Symptoms in Type 1 Diabetes with a Nutrient-Dense, Plant-Rich (NDPR) Diet: Case Studies

Joel H. Fuhrman, MD, PC, & Deana M. Ferreri, PhD

Abstract

Type 1 diabetes (T1D), in contrast to type 2 diabetes (T2D), is an autoimmune disease rather than a lifestyle disease. However, diet and lifestyle factors such as nutrient density, glycemic load, fiber intake, and exercise do affect glycemic control, cardiovascular risk, and risk of complications in patients with T1D. Patients with T1D may be able to reduce insulin requirements and achieve better glycemic control if practicing dietary methods to increase plant fibers and micronutrient density, and decrease glycemic load. We propose that anti-inflammatory effects of foods central to a nutrient-dense, plant-rich (NDPR) diet—vegetables, legumes, nuts and seeds, and low-sugar fruits—may slow or prevent further destruction of beta cells if dietary intervention is initiated early enough. Herein, we present 3 cases of patients with T1D who have adopted an NDPR diet at varying times following T1D diagnosis. One patient, who began an NDPR diet at age 3 immediately following diagnosis, has not yet required insulin therapy nearly 3 years after diagnosis, and has experienced a steady decline in autoantibody levels. Another child, who began an NDPR diet several months after diagnosis, maintains a low dose of insulin, a favorable HbA1c, and more consistent blood glucose readings. A patient in his mid-40s, who began an NDPR diet 13 years after T1D diagnosis, dramatically reduced insulin requirements and C-reactive protein, and maintains favorable HbA1c and cardiovascular markers.

KEYWORDS: Type 1 diabetes; Nutrition; Plant-based diet; Nutrient density; Autoimmunity; Glycemic control

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Fuhrman, MD[a]
& Ferreri, PhD[a]

Affiliations
[a]Joel Fuhrman MD, PC, Flemington, NJ, USA

Corresponding Author
Joel Fuhrman. Email: mdoffice@drfuhrman.com

Introduction

Diets of patients with T1D in the United States

US children with type 1 diabetes overall are eating diets of poor nutritional quality. According to 3-day dietary records from 250 families with a child with type 1 diabetes, fruit, vegetable, and whole grain intake was less than half of the recommended intake. The typical breakdown by calories was 22% from refined grains, 16% from dairy, 14% from meat, and 25.5% from desserts and chips, and only 6.54% from whole grains, 2.52% from nuts, 2.29% from vegetables, and 3.47% from fruit [1]. Similarly, most adults with T1D tend to fall short of fiber, vegetable, and fruit intake recommendations [2,3].

Plant-rich diets and glycemic control

Low-carbohydrate diets are often used by patients or recommended by physicians. These diets are low in glycemic load and may favorably affect glucose and insulin levels in short-term interventions, but have potential downsides that must be considered. The American Diabetes Association cautions against long-term high-protein diets because their long-term effects on kidney function are unclear and there is a lack of data on long-term adherence to and efficacy of these diets in patients with diabetes [4]. Generally, plant-based diets are lower in protein than omnivorous diets. Reduced protein diets are thought to slow the progression of chronic kidney disease (including diabetic kidney disease). Although very few studies have compared plant and animal proteins in diabetic kidney disease, a plant-based diet with a variety of vegetables, legumes, and nuts and seeds provides adequate amino acids despite its lower total protein content [5,6].

Additionally, studies comparing animal and plant protein suggest that a diet rich in plant protein sources may favorably affect glycemic control [7,8]. Potential mechanisms for benefits of diets rich in whole plant foods on glycemic control include higher fiber and magnesium intake, a reduction in oxidative stress (absence of heme iron and increased intake of carotenoids and other antioxidant nutrients), weight loss, amino acid distribution of plant protein, and the inclusion of nuts as a low-glycemic and monounsaturated fat-rich calorie source [9,10,11,12,13,14]. Strengthening the case for plant protein sources is an epidemiologic association between higher animal protein intake and lower plant protein intake with a greater risk of all-cause mortality [15]. Similar observations have been made in studies of low-carbohydrate diets; substituting carbohydrates for animal protein and animal fats was associated with an increased risk of all-cause mortality, whereas substituting plant protein and plant fats for carbohydrates was associated with a reduced risk of all-cause mortality [16].

