Update in Management of Childhood Diabetes Mellitus with Hi-Technology Devices

Jeerunda Santiprabhob, M.D.

Department of Pediatrics, Faculty of Medicine Siriraj Hospital, Mahidol University, Bangkok 10700, Thailand.

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Type1 diabetes is a very demanding medical condition for patients and others involved, including parents, family members, and medical personnel. It requires extensive behavioral changes, frequent glucose monitoring, and daily insulin injection.

It has been well established that near normal glycemic control can prevent and delay the onset of microvascular complications from diabetes.[1] The American Diabetes Association (ADA) recommends A1C of less than 7.0% in adults with diabetes. In 2005, ADA released a statement of care for children and adolescents with type 1 diabetes, which the targeted A1C and blood glucose (BG) levels are shown in Table 1.[2] With tight glucose control, hypoglycemic episodes are inevitable and might be harmful for children especially the younger ones. Thus targeted A1C in children is higher than in adults.

In order to achieve good glycemic control, children with diabetes are required to learn all important self-management skills, including daily insulin injection, self-monitoring of blood glucose (SMBG), diabetes nutrition, and handling special occasions, e.g., sick day, party etc. Insulin injection and SMBG play important roles in diabetes management. They are probably the hardest parts for children and their families to adjust themselves to the fact that they are living with diabetes. ADA recommends children with type 1 diabetes performed SMBG at least 4 times a day. Knowing the BG levels will help children and their medical personnel modify their current diabetes management and lead to better glycemic control.[3] Perhaps performing SMBG 4 times a day provides sufficient glucose data but it should be noted that these numbers do not represent 24-hour-BG levels. Patients who have poor glycemic control, discrepancy between BG level and A1C, or unpredictable hypo-/hyperglycemic episodes might benefit from obtaining 24-hour continuous glucose monitoring. In term of insulin treatment, there are two types of insulin regimen: first, the conventional therapy in which patients take insulin injection two or three times a day; and second, the intensive therapy in which patients take multiple daily insulin injections (MDI) or use continuous subcutaneous insulin infusion (CSII or insulin pump). The data supported that patients with intensive insulin therapy had better glycemic control than those with conventional therapy.[1] In this article, the advantages of hi-technology devices, continuous glucose monitoring system (CGMS) and CSII are discussed.

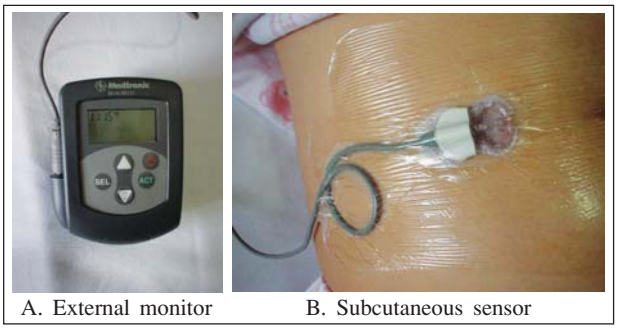
TABLE 1. Plasma BG and A1C goals for type 1 diabetes by age group

Values by age	Plasma BG (mg/dL)		A1C
	Before meals	Bedtime/overnight	
Toddlers and preschoolers (<6 yr)	100-180	110-200	<8.5% (but > 7.5%)
School age (6-12 yr)	90-180	100-180	<8%
Adolescents and young adults (13-19 yr)	90-130	90-150	<7.5%

Continuous glucose monitoring system (CGMS)

Several studies have shown that 24-hr profiles of glucose values can result in better glucose management and a reduction of A1C.[4,5] Continuous glucose monitoring will provide glucose trends and patterns and allow patients to understand the impact of changes in their insulin regimen, activities and diet on their glucose levels. Also, it will provide glucose levels during the night and reveal hypo- and hyperglycemic episodes which patients are not aware of.

The Medtronic MiniMed (Northridge, California) continuous glucose monitoring system (CGMS) was the first frequent glucose-monitoring device approved for use in the United States and available for purchase only by healthcare providers. The system consists of a subcutaneous sensor and an external monitor (Fig 1). The sensor is inserted into the skin using an automatic insertion device, with an introducer needle that is removed immediately after insertion. The sensor uses interstitial fluid for evaluating glucose levels. The sensor is connected to the monitor by a small wire. The monitor, which is similar in size to a pager, is worn externally. The patient must initially calibrate the CGMS by using a fingerstick blood-glucose measurement from glucometer. Four fingerstick blood-glucose measurements are required each day for recalibrations. The monitor allows patients to enter the time of meals, medication, exercise, and other events. The sensor stores glucose level every 5 minutes for up to 72 hours (288 readings a day and up to 864 readings in 72 hours) but the system does not provide real-time data. At the end of 3 days, the patient returns to the healthcare professional and data from the sensor and



A. External monitor B. Subcutaneous sensor

Fig 1. The Medtronic MiniMed (Northridge, California) continuous glucose monitoring system (CGMS)

monitor is downloaded.[6] The examples of data provided by the system are shown in Fig 2.

