Utility of an Increment in the Basal Rate during Mealtime in Place of Pre-meal Boluses for Preschool-aged Children with Type 1 Diabetes Using CSII

Junichi Suzuki, Tatsuhiko Urakami, Ayako Yoshida, Hiroshi Saito, Mika Wada, Shouri Takahashi, and Hideo Mugishima

Department of Pediatrics, Nihon University School of Medicine, Tokyo, Japan

Introduction

In recent years, continuous subcutaneous insulin infusion (CSII) using a rapid-acting insulin analog (Ra) has increasingly been utilized for young children with type 1 diabetes mellitus (T1DM). Blood glucose levels are highly variable, and achieving adequate diabetes control is quite difficult for this age group with T1DM. Studies have demonstrated CSII using Ra to be useful for improving glycemic control and making insulin delivery more convenient (1–6). This treatment option seems more suited than any other insulin regimen for young children with T1DM.

Recent insulin pumps used for CSII allow programming of various basal insulin rates at different times of day to accommodate changes in the required insulin level. Nevertheless, the children themselves or their parents need to push a button to administer insulin boluses before each meal. Accordingly, administration of the boluses is very difficult for children attending a kindergarten or day nursery because neither kindergarten teachers nor nurses can give the boluses in place of a child's parents. Therefore, we introduced an increment in the insulin basal rate during a one-hour mealtime in place of pre-meal boluses in 4 preschoolers with T1DM using CSII.

Case Report

Four preschoolers, aged 6.8, 6.5, 5.2 and 4.7 yr, with T1DM were treated with CSII using an Ra. The subject characteristics are shown in Table 1. All the patients used a Paradigm MMT-712 Insulin Pump and Quick Set infusion sets. All components were manufactured by Medtronic Japan Co., Ltd. The same daily dose of insulin used prior to introduction of CSII was used as the starting daily dose for CSII. Approximately half of this starting dose was administered as the basal dose, and the remaining half was divided among the three main meals as pre-meal boluses. The basal rate and pre-meal insulin doses were adjusted according to the results of self-monitoring of the blood glucose level to maintain adequate glycemic control. When the patients rejected lunch and/or snacks in cases such as when they were sick, the planned increments in the basal rates during the mealtime were not implemented, and their parents visited the kindergartens to handle the changes in blood glucose through additional boluses and adjustment of the basal rates. When the patients experienced problems, such as discontinuation of insulin delivery, they first attempted to resolve...
the problem by replacing the devices, including catheters and reservoirs. If the problem still remained, they removed the pumps and reverted to their former MDI regimen.

They were not able, however, to operate the CSII and thus could not give themselves pre-meal boluses while at kindergarten. Initially, the children's mothers visited the kindergartens daily to give the boluses, which was a considerable burden on everyone concerned. None of the children had previously shown unpredictable patterns of meal intake or had any experienced episodes of severe hypoglycemia. Eventually, we introduced increments in the basal rates during a one-hour lunchtime and snacks in place of administration of pre-meal boluses. In practice, the bolus rates were increased to 1.5 or 3.0 units per one hour, i.e., similar to the doses of the boluses, during the one-hour mealtime (Fig. 1). There was no significant difference in mean blood glucose levels before supper or in HbA1c values during the 6 mo before and after administration of the new treatment; that is, the blood glucose levels of the children were 138 ± 15, 139 ± 13, 138 ± 11 and 130 ± 9 mg/dl before the new treatment and 116 ± 13, 136 ± 17, 141 ± 18 and 123 ± 13 mg/dl after the new treatment (not significant, respectively), their HbA1c levels were 7.7 ± 0.5, 8.6 ± 0.1, 7.0 ± 0.2 and 7.0 ± 0.2% before the new treatment and 7.3 ± 0.2, 8.4 ± 0.5, 7.1 ± 0.2 and 7.1 ± 0.3% after the new treatment (not significant, respectively). No episodes of either severe hypoglycemia or extreme hyperglycemia occurred during the new treatment. All of the parents were satisfied with this treatment regimen.

### Table 1 Subject characteristics

| Sex | Age at start of study (yr, mo) | Age at onset (yr, mo) | Duration of diabetes (yr, mo) | Titer of GAD antibody at onset (U/ml) | Height at start of study (cm) | Weight at start of study (kg) |
|-----|---------------------------------|----------------------|-------------------------------|---------------------------------------|-----------------------------|-----------------------------|
| Case 1 | F | 6yr, 10mo | 2yr, 6mo | 4yr, 4mo | 23.0 | 119.7 | 28.0 |
| Case 2 | M | 6yr, 6mo | 1yr, 3mo | 5yr, 3mo | 0.3 | 113.7 | 20.8 |
| Case 3 | M | 5yr, 2mo | 2yr, 11mo | 2yr, 3mo | 16.0 | 106.5 | 17.8 |
| Case 4 | F | 4yr, 7mo | 1yr, 0mo | 3yr, 7mo | 46.7 | 99.8 | 17.4 |

### Discussion

In Japan, CSII using an Ra has recently become an important strategy for intensive insulin therapy among children and adolescents with T1DM (7). The effectiveness of this new treatment in improving glycemic control and reducing the risk of severe hypoglycemia is more emphasized in preschool-aged children (1–6). However, missed insulin boluses have been reported to be the primary cause of deterioration of glycemic control in patients on CSII (8). Either the patients or their parents should administer insulin boluses regularly before each meal. In addition, it is very difficult to administer boluses to preschoolers who are unable to operate a CSII while they attend a kindergarten or day nursery. Some new pumps offer different modes for applying prandial boluses; however, they cannot administer the boluses automatically without manipulation by either the children themselves or their parents. Accordingly, a different tool in place of pre-meal boluses is necessary for controlling postprandial blood glucose levels. An increment in the basal rate during mealtime could be, in practical terms, a helpful tool for achieving this purpose in patients with T1DM who cannot operate the CSII by themselves.

On the other hand, young children have notably high day-to-day variability in food consumption, and therefore, some parents prefer to give an insulin bolus after meals to adjust the dose to the actual food intake (8). However fixed-
dose administration of insulin is available for children who generally show predictable patterns of meal intake. For these children, an increment in the basal rate during mealtime seems a useful tool in place of the administration of pre-meal boluses for controlling postprandial blood glucose levels.

In conclusion, an increment in the basal rate during mealtime in place of the administration of pre-meal boluses could be useful for controlling postprandial blood glucose levels in young children with T1DM using CSII.

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