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# An unusual use of personal insulin pump by a patient with type 1 diabetes on a ketogenic diet — a case report

## ABSTRACT

In this case report we present a 28-year-old woman with type 1 diabetes mellitus on a ketogenic diet for 5 months, using a personal insulin pump in an unusual way. The patient was admitted to the Department of Internal Medicine and Diabetology due to vomiting and diarrhea that had lasted for several days. On a daily basis, she used personal insulin pump for only several hours a day (a 5-hour basal rate of 0.6 units/hour of fast-acting insulin) in order to avoid dawn phenomenon, without any prandial insulin, and she used continuous glucose monitoring for 24 hours a day for glycemia control. Additionally she was taking 30 units of long acting insulin analog before sleep. The patient was unwilling to change her treatment method and she was discharged from the hospital against medical advice. Due to the increase in popularity of ketogenic diet, there is a need for large studies assessing its safety and efficacy. Moreover, our case draws attention to the fact that patients can use modern technologies, which

are developed to improve the glycemic control, in unconventional ways. (Clin Diabetol 2019; 8, 4: 223–226)

**Key words:** diabetes mellitus type 1, ketogenic diet, personal insulin pump, insulin, continuous glucose monitoring

## Introduction

Over the last decades, there has been a significant technological progress in the treatment of type 1 diabetes, mainly regarding new insulin preparations, continuous glucose monitoring and personal insulin pumps. However, many patients still do not achieve glycemic targets [1] and have difficulty controlling postprandial hyperglycemia, which significantly influences HbA<sub>1c</sub> values [2]. Only 30% of adults with type 1 diabetes reach the HbA<sub>1c</sub> target of < 7% [3]. Treatment of type 1 diabetes with intensive functional insulin therapy, including continuous subcutaneous insulin infusion (personal insulin pumps), is a recognized and effective method of treatment [4]. Clinical recommendations for dietary management of patients with diabetes indicate the need to individualize the daily amount of carbohydrates consumed in the range of 25–60% of the total daily energy requirement [5]. According to the 2019 Guidelines of Diabetes Poland, there is insufficient scientific data to determine one optimal carbohydrate dietary intake for patients with diabetes. However, it is believed that carbohydrates should account for approximately 45% of the daily energy requirement and a reduced amount of carbohydrates, i.e. 25–45% can be consumed temporarily by patients who are not

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Clinical Diabetology 2019, 8, 4, 223–226

DOI: 10.5603/DK.2019.0017

Received: 26.01.2019

Accepted: 29.04.2019

physically active. Fats should constitute 25–40% of the daily energy intake [6]. Due to the fact that both the type and amount of carbohydrates consumed affect postprandial glycemia, patients as well as researchers are very interested in low-carbohydrates diets, including a diet with a very low amount of carbohydrates, i.e. ketogenic diet, also in patients with type 1 diabetes [7–9]. The ketogenic diet has already been used in the treatment of type 1 diabetes before the invention of insulin [10], and therefore, the history has come full circle. There is no single definition of a diet with a very low carbohydrate content; however, the most common daily amount of carbohydrates in such a diet is less than 50 g or less than 10% of the total daily energy intake, with increased amount of fats and proteins consumed [3, 11]. When a ketogenic diet is used, ketosis occurs as a result of an increased production of so-called ketone bodies: acetoacetate, beta-hydroxybutyrate and acetone. Ketonemia reaches the maximum value of 7–8 mmol/L, at blood pH within a normal range. When using a balanced diet, the average blood ketone concentration is < 0.3 mmol/L, whereas in diabetic ketoacidosis blood ketone concentration can exceed 20 mmol/L with coexisting decrease in blood pH [12, 13]. Nowadays, patients are looking for alternative therapeutic methods, especially for various types of diets, that would improve their health. Popular websites often publish information about alleged benefits of these methods which have not been confirmed in scientific studies [14]. In recent months there has been a debate in the scientific community, caused by the publication of the paper by Lennerz et al. [15], regarding the relevance of promoting a diet with a very low carbohydrate content in patients with type 1 diabetes [9, 16]. These authors, using an online questionnaire filled out by patients, evaluated glycemic control and adverse events, such as the occurrence of diabetic ketoacidosis, hypoglycemia, and hospitalization due to decompensation of diabetes, in children and adults with type 1 diabetes who were on a ketogenic diet [15]. The study participants were recruited from a Facebook group established in April 2014 and associating, at the time of the study, 1,900 people with type 1 diabetes on a very low carbohydrate diet (up to 30 grams/day). Finally, 493 people completed the study questionnaire, of which 316 were qualified for further observation. The results obtained indicated a good glycemic control (mean  $HbA_{1c}$  was  $5.67 \pm 0.66\%$ ), a low rate of hypoglycemia (in 2 patients) or ketoacidosis (in 4 patients). One can get the impression that the results of the cited work encourage the use of a ketogenic diet; nevertheless, both the authors themselves and experts commenting on the study underline the need to verify these results in well-designed, large clinical trials.

Data on the prevalence of diabetic ketoacidosis (DKA) in adults with type 1 diabetes, unlike data regarding children, are limited. Based on a recent systematic review of the literature, the incidence of DKA was estimated at 50–100 cases per 1,000 adult patients with type 1 diabetes [17]. The data on the incidence of DKA at the level of 2% of patients presented by Lennerz et al. [15] are lower than the estimated annual risk of DKA episode in patients not using the ketogenic diet [17]; however, due to the fact that these data come from a small survey, it is not possible to conclude on that basis that the risk of developing ketoacidosis in patients on a ketogenic diet is low and that in this aspect the diet can be considered safe. Moreover, generally acknowledged contraindications to the use of the ketogenic diet, which include disorders of lipid metabolism, porphyria and pyruvate carboxylase deficiency, should be taken into account [18].

