Assessment of diabetes control in insulin pump therapy in late adolescents and young adults with type 1 diabetes

Ocena wyrównania cukrzycy u starszej młodzieży i młodych dorosłych z cukrzycą typu 1 leczonych przy pomocy pomp insulinowych

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Abstract

Advances in medical technology, including insulin pump therapy, have not led to the expected improvement in glucose control of type 1 diabetes, especially in late adolescents and young adults. **Objectives.** The aim of the study was to evaluate metabolic control in insulin pump therapy (IPT) in late adolescents and young adults with type 1 diabetes mellitus. **Material and Methods.** The study was conducted in 86 subjects with type 1 diabetes, and included 45 patients aged 16–19 years (mean 17.6±1.2) treated in a pediatric outpatient clinic and 41 subjects aged 19–26 years (mean 22.8±2.2) treated in an adult outpatient clinic of the same university hospital, who received the same refund of IPT. **Results.** Late adolescents had a lower BMI (22.7±2.9 kg/m² vs. 24.2±3.2 kg/m²; $P<0.05$), higher HbA$_1$c (69.4±15.1 mmol/mol vs. 58.5±11.8 mmol/mol; $P<0.001$) and mean blood glucose levels (10.4±2.6 mmol/l vs. 9.2±1.4 mmol/l, $P<0.05$), and received higher insulin doses per day (0.85±0.23 IU/kg vs. 0.65±0.13 IU/kg; $P<0.001$). The mean diabetes and IPT duration, number of visits, basal/bolus insulin ratio, number of insulin boluses, blood glucose tests and the episodes of hypoglycemia were similar. **Conclusions.** Metabolic control in late adolescents with type 1 diabetes on IPT is significantly worse than in young adults, despite higher doses of insulin and very similar way of treatment and self-control. This may be related to the patients age or the less rigorous approach to therapeutic recommendations resulting from pediatric diabetes care.

Key words

type 1 diabetes mellitus, insulin pump therapy, glycemic control, adolescents, young adults

Streszczenie

Znaczny postęp, jaki dokonał się w ostatnich latach w leczeniu cukrzycy, nie przełożył się na uzyskanie optymalnego wyrównania metabolicznego cukrzycy typu 1, zwłaszcza u młodzieży i młodych dorosłych. **Cel pracy.** Celem badania była ocena wyrównania cukrzycy typu 1 u starszej młodzieży i młodych dorosłych leczonych metodą osobistej pompy insulinowej (OPI). **Materiał i metody.** Do badania zostało włączonych 86 osób – w tym 45 osób w wieku 16–19 lat (śr. 17,6±1,2) w poradni diabetologiczno-pediatrycznej i 41 osób w wieku 19–26 lat (śr. 22,8±2,2) w poradni diabetologicznej dla dorosłych tego samego szpitala uniwersyteckiego. Obie grupy miały taki sam stopień refundacji leczenia. **Wyniki.** Starsza młodzież miała niższy wskaźnik BMI (22,7±2,9 kg/m² vs. 24,2±3,2 kg/m²); $P<0,05$, wyższe stężenie HbA$_1$c (69,4±15,1 mmol/mol vs. 58,5±11,8 mmol/mol; $P<0,001$) i średnie glikemie (10,4±2,6 mmol/l vs. 9,2±1,4 mmol/l, $P<0,05$) oraz otrzymywała większe dzienne dawki insuliny (0,85±0,23 IU/kg vs. 0,65±0,13 IU/kg; $P<0,001$). Średnie czasy trwania cukrzycy oraz terapii pompą insulinową, liczba wizyt w przychodni, wskaźnik baza/bolusy, liczba bolusów, liczba pomiarów glikemii i epizodów hipoglikemii były podobne. **Wnioski.** Wyrównanie metaboliczne u starszej młodzieży z cukrzycą typu 1 leczonej metodą OPI jest istotnie gorsze niż u młodych dorosłych leczonych w ten sam sposób, mimo stosowania większych dawek insuliny i bardzo podobnego sposobu prowadzenia terapii i samokontroli. Być może, jest to związane z samym wiekiem pacjentów lub mniej rygorystycznym podejściem do zaleceń terapeutycznych, wynikającym z opieki diabetologiczno-pediatrycznej.

