Improving Diabetes Control in Adolescents

Physiologic (1,2), social, and psychological factors (3–10) make diabetes more difficult to control in adolescents than in younger children and adults. The Diabetes Control and Complications Trial (DCCT), however, demonstrated that by working closely with a diabetes treatment team, adolescents randomized to receive intensive therapy could improve their blood glucose control and sustain the improvement over a mean period of 7.4 years. Whereas the conventionally treated adolescent subjects had a mean HbA_{1c} level of 9.76%, the intensively treated adolescents lowered their mean HbA_{1c} to 8.06% and thereby reduced their risk of progression of diabetic retinopathy and microalbuminuria. Few subjects consistently achieved and maintained normal blood glucose values or target ($\leq$6.05%) HbA_{1c} levels (11).

Intensive insulin therapy with the goal of maintaining blood glucose levels as close to the normal range as is safely possible is now the recommended standard of care for adolescents with type 1 diabetes (12). The challenge is to implement intensive insulin therapy in routine clinical practice—a challenge that is even more daunting when one considers that the adolescent subjects in the DCCT were the most difficult to manage and required a disproportionate share of the supportive care provided by the diabetes team (11). The outcomes of the DCCT resulted from the strenuous efforts of a diabetes team (nurses, dietitians, mental health professionals, and diabetologists) that worked closely with a relatively small number of selected volunteers (13).

Adolescents who switch from two to three daily insulin injections, without any other intervention, can modestly lower their HbA_{1c} levels (14). However, the prescribed number of daily insulin injections does not per se ensure improved blood glucose control. A cross-sectional survey of 2,873 children and adolescents with type 1 diabetes showed no differences in glycemic control among adolescents treated with two, three, or four or more daily insulin injections, suggesting that other factors are important in determining glycemic outcomes (15). Because intensive insulin therapy is based on defined target blood glucose goals before and after meals, at bedtime, and overnight (2:00–4:00 A.M.), frequent blood glucose monitoring (BGM) is the *sine qua non* of a successful intensified treatment regimen. Likewise, increasing the frequency of insulin administration and BGM without appropriate diabetes education, self-management training, and psychosocial support is likely to result in modest and transient improvements in HbA_{1c} levels. Intensive insulin therapy must be part of a comprehensive program of self-management training that teaches the youth to interpret the data obtained from BGM, to make appropriate food choices, and to select insulin doses based on blood glucose levels, anticipated carbohydrate consumption, and exercise. The goal must be to equip the adolescent patient with the problem-solving skills necessary to maintain nearly normal blood glucose levels in the context of the adolescent lifestyle.

In this issue of *Diabetes Care*, Boland et al. (16) report the results of a 1-year study of an intensive therapeutic program in adolescents attending a university hospital children's diabetes clinic staffed by a highly skilled and experienced diabetes team. Subjects were recruited to the Adolescents Benefit from Control of Diabetes Study with the specific goal of implementing intensive therapy to improve their control and to determine whether continuous subcutaneous insulin infusion (CSII) or multiple daily injections (MDI) more favorably affected clinical and psychosocial outcomes. All of the patients in the study received intensive management comparable with that used in the DCCT, including the following: *1*) advice to monitor blood glucose levels $\geq$4 times per day, *2*) dietary counseling that emphasized carbohydrate counting, *3*) follow-up visits every 4–6 weeks, and *4*) frequent telephone communication between visits to adjust treatment regimens. Application of "DCCT style" therapy resulted in decreased HbA_{1c} levels and showed specific advantages of CSII over MDI therapy.

This is an important study for clinicians grappling with the challenge of how to improve the blood glucose control of their adolescent patients. There has recently been increasing interest in CSII for the management of adolescents with diabetes, especially with the availability of smaller and improved pumps. However, other than the DCCT experience, the published literature is sparse concerning the safety and efficacy of therapy with CSII in youth. The adolescents who selected CSII as the method of insulin delivery achieved and maintained nearly normal glycemic control for 12 months, had a lower frequency of severe hypoglycemia, and showed no difference in quality of life in comparison with patients who chose MDI. Because this was not a randomized study, one cannot conclude with certainty that CSII is the preferred mode of therapy for all adolescents with type 1 diabetes. However, it does show that when CSII is offered to adolescents, those who choose it and are managed by a skilled diabetes team can do well with it. Years ago, Schiffrin et al. (17) reported similar results and came to the same conclusions in a randomized crossover study to assess the feasibility of improving glycemic control in adolescents. Although subjects who received intensive treatment in the DCCT were not randomly assigned to MDI or CSII, a comparison among all subjects, regardless of age, who used either of these methods for $\geq$90% of the study time showed that CSII-treated patients maintained a significantly lower mean HbA_{1c} during the trial, 6.8 vs. 7.0% in the MDI-treated subjects. The frequency of hypoglycemia with coma and seizure and diabetic ketoacidosis was modestly higher in subjects treated with CSII than with MDI (13). Only a randomized controlled study can definitively resolve the issue of whether one method of insulin delivery is superior to the other.

A recent report claimed that nearly normal glycemia can be achieved in children and adolescents with a much lower frequency of hypoglycemia (18) than was observed in the study by Boland et al. However, controlled studies have clearly shown that an increased frequency of severe hypoglycemia is the principal

adverse effect of intensive diabetes management (11,19–22). Severe hypoglycemia was less frequent with treatment by CSII than MDI (76 compared with 134 events per 100 patient-years). Nevertheless, it was a disturbingly common occurrence in this population of intensively treated adolescents. By comparison, the intensively treated adolescent cohort in the DCCT had 86 episodes of severe hypoglycemia per 100 patient-years (11). The reason is not apparent for the even higher rate of severe hypoglycemia in the adolescents treated with MDI in this study compared with the adolescent cohort in the DCCT.

Technical mastery of self-care skills (including safely operating a pump) and a thorough knowledge of the disease and its treatment are necessary but not sufficient to obtain desirable outcomes. The motivation and willingness to adhere to a complex treatment regimen and to perform the tasks required to safely achieve target blood glucose levels is crucial to ensure long-term success. This, in turn, depends on the cognitive maturity of the adolescent (23), and on the involvement and support of parents (24) and a diabetes team (13). Few physicians, whether specialists or generalists, have the resources or time to provide quality total care for adolescents with diabetes. Modern management of this disease, therefore, requires teamwork. This was one of the most important messages of the DCCT and was, undoubtedly, an important reason for the success achieved by Boland and her colleagues. Diabetes clinics and office practices with fewer resources are unlikely to be able to emulate these results. This should not, however, detract from the message: with appropriate diabetes education, self-management training, support, and the use of a physiologic insulin-replacement regimen, adolescents can improve their diabetes control. It is abundantly evident that adolescents with diabetes should be referred to regional centers of excellence. The Yale diabetes team has shown us how to do it. We must attempt to emulate their example.

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