In this report we present a case of a patient with type 1 diabetes on a ketogenic diet, using a personal insulin pump in an unusual way.

### Case presentation

A 28-year-old female, diagnosed with type 1 diabetes at the age of 13, who has been treated for 5 years with personal insulin pump (Medtronic Minimed G640) with compatible continuous glucose monitoring system (CGMS) was admitted to the Department of Internal Medicine and Diabetology on July 2017 due to vomiting and diarrhea that had lasted for several days. The patient explained that she used personal insulin pump for only several hours a day, providing a 5-hour infusion of fast-acting insulin analog (insulin aspart, Novo Nordisk, 0.6 units/hour) in order to avoid dawn phenomenon between 2 a.m. and 7 a.m. Therefore, she connected the insulin pump tubing before going to sleep and disconnected it after waking up. Additionally she administered a single daily dose of basal insulin (30 units of insulin glargine U300, Sanofi Aventis) before going to sleep. She did not administer insulin boluses before meals.

In addition, for 5 months the patient has been using a ketogenic diet to avoid the need for prandial insulin. This behavior was probably caused by the lack of acceptance of the disease (the patient refused a psychologist consult). She declared the following daily intake of nutrients: 10 g carbohydrates, 15 g proteins, 120 g fats. On the day of admission to the Diabetology Department, the patient was in a good general condition. A physical examination did not reveal any abnormal findings, except for dryness of the oral mucosa. The BMI was 20.5 kg/m<sup>2</sup> (body weight 62 kg, height 174 cm). The only abnormal results of the laboratory tests were

**Table 1. Blood glucose levels during hospitalization [mg/dL]**

Date\Time	3:00	8:00	12:00	16:00	21:00	24:00
14.07.2017	–	–	–	147	113	87
15.07.2017	72	79	106	75	82	107
16.07.2017	107	116	100	110	104	85
17.07.2017	71	100	144	85	114	–
18.07.2017	–	80	–	–	–	–

the increased concentration of betahydroxybutyrate in the venous blood (6 mmol/L), with normal blood pH, and ketonuria (+++). Blood glucose at admission was 147 mg/dL. During the hospitalization glycemic values were within normal range, which is presented in Table 1. The results of other laboratory tests (complete blood count, serum aminotransferases [AST and ALT] and lipid concentration, venous blood gasometry) did not show significant deviations from the reference values.

After intravenous rehydration (the patient did not consent to the administration of glucose either orally or intravenously) and treatment with proton pump inhibitor administered intravenously, dyspeptic symptoms resolved and the patient was discharged on the fourth day of hospitalization at her own request, against medical advice. During the hospitalization, the patient did not agree to diet modification or administration of prandial insulin.

According to the patient, after she had been diagnosed with diabetes her mean HbA<sub>1c</sub> values oscillated around 7%. The introduction of the ketogenic diet resulted in a reduction in HbA<sub>1c</sub> value from 6.4% to 5.4%, and the blood glucose self-monitoring values remained in the range of 60–90 mg/dL. Moreover, she did not observe body weight reduction while being on the diet. The patient monitored her blood ketone concentration on a daily basis using an Optium Xido Abbott Diabetes glucose meter, thus assessing the state of ketosis. While on a ketogenic diet, the patient had never had symptoms like the one observed just before hospitalization. She claimed that the way she use a personal insulin pump in combination with basal insulin injected with a pen and a ketogenic diet has been accepted by her diabetologist; however, she did not have any medical documentation confirming this information. It is also worth noting that the amount of fat consumed by the patient in proportion to the other nutrients (about 90% of the total daily caloric supply) is not in accordance with any recommendations of diabetic or dietary associations. Average daily blood glucose values of 60–90 mg/dL, which in the long-term perspective may have a negative effect on neurocyte function, also raise concern [19].

It should be emphasized that due to the lack of randomized, prospective trials assessing the safety of the ketogenic diet, its impact on individual metabolic pathways, the body composition by percent of mass or long-term systemic effects is not known. However, it has been proven that excessive protein supply may adversely affect kidney function in people with reduced renal filtration, and patients with type 1 diabetes are at particularly high risk of this complication [20, 21]. In addition, high-fat products contribute to the progression of atherosclerotic lesions and increased visceral fat, which increases insulin resistance [22].

Taking into account lack of the patient's consent to psychological consultation, strict carbohydrate restriction and BMI values at the lower limit of the normal range, anorexia-related eating disorders should be considered. It is also important that the patient, although using insulin reservoirs and infusion sets for insulin administration for only a few hours daily, is subject to the same reimbursement principles as the patients who use them 24 hours a day, which is not negligible, given the reimbursement-related costs incurred by the payer.

## Summary

The presented clinical case shows that the patients can use the recommended forms of therapy in their own way, not necessarily consistent with the current principles of the treatment of type 1 diabetes [4, 5]. According to our knowledge, this is the first report describing the unconventional use of a personal insulin pump in the treatment of type 1 diabetes, where the pump therapy, used only to prevent the dawn phenomenon in the early morning hours, is combined with the single daily injections of a long-acting insulin analog, while eliminating prandial insulin boluses through the use of a ketogenic diet. Modern technologies developed to improve blood glucose monitoring and insulin therapy certainly facilitate obtaining the desired glycemic control by patients using different diets; however, it should be noted that the presented diet does not meet the principles of healthy nutrition in type 1 diabetes, so it should not be accepted by a health care provider. The case of the described patient

points out the need to carry out large trials assessing short- and long-term safety, but also the effectiveness of the ketogenic diet, which patients use more and more often. It also indicates that modern tools, in this case an insulin pump, can be used by patients in an unconventional way.

### Conflict of interests

The authors declare no conflict of interest.

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