Słowa kluczowe

cukrzyca typu 1, terapia pompą insulinową, kontrola glikemii, młodzież, młodzi dorośli

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Introduction

The introduction of insulin analogues and advances in the technology of insulin administration have not led to the expected improvement in the control of type 1 diabetes. The mean HbA$_1$c assessed in patients with diabetes type 1 treated at diabetes centers in the United States was 68 mmol/mol (8.4%), despite the fact that 60% of patients were on insulin pump therapy [1]. A detailed analysis of HbA$_1$c levels in adolescents and young adults revealed that glucose levels are rising sharply from 10 to 16 years of age, then some stability is achieved at the age of 16–19 with mean HbA$_1$c levels of 74 mmol/mol (8.9%). The maximum levels of HbA$_1$c are recorded at approximately 19 years of age and gradually decrease later [1,2]. In patients over 26 years old, metabolic control improves significantly (HbA$_1$c 61 mmol/mol, 7.7%) [1–3]. A similar relationship between age and metabolic control was also observed in European countries [4]. The deterioration of glycemic control before the age of 16 may be attributed to the growing independence of young people and the gradual decrease in the supervision of therapy by parents [5]. The improvement observed in adults aged 25–26 years of age may result from life activity associated with a certain stabilization of professional and familial circumstances or with a different system of equipment refund [6].

People with type 1 diabetes who are 16–19 years old are a special group of patients because of their highly active lifestyle, emerging adulthood, and greater freedom in making therapeutic decisions previously assisted or made entirely by parents. At the same time, during the period of the worst metabolic control (18–19 years of age), adolescents are transferred from pediatric diabetes outpatient clinics to diabetes clinics for adults. Available publications do not provide analyses on metabolic control and therapy-related factors in late adolescents aged 16–18 and young adults aged 19–26 with type 1 diabetes treated with insulin pump therapy. Both age groups have a very active lifestyle (school, study, exams, starting work, sports, and social events).

The aim of the study was to evaluate the metabolic control of type 1 diabetes in late adolescents and young adults treated with insulin pumps, who receive similar refund of insulin pump therapy, but who are staying under the care of two different health care centers of the same hospital, i.e., a pediatric and an adult diabetes outpatient clinics.

Material and methods

The study was conducted in 86 young patients with type 1 diabetes treated in diabetes outpatient clinics at the University Hospital SPSK1 No. 1 in Szczecin. There were 265 children and adolescents treated with insulin pump therapy under the care of the pediatric outpatient clinic. The group of late adolescents aged 16-19 comprised 89 subjects, and complete data were available for 45 of them. The total number of patients utilizing insulin pump therapy at an adult diabetes outpatient clinic was 179, number of young adults aged 19–26 was 49, and complete data were extracted for 41 subjects of this age. Due to different practices of transferring patients from a pediatric clinic to an one clinic, both groups included subjects aged 19 years. According to the current health insurance system, both groups received the same treatment refund, regardless of the number of visits to the clinic. Patients also received a full refund for insulin pumps and partial refund for accessories, applicable in Poland for patients with type 1 diabetes until the age of 26 years. Both clinics used the same insulin pumps (Medtronic and Roche devices), and the medical staff were educated on insulin pump therapy in the same way.

Data on metabolic control were obtained from the medical records kept in both clinics, including reports from insulin pumps from the 14 days prior to the last visit. The mean HbA$_1$c value was calculated as the mean of the measurements taken during routine visits over the past year. HbA$_1$c was measured in a hospital laboratory using the HPLC technique, standardized for the National Glycohaemoglobin Standardization Programme (NGSP) method.

Statistical analysis was performed with the Statistica 12.5 package (StatSoft, Poland). The results are presented as the arithmetic means and standard deviations (SDs), or medians. The distributions of the analyzed parameters were assessed using the Shapiro-Wilk test. The values of variables between groups were analyzed using the Mann-Whitney U test. Statistical significance was adopted at p < 0.05. The study was approved by the Bioethics Committee of the Pomeranian Medical University in Szczecin (KB-0012/162/05/17).

Results

Characteristics of the study groups are presented in Table I. The body mass index (BMI) was significantly lower in late adolescents than in young adults, but was within the normal range in both groups. The duration of diabetes and insulin pump therapy and the mean number of visits to the clinic in the last year were similar in both groups.

The mean HbA$_1$c in late adolescents (69.4 mmol/mol, 8.5%) was significantly higher than in young adults (58.5 mmol/mol, 7.5%). The mean glucose level measured within 14 days prior to the visit was also significantly higher in the younger age group, while the mean lipid levels were comparable (table I).

Data on the insulin dosage and blood glucose measurements are presented in Table II. The mean daily dose of insulin, both total and per kg of body weight, was significantly higher in the younger age group, despite worse metabolic control. The groups did not differ in terms of the basal-bolus ratio (40%–60%) or the mean daily number of insulin boluses calculated for the last 14 days. The number of daily blood glucose test and the number of blood glucose levels below 3,9 mmol/l within 14 days prior to the last visit were similar in both groups.