Plant-based dietary interventions in T1D

Randomized controlled trials of plant-based diets in T1D are not available. However, several studies suggest that increasing nutrient-rich plant foods improves glycemic control.

In adolescents with T1D who underwent a behavioral nutrition intervention designed to increase intake of nutrient-dense, low-glycemic plant foods, better diet quality and higher fiber intake were associated with better glycemic control [17].

Several randomized controlled trials (RCTs) have been performed on plant-rich diets in T2D, suggesting this type of diet improves glycemic control. In a meta-analysis of 6 trials, vegetarian and vegan diets were associated with a 0.39 percentage point decrease in HbA1c, plus lower total energy intake and higher fiber intake compared with omnivorous diets [18].

An NDPR diet combines the low-glycemic load of a low-carbohydrate, high-protein diet and the high fiber content of vegan diets, with moderate fat in the form of whole foods (nuts, seeds, and avocado) and a low intake of grains. The authors conducted a pilot study on 10 patients with T2D; after 1 year of an NDPR diet, 90% of participants had been able to eliminate all of their diabetes medications, and the mean HbA1c had dropped to 5.8% from 8.2%, suggesting improved glycemic control [19].

Glycemic control and cardiovascular health in T1D

Studies suggest that better glycemic control attenuates cardiovascular risk in T1D patients, with risk of cardiovascular death decreasing with decreasing HbA1c [20]. Data from 27 years of follow-up in the type 1 cohort of the Diabetes Control and Complications Trial (DCCT) found that each percentage point increase in HbA1c was associated with a 31% increase in risk of any cardiovascular disease (CVD), and a 42% increase in risk of major atherosclerotic cardiovascular events [21]. In another study, 5 cardiovascular risk factors were evaluated—low-density lipoprotein cholesterol (LDL-C), blood pressure, microalbuminuria, HbA1c, and smoking status. For T1D patients with all 5 risk factors in the unfavorable range, the hazard ratio (HR) for myocardial infarction was 12.34 compared with control subjects without T1D. In comparison, those with all 5 risk factors at favorable levels had a substantially lower risk of myocardial infarction (HR 1.82 compared to 12.34), though still greater than control subjects [22].

Nutrition and autoimmunity

Autoimmune-related inflammation is thought to enhance beta-cell destruction in early T1D. A whole NDPR diet approach provides the benefit of anti-inflammatory effects of antioxidant vitamins, carotenoids, flavonoids, fiber, and other phytochemical compounds, which may counteract autoimmunity. In contrast, a typical Western diet promotes inflammation and may contribute to autoimmunity [23,24,25]. A study comparing the American Heart Association's recommended diet to a similar diet replacing the animal protein sources with plant protein sources in patients with coronary artery disease reported 32% lower concentrations of high sensitivity C-reactive protein (hsCRP)—a marker of inflammation—in the vegan diet group [26]. Dietary interventions—particularly fasting, a vegan diet, and fasting followed by a vegetarian diet—have shown promise for reducing pain in rheumatoid arthritis [27,28,29,30,31]. In psoriasis, fasting, a vegetarian diet, a low-calorie diet, and supplementation with omega-3 fatty acids have improved symptoms [32]. In systemic lupus erythematosus, omega-3 supplementation and vitamin D supplementation reduced markers of inflammation [33]. In an observational study of children at risk for T1D with an average follow-up of 6.2 years, intake of omega-3 fatty acids had an inverse association with the risk of developing islet autoimmunity [34]. A systematic review of RCTs of vitamin D supplementation in patients with new-onset T1D cited beneficial effects on daily insulin dose, C-peptide, and HbA1c [35]. Vitamin D supplementation in early life has been linked to a reduction in risk of T1D [36].

Case reports: nutrition and autoimmunity in T1D

There is much interest in interventions that may preserve remaining beta-cell function in new-onset T1D. In patients with new-onset T1D, trials on antibodies, antigens, and other immunomodulatory and anti-inflammatory agents are ongoing; however, clear evidence of an effective treatment has not yet been found [37].