While the system may benefit all diabetes patients, it may be suitable for specific uses under the following conditions:

- Elevated A1C, many episodes of diabetic ketoacido sis
- Frequent episodes of hypoglycemia or hypoglycemia unawareness
- Unexplained BG excursions
- Evaluation of the efficacy of a therapeutic regimen
- Evaluation of behavioral modifications affecting glycemic control

Many studies on the CGMS have concluded that improved diabetes control can be achieved when patients and healthcare providers access the detailed glucose information.[7,8] The healthcare providers can observe the effectiveness of the therapy and able to make their adjustment while the patients have better understanding of the cause-and-effect relationship between daily activities and the BG levels.

Continuous subcutaneous insulin infusion (CSII) or insulin pump

CSII is an alternative to MDI when patients desire to have an improved blood glucose control or greater lifestyle flexibility. The pump uses short - or rapid-acting insulin, making insulin absorption from subcutaneous tissues more predictable. Insulin delivery is provided in a combination of a continuous basal rate and meal bolus insulin (Fig 3). The pump contains a syringe of insulin that connects to a catheter with a Teflon cannula at the end. Similar to CGMS, the cannula is inserted into the skin usually in the

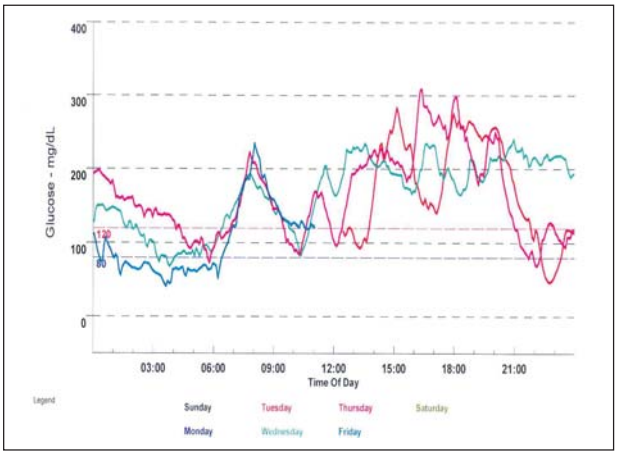


Fig. 2 Three-days-glucose data from CGMS

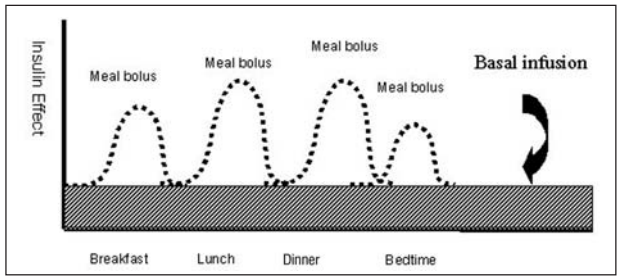


Fig. 3 Continuous subcutaneous insulin infusion (CSII)

abdomen, using an automatic insertion device, with an introducer needle that is removed immediately after insertion (Fig 4). The user programs the insulin pump to deliver insulin in a basal mode (continuous infusion) and a pre-meal bolus before eating.[9] Patients need to change the infusion site every two days. The benefits of CSII are as follows:

- Convenience

Patients do not need to carry insulin syringe/pen or insulin vial.

- Lifestyle flexibility

Patients receive basal insulin continuously, and they are able to adjust the basal insulin to match the activities, e.g. decrease basal insulin prior to exercise or disconnect the pump for an hour when they participate in active sport. Patients can wake up late or have late meal without having hypoglycemic or hyperglycemic episodes.

- Decreased glucose variability

Basal insulin can be programmed at different rates, e.g. lower insulin at night or higher insulin in predawn hours. Pre-meal bolus insulin is calculated to match food intake. With adjustable insulin delivery, patients using CSII have less glucose variability and fewer hypoglycemic episodes compared to patients with MDI.[10]

- Improved glycemic control

Studies have shown that patients have improved glycemic control while using CSII.[11,12]

Although CSII has many advantages, there are several potential problems: pump malfunction, infected injection site and occlusion in infusion set. More importantly, CSII is much more costly compared to MDI.

Fig 4. Steps of using the insulin pump. A. The user primes the infusion set with insulin. B,C. Using an automatic insertion device to insert a cannula into the skin with an introducer needle that is removed immediately after insertion. D. Infusion site and insulin pump

There are hi-technology devices available for patients with diabetes nowadays. Theses devices can facilitate patients with diabetes to live with the disease more comfortably and possibly with better glucose control. In order to achieve these goals, patients are still required to have basic diabetes self-management skills.

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