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Table I. Clinical characteristics of investigated subjects
Tabela I. Kliniczna charakterystyka badanych osób

Parameter	Late adolescents (n=45)	Young adults (n=41)	p-Value
Sex (females/males)	18/27	24/17	ns
Age (yr)	17.6±1.2	22.8±2.2	<0.001
Height (cm)	172±9	173±9	ns
Body weight (kg)	67.5±12.0	72.4±13.4	ns
BMI, kg/m^2	22.7±2.9	24.2±3.2	<0.05
Diabetes duration (yr)	7.8±3.6	10.8±5.0	ns
Pump therapy duration (yr)	6.0±2.8	6.9±3.6	ns
Number of visits (last year)	5.0±2.0	4.3±3.1	ns
HbA$_1$c, mmol/mol	69.4±15.1	58.5±11.8	<0.001
HbA$_1$c, %	8.5±1.4	7.5±1.1	<0.001
Mean glycemia (mmol/l)	10.4±2.6	9.2±1.4	<0.05
HDL cholesterol (mmol/l)	1.6±0.4	1.7±0.8	ns
LDL cholesterol (mmol/l)	2.4±0.7	2.6±1.0	ns
Triglicerides (mmol/l)	1.1±0.5	1.0±0.4	ns

Data are presented as mean ± standard deviation; ns – statistically non-significant. BMI – body mass index; HbA$_1$c – glycosylated hemoglobin; HDL – high density lipoprotein; LDL – low density lipoprotein.

Table II. Parameters of insulin pump therapy
Tabela II. Parametry terapii pompą insulinową

Parameter	Late adolescents (n=45)	Young adults (n=41)	p-Value
Daily dose of insulin (IU)	57.4±16.5	47.7±14.1	<0.001
Daily dose of insulin/kg (IU/kg)	0.85±0.23	0.65±0.13	<0.001
Basal daily insulin (%)	41±14	39±10	ns
Bolus daily insulin (%)	59±14	61±11	ns
Boluses per day (n)	6.0±2.8	4.3±3.1	ns
Blood glucose tests per day (n)	5.1±2.3	5.6±2.9	ns
Episodes of glycemia < 3,9 mmol/l in last 14 days*(n)	3.0 (0.0–19.0)	2.0 (0.0–15.0)	ns

Data reported as mean ± standard deviation or as median* (IQR); ns – statistically non-significant.

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Discussion

Insulin pump therapy is an approved method of treatment for type 1 diabetes, but the results are still disappointing, especially in young people [7]. The fact that poor metabolic control is particularly evident in late adolescents suggests the significant role of the patient's age and age-associated behaviors [1,3,4,8]. Some reports indicate that poor metabolic control is related to a longer duration of diabetes, female gender, lower economic status, season of the year, and the type of diabetes health center that is monitoring the patient [9]. Higher HbA$_1$c levels may also be associated with fewer visits to the clinic, fewer boluses, and fewer blood glucose tests per day [10,11]. Worse glycemic control may also be the result of the improper or incomplete use of the insulin pump settings [12]. The early introduction of insulin pump therapy after the diagnosis of diabetes has no effect on metabolic control [13]. The patient's knowledge of diabetes mellitus appears to have no influence on treatment outcome, either [12].

In our study the mean level of HbA$_1$c in the group of late adolescents (69.4 mmol/mol, 8.5%) was significantly higher than in young adults (58.5 mmol/mol, 7.5%). Worse metabolic control was not related to the gender or the duration of diabetes and pump therapy, as they were comparable in both groups. The number of visits to the clinic and the daily number of blood glucose tests were also similar. Lower HbA$_1$c levels in young adults did not result from hypoglycemia, as the number of measurements below 3.9 mmol/l was similar. The basal/bolus, daily insulin ratio, as well as the number of boluses per day, were also very similar between the analyzed groups. The daily insulin doses differed significantly and were higher in late adolescents (0.85 IU/kg body weight) than in young adults

(0.65 IU/kg). Higher doses of insulin and concurrent worse metabolic control may be cause by higher insulin resistance characteristics for this age [14]. However, it cannot be ruled out that this is typical by a more liberal approach to diet and a greater intake of carbohydrates. Unfortunately, data on the type of preferred and consumed meals were not recorded in the available medical documentation. It should be emphasized that both groups were treated in two different clinics of the same hospital – the pediatric diabetes outpatient clinic and the outpatient clinic for adult diabetes patients. Perhaps this factor could have a significant impact on the difference in metabolic control of patients, although both clinics used the same insulin pumps, and the medical staff were educated on pump therapy in the same way. As the metabolic control of diabetes in the group of adolescents is still inadequate in many countries, time of transferring patients from pediatric care to adult care is widely discussed [15–17]. Although some observations indicate that transfer interventions may reduce numbers of acute complications of argued [17], there is no one proper transition program. It may be argued that late adolescents with type 1 diabetes should be transferred to adult outpatient clinics earlier.