Similar to Case 1, another case report described a child who has avoided initiating insulin therapy for a long period of time. In this case, the child was diagnosed at age 5, was treated with insulin for 5 weeks, and then entered a remission phase. After 3 weeks of remission, he began treatment with a low-glycemic, gluten-free diet, containing 24% of energy from carbohydrate, 26% protein, and 49% fat. No other details of the diet were provided. The patient has not required re-initiation of insulin therapy 20 months after the initial diagnosis. No change in autoantibody levels was observed [38].

A few interventions and case reports have investigated supplementation with vitamin D and/or omega-3 fatty acids with the aim of preserving beta-cell function via anti-inflammatory effects. A report described two 7-year-old boys diagnosed with T1D who maintained endogenous insulin secretion 1 to 2 years after diagnosis. The children were given supplements of 1000 IU/day of vitamin D plus omega-3 docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA), and a small amount of long-acting insulin each night. In lab tests either one or two years after diagnosis, C-peptide suggested endogenous insulin secretion continued, and HbA1c was favorable. The authors propose the immunomodulatory and anti-inflammatory effects of vitamin D and DHA and EPA were responsible [39]. On the other hand, a 9-month trial on vitamin D supplementation in adults with new-onset T1D did not report significant differences in HbA1c, insulin requirements, or C-peptide compared with placebo [40].

A 6-month intervention investigated 2000 IU/day of vitamin D plus calcium in children who had been diagnosed with T1D within the prior 1–2 years. A group of age-matched children were used as a control group. There was a trend toward a slower reduction in stimulated C-peptide in the supplementation group; however, it was not statistically significant [41].

Case Reports

Two children (Cases 1 and 2) sought care soon after T1D diagnosis in our family practice office in Flemington, New Jersey. One patient (Case 3, an adult) initiated an NDPR diet upon reading one of my (Fuhrman) books containing guidelines on the eating style. Patients (or their parents) provided copies of lab reports and additional medical records and information to supplement their charts, such as typical meals and blood glucose readings. Written informed consent for the publication of these case reports was obtained from each patient or the patient's parent/legal guardian.

The NDPR diet has been described previously [19,42]. Briefly, the goal of the NDPR diet is high fiber, micronutrient, and antioxidant intake with a relatively low glycemic load. This is achieved by predominantly consuming green and other non-starchy vegetables, legumes, nuts and seeds, and low-sugar fruits, such as berries. Whole grains and animal products are limited; refined carbohydrates, added sugars, and oils are avoided. Supplementation with vitamin B12, vitamin D3 (with a goal 25(OH)D 25–45 ng/ml), vitamin K2, zinc, iodine, and omega-3 fatty acids DHA and EPA is recommended.

Case 1

A now 6-year-old boy was diagnosed with early stage T1D at age 3 by his pediatrician. A postprandial glucose reading at the time of diagnosis was 185 mg/dl. An oral glucose tolerance test (OGTT) was ordered, the result of which was 203 mg/dl at 2 hours. HbA1c was 5.7% (October 2015, Table 1). Approximately 1 month after diagnosis, the patient visited our office and began treatment with an NDPR diet. Lab results over the span of 30 months show a steady decline in autoantibodies GAD65 and IA-2, and a decrease in HbA1c from 5.7% to 5.3% (Table 1). Currently, at age 6, he has not yet required exogenous insulin. His postprandial blood glucose readings are typically between 80 and 100 ng/ml.

Table 1: Case 1

	10/2015	12/2015	3/2016	8/2016	12/2016	2/2017	9/2017	4/2018
HbA1c (%)	5.7	5.6	5.3	5.4	5.3	5.1	4.8	5.3
IA-2 (U/ml)	6.81	3.66	2.08	3.74	-	1.86	2.25	1.92
GAD65 (U/ml)	5.67	7.24	3.6	3.1	-	1.65	2.88	0.88

The patient's mother feels he does not tolerate legumes well (experiences occasional bloating and fatigue), and therefore nuts and seeds provide a higher proportion of calories than in standard NDPR guidelines, which recommend both legumes and nuts and seeds as major calorie sources. He also consumes small portions of animal protein. A typical day's diet is as follows:

Breakfast: green smoothie (water, spinach, kale, romaine, flaxseed, avocado, frozen wild blueberries, 1/4 of a banana), small bowl of Mediterranean pine nuts and walnuts.

