Factors Correlating With Improved A1C in Children Using Continuous Subcutaneous Insulin Infusion

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The Diabetes Control and Complications Trial demonstrated that tight metabolic control in patients with type 1 diabetes reduces the risk of microvascular complications (1). Subsequently, the use of continuous subcutaneous insulin infusion (CSII) to achieve strict metabolic control increased exponentially. The advantages of CSII over multiple daily injections include increased lifestyle flexibility, variable basal infusion rates with boluses given before meals, and only one injection for insulin administration every few days (2). CSII in children lowers A1C and decreases hypoglycemia (3,4). The American Diabetes Association recommended A1C treatment goals for pediatric patients of 7.5–8.5% for those aged <6 years, ≤8% for those aged 6–12 years, <7.5% for those aged 13–19 years, and <7% for those aged 19–22 years (5), but few children and adolescents reach these goals. The reason for this remains unclear. We conducted this study to determine the percentage of children using CSII who reached their A1C goal and to identify differences between children who met their goal and those who did not.

RESEARCH DESIGN AND METHODS

— Medical records of all patients (aged 2–22 years, $n = 236$) with type 1 diabetes for ≥1 year using CSII for ≥6 months who were followed at the University of Wisconsin pediatric diabetes clinic were reviewed. Data from the time of initiation of CSII were analyzed. Age, duration of diabetes, A1C before CSII initiation, duration of CSII use, number of visits to the diabetes clinic in the previous year, number of basal rates and catheter sites (arms, legs, buttocks, or abdomen), and days between catheter changes were evaluated. A1C was determined using the DCA 2000+ instrument (Bayer Diagnostics, Tarrytown, NY).

Baseline A1C, age, days between catheter changes, number of visits to the diabetes clinic, and basal rates were summarized by standard descriptive statistics in terms of means, SDs, and ranges. Comparisons of outcome measures between children who did and did not reach their A1C goal at their last clinic visit were performed using a nonparametric Wilcoxon's rank-sum test. The comparisons of duration of diabetes and duration of CSII use between children who reached their A1C goal and those who did not were age adjusted by fitting ANCOVA models. Categorical variables were analyzed using χ^2 analysis. All data analyses were performed using SAS version 6.12. A two-sided significance level of 0.05 was used.

RESULTS

— The mean ± SD age of the subjects was 14.5 ± 3.9 years, the duration of diabetes was 6.8 ± 3.7 years (range 1.0–18.6), the duration of CSII use was 2.9 ± 3.7 years (0.5–9.8), and the age at initiation of CSII was 11.7 ± 3.5 years.

We found that 38% of patients using CSII (90 of 236) met their A1C goal at their most recent clinic visit. Patients who met their goal were significantly younger, had a shorter duration of diabetes, had a lower A1C before CSII, and had more catheter sites. There were no significant differences regarding sex, number of visits to the diabetes clinic in the previous year, days between catheter changes, duration of CSII use, or number of basal rates (Table 1).

The mean ± SD A1C of the group that met its goal was 6.9 ± 0.7% (range 4.6–8.5), whereas mean A1C was 8.6 ± 0.9% (6.9–11.4) in the group that did not meet its goal (normal A1C ≤6%). When analyzed by age-group, 63% of those aged 6−12 years, 33% of those aged 13–19 years, and 22% of those aged 19–22 years met their A1C goal ($P < 0.001$). Those aged 6–12 years who met their goal had a significantly better A1C before initiating CSII than patients who did not meet their goal (7.1 ± 0.6 vs. 8.6 ± 0.9%, respectively, $P < 0.001$). A logistic regression analysis model was fitted to further examine the association between age and the probability of meeting the A1C goal. The odds ratio of age was 0.87 (95% CI 0.80–0.94), which indicates that the probability of meeting the A1C goal decreases significantly with increasing age. In the group aged 13–19 years, subjects who met their goal had a better A1C before CSII initiation (6.8 ± 0.7 vs. 8.6 ± 0.9%, respectively, $P < 0.001$), a shorter mean duration of diabetes (5.8 ± 3.5 vs. 7.6 ± 3.5 years, $P = 0.006$), and a greater number of catheter sites (1.5 ± 1.0 vs. 1.2 ± 0.4, $P = 0.019$). In the group aged >19 years, those who met their A1C goal were more likely to be male ($P = 0.05$).

CONCLUSIONS

— It is concerning that few children using CSII, the best insulin delivery system currently available, reached their A1C goal. Overall, we found that children who met their A1C goal were younger than those who did not.

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Abbreviations: CSII, continuous subcutaneous insulin infusion.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Comparison of patients using CSII who met the A1C goal versus those who did not*

	A1C goal not met	A1C goal met	*P*
n	146	90	
Sex			0.070*
Female	55 (81)	43 (39)	
Male	45 (65)	57 (51)	
Age (years)	15.3 ± 3.65	13.4 ± 3.98	<0.001†
A1C % CSII	8.6 ± 0.92	6.9 ± 0.66	<0.001†
Aged 6–12 years	8.6 ± 0.58	7.1 ± 0.62	
Aged 13–19 years	8.6 ± 0.94	6.8 ± 0.67	
Aged >19 years	8.4 ± 1.03	6.4 ± 0.35	
No. of clinic visits	2.8 ± 1.21	2.6 ± 1.20	0.423†
No. of days between catheter changes	2.6 ± 0.60	2.6 ± 0.69	0.884†
No. of catheter sites	1.2 ± 0.42	1.4 ± 0.78	0.015†
No. of basal rates	5.0 ± 2.10	4.6 ± 2.05	0.113†
A1C % before CSII	8.2 ± 1.19	7.4 ± 0.99	<0.001†
Duration of diabetes (years)	7.5 ± 3.59	5.6 ± 3.53	0.008‡
Duration of CSII (years)	3.1 ± 1.77	2.5 ± 1.44	0.169‡

Data are *n* (%) or means ± SD unless otherwise indicated. *χ^2 analysis. †Wilcoxon's rank-sum test. ‡ANCOVA (comparison was adjusted for age).

This may be due to greater parental control of diabetes management and less insulin resistance related to puberty. We also found that shorter duration of diabetes was associated with better A1C when using CSII. This emphasizes the need for continued diabetes education in patients with longstanding disease (6). It is not surprising that patients who had a lower A1C before initiating CSII were also more likely to meet their goal while using CSII. Finally, we found that children with more catheter sites were more likely to meet their A1C goal. This may be due to better insulin absorption from multiple catheter sites with subsequently less lipohypertrophy (7). Using more catheter sites may be particularly important in children who have a smaller body surface area than adults.

Limitations of this study include its retrospective nature and lack of data regarding total daily insulin dose, percentage of insulin delivered as a bolus, and frequency of hypoglycemia.

The group aged 6–12 years using CSII was most successful at reaching their goal A1C. Success of children in this age-group suggests that starting children on CSII at a younger age is logical. Adolescents were less successful reaching their target A1C, which reinforces the need for close follow-up in these patients. The fact that only 22% of those aged 19–22 years reached an A1C <7% is concerning and requires further investigation.

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