Conclusions

Metabolic control in late adolescents with type 1 diabetes treated with insulin pumps is significantly worse than in young adults treated the same way, despite higher doses of insulin administered in similar regimens. This may be related to patient age or the less rigorous approach to the therapeutic recommendations resulting from pediatric diabetes care.

References

1. Miller KM, Foster NC, Beck RW et al. *Current state of type 1 diabetes treatment in the U.S.: updated data from the T1D Exchange clinic registry*. Diabetes Care. 2015; 38(6): 971-978.
2. Clements MA, Foster NC, Maahs DM et al. *Hemoglobin A1c (HbA$_1$c) changes over time among adolescent and young adult participants in the T1D exchange clinic registry*. Pediatr Diabetes. 2016; 17(5): 327-336.
3. Foster NC, Miller KM, Tamborlane WV et al. *Continuous Glucose Monitoring in Patients With Type 1 Diabetes Using Insulin Injections*. Diabetes Care. 2016; 39(6): e81-82.
4. Hofer SE, Raile K, Fröhlich-Reiterer E et al. *Tracking of metabolic control from childhood to young adulthood in type 1 diabetes*. J Pediatr. 2014; 165: 965-961.
5. Gordon CM, Mansfield MJ. *Changing needs of the patient with diabetes mellitus during the teenage years*. Curr Opin Pediatr. 1996; 8: 319-327.
6. Grzanka M, Matejko B, Cyganek K et al. *Efficacy and safety of insulin pump treatment in adult T1DM patients – influence of age and social environment*. Ann Agric Environ Med. 2012; 19(3): 573-575.
7. Thabit H, Hovorka P. *Continuous subcutaneous insulin infusion therapy and multiple daily insulin injections in type 1 diabetes mellitus: a comparative overview and future horizons*. Expert Opin Drug Deliv. 2016; 13: 389-400.
8. Kaiserman K, Rodriguez H, Stephenson A et al. *Continuous subcutaneous infusion of insulin lispro in children and adolescents with type 1 diabetes mellitus*. Endocr Pract. 2012; 18: 418-424.
9. Gerstl EM, Rabl W, Rosenbauer J et al. *Metabolic control as reflected by HbA$_1$c in children, adolescents and young adults with type 1 diabetes mellitus: combined longitudinal analysis including 27 035 patients from 207 centers in Germany and Austria during the last decade*. Eur J Pediatr. 2008; 167: 447-453.
10. Osan JK, Punch JD, Watson M et al. *Associations of demographic and behavioural factors with glycaemic control in young adults with type 1 diabetes mellitus*. Intern Med J. 2016; 46(3): 332-338.
11. Lau YN, Korula S, Chan AK et al. *Analysis of insulin pump settings in children and adolescents with type 1 diabetes mellitus*. Pediatr Diabetes. 2016; 17: 319-326.

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12. Wen W, Frampton R, Wright K et al. *A pilot study of factors associated with glycaemic control in adults with Type 1 diabetes mellitus on insulin pump therapy*. Diabet Med. 2016; 33(2): 231-234.

13. Shalitin S, Lahav-Ritte T, Lebenthal Y et al. *Does the timing of insulin pump therapy initiation after type 1 diabetes onset have an impact on glycemic control?* Diabetes Technol Ther. 2012; 14(5): 389-397.

14. Szadkowska A, Pietrzak I, Mianowska B. *Insulin sensitivity in type 1 diabetic children and adolescents*. Diabet Med. 2008; 25: 282-288.

15. Wafa S, Nakhla M. *Improving the Transition from Pediatric to Adult Diabetes Healthcare: a Literature Review*. Can J Diabetes. 2015; 39(6): 520-528.

16. de Beaufort C, Jarosz-Chobot P, Frank M et al. *Transition from pediatric to adult diabetes care: smooth or slippery?* Pediatr Diabetes. 2010; 11(1): 24-27.

17. Schultz AT, Smaldone A. *Components of Interventions That Improve Transitions to Adult Care for Adolescents With Type 1 Diabetes*. J Adolesc Health. 2017; 60(2): 133-146.