Lunch: raw vegetables with hummus, salad (spinach, kale, romaine, flaxseed, pine nuts, and avocado with a little bit of pomegranate balsamic vinegar), homemade veggie burger (mixture of mushrooms, broccoli, spinach, cauliflower, carrots, yam, red cabbage, onion, seasoning), half an apple.

Dinner: bowl of steamed cauliflower "rice," steamed vegetables (onion, broccoli, bok choy, carrots, parsnips), a small (2 oz./57 g) serving of organic, pasture-raised animal protein, and a salad.

Case 2

A 7-year-old boy (now age 10) was diagnosed with T1D. Subsequently, he visited our office and began an NDPR diet (January 2016). At that point, his HbA1c was 12.8% (Table 2) and he was taking 3 units/night Lantus plus Humalog with meals as needed; a total of typically 6–10 units/day. Extreme highs and lows were typical; blood glucose readings were typically at 117–260 ng/ml with lows of 49 ng/ml. Currently, on an NDPR diet, his HbA1c is 6.8% (Table 2), current insulin use is approximately 4–6 total units/day, and typical blood glucose readings range from 70 to 90.

Table 2: Case 2

	1/2016	3/2016	9/2016	4/2017	2/2018
HbA1c (%)	12.8	8.0	6.5	8.6	6.8

A typical day's diet is as follows:

Breakfast: leftovers from the previous night's dinner.

Lunch: vegetable-bean soup, salad with nut/seed-based dressing, one portion of fresh fruit.

Dinner: a few examples are raw carrots and celery with hummus, sunflower seed butter, and nuts and seeds; lentil loaf, string beans, and cauliflower mash; 3-bean chili; lentil-stuffed peppers and blanched broccolini; or a bean wrap w/avocado, steamed broccoli, cauliflower, and carrots.

Case 3

A now 45-year-old male physician was initially diagnosed with T2D at the age of 22 (1994) following approximately 1 month of severe polydipsia and polyuria. After 6 years on oral medications (glipizide, metformin, rosiglitazone), he was diagnosed with T1D at the age of 28 (2000) and began insulin therapy. In 2013, when he initiated the change to an NDPR diet, he was using an insulin pump, and his insulin usage was approximately 70–100 units/day. He regularly experienced severe hypoglycemia. At 5'7.5" (171.45 cm) he weighed 185 lb. (83.9 kg) and exercised 3–4 days/week. His insulin use decreased dramatically within 1 month of an NDPR diet to 16 units of Lantus/day plus 4 units of Humalog/meal. His current insulin use is 13 units of Tresiba/day plus 14–25 units/day of Novolog. His HbA1c remains favorable at 6.5% (Table 3).

Table 3: Case 3, HbA1c

	08/2000	04/2012	01/2018
HbA1c (%)	10.0	5.9	6.5

Since many patients are diagnosed with T1D in childhood, they live with the disease, often exposed to bouts of hyperglycemia and hyperinsulinemia for many years, leading to accumulated vascular damage and risk of complications. Life expectancy for patients with T1D has improved over time, but still the disease is expected to reduce the lifespan of its sufferers by approximately 8–13 years [43,44]. Dietary interventions have the potential to improve glycemic control and mitigate cardiovascular risk.

The patient in Case 3 has a favorable lipid profile and has reduced C-reactive protein level from 4.5 to 0.2 mg/L (Table 4). He continues to exercise regularly and now weighs 149.6 lb. (67.9 kg) with approximately 10–11% body fat and a BMI between 22 and 23. Most of his meals are in accordance with NDPR guidelines; he consumes very little meat and dairy, and he avoids white flour products, white rice, added sugars, processed foods, and fried foods.

Table 4: Case 3, cardiovascular risk parameters

Date:	08/2000	08/2012	12/2014	01/2018
C-reactive protein (mg/L)	-	4.5	0.2	-
Total cholesterol (mg/dl)	139	110	-	96
LDL cholesterol (mg/dl)	93	68	-	57
HDL cholesterol (mg/dl)	30	34	-	29
Triglycerides (mg/dl)	78	38	-	34

Discussion

In Cases 1 and 2, new-onset diabetes was treated with an NDPR diet. In Case 1, the patient does not require insulin therapy and the steady decline in GAD65 and IA-2 antibody levels (Table 1) suggests that the autoimmune response has been attenuated. Similar reductions in antibody levels have been observed in other diabetic children in the practice, even when insulin production remains below normal. For example, I (Fuhrman) have observed such a diabetic child who improved sufficiently to only require insulin during viral infections but otherwise does not require insulin, now 2 years after presentation.

We propose that, if started early enough, it is possible to reverse the course of T1D with dietary intervention in some children, preserving the remaining beta-cell function by blunting autoimmunity and autoimmune-related inflammation. In Case 2, the patient continues to require minimal insulin (approximately 4–6 total units/day) more than 2 years after diagnosis and maintains a favorable HbA1c (Table 2). Future studies could test whether an NDPR diet, initiated promptly at diagnosis, is associated with a lengthening of the remission phase, ie, a slowing of the rate of beta-cell destruction and delayed need for exogenous insulin, and, in some cases, perhaps permitting a complete recovery. Prolonging remission may have a significant benefit for the patient's future cardiovascular health, based on comparisons of remitters and non-remitters [45,46]. Future studies are required to determine whether early dietary intervention combined with vitamin D and omega-3 supplementation in new-onset T1D helps to attenuate the inflammation-related autoimmune attack on beta cells.

We have observed all patients experience better glycemic control as a result of an NDPR diet. Minimizing cumulative exposure to hyperglycemia and vascular damage over time is especially important for patients diagnosed with T1D as young children.

Case 3 highlights the capacity for diet and lifestyle changes to reduce insulin requirements and maintain cardiovascular health in adults with T1D. The patient has drastically reduced his insulin requirements while his HbA1c remains in a favorable range (Table 3), lipids are in the low-risk range, and C-reactive protein reduced dramatically, bringing it into the low risk range (Table 4).

Insulin therapy, though necessary in T1D, may have detrimental side effects when used excessively. There is an association between long-term insulin therapy and cancer risk [47]. Reducing insulin requirements, thereby reducing the cumulative exposure to exogenous insulin, is a worthwhile goal in T1D.

Maintaining cardiovascular parameters in a low-risk range is crucial to quality of life, as the risk of cardiovascular events is elevated in T1D patients by at least 2-fold compared with the general population [2].

Our medical practice has recommended an NDPR diet to T1D patients for over 25 years, both children and adults who have lived with the disease for most of their lives. This approach as made a marked difference in the health and quality of life of individuals with T1D, preventing hypoglycemia and hyperglycemia, reducing fingerstick requirements, and lowering insulin use. The observed outcomes can also lead to a greater understanding of the pathophysiology of the disease improving patient management with implications for future study. In children and adults, insulin requirements have been drastically reduced and glycemic control enhanced by this intensive dietary change, presumably reducing the risks associated with insulin therapy, and reducing the risk of complications and cardiovascular disease.

Intervention studies using the NDPR diet for T1D are warranted, both in new-onset disease, to determine whether insulin therapy could be delayed or avoided, and in established disease, where there is potential to reduce insulin needs, and improve glycemic control and cardiovascular risk factors.

Conflict of Interest

The authors declare Joel Fuhrman is the author of multiple books and the owner of a website that provide guidelines for following an NDPR diet. Deana Ferreri is an employee of Joel Fuhrman.

Contributions of Authors

Joel Fuhrman is the physician who treated the patients. Deana Ferreri wrote sections of the manuscript. Joel Fuhrman wrote sections of the manuscript. Both authors contributed to manuscript revision and read and approved the submitted version.

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