

## Hyperglycemia and Sick Day Management in Students with Diabetes

By Francine R. Kaufman, MD

**D**iabetes needs to be managed throughout the day — and night. Whether the student with diabetes is at home, with a parent or another care giver, or at school, provision must be made for optimal diabetes management at all times. This affords the student with diabetes the greatest chance of being safe and well.

### The Diabetes Regimen

Optimal blood glucose control is the goal of diabetes management for children and adolescents. As proven by the landmark Diabetes Control and Complications Trial over a decade ago, and other studies since then (Diabetes Control and Complications Trial Research Group, 1993, 1994; Kaufman & Halvorson, 1999a), effective diabetes management allows for the reduction in short- and long-term diabetes complications, normalization of growth and pubertal development, and improvement in physical and psychosocial well-being (Varni et al., 2003). To achieve the desired outcomes, patients, families, school personnel and other care givers responsible for children with diabetes must integrate a comprehensive diabetes regimen into the child's daily life (ADA, 2005) (see Table 1).

### What Is Hyperglycemia?

One of the major issues that children and adolescents with diabetes face is that of elevation of the blood glucose level, or hyperglycemia. *Hyperglycemia* is defined as glucose levels above the target range. The target ranges by age as suggested by the American Diabetes Association in its recent position statement *Care of Children and Adolescents with Type 1 Diabetes* (2005) are given in Table 2. Although these target ranges have been developed for children with Type 1 diabetes, they are

generally applicable to children with Type 2 diabetes as well.

Almost all children with diabetes will experience blood sugar elevations above their target range at various times throughout the day. For many children, these elevations are only minimally above the target range (less than 250 mg/dL) and are short in duration. For other children, there may be daily spikes of the blood glucose level that are very high (in excess of 250 mg/dL) and of longer duration.

### Causes of Hyperglycemia

An elevated blood glucose level occurs because there has been a mismatch of insulin (or other glucose-lowering agents), activity, and food (Buckingham et al., 2001). For example, more food could have been ingested than what was covered by

the insulin dosage. This could occur because the child is not taking an adequate amount of insulin for a unit of carbohydrate in the diet (this is called the insulin-to-carbohydrate ratio) or because the child just simply ate more carbohydrate than calculated. The former would indicate that the overall diabetes management plan is not optimal, while the latter would indicate that the child or care giver needs to learn to count carbohydrate more accurately. Another example of this mismatch is when a child who is ordinarily active is sedentary all day (Kaufman, 2003).

There are several other causes of hyperglycemia. Intercurrent illness, injury or infection can lead to hyperglycemia (Laffel, 2000). Although children with diabetes are generally not more susceptible to illness or infection than others, once contracted,

**TABLE 1. COMPONENTS OF THE DIABETES REGIMEN (ADA, 1997, 2000)**

- Measuring the blood sugar (glucose) level by finger stick multiple times a day (Anderson et al., 1997)
- Administering glucose-lowering medications such as insulin or oral hypoglycemic medications (for Type 2 diabetes), so that blood glucose targets can be met (Insulin may need to be given by multiple daily insulin injections or by using an insulin pump.) (Kaufman & Halvorson, 2001).
- Setting blood glucose targets with pre-meal, post-meal and bedtime values
- Defining what action should be taken if glucose levels are outside the blood glucose target ranges
  - i. Supplemental doses of insulin following an algorithm are given to correct an abnormally elevated glucose level, before meals and snacks, and at other times.
  - ii. Additional carbohydrate is administered to ameliorate low blood sugar, and severe hypoglycemia may need to be treated with a glucagon injection.
- Detailing for the school nurse and other school personnel — as well as any care giver — the student's individual Diabetes Medical Management Plan

**TABLE 2. TARGET RANGE FOR BLOOD GLUCOSE AND HEMOGLOBIN A1C BY AGE**

Age	Pre-meal Glucose (mg/dL)	Post-meal Glucose (mg/dL)	A1c (%)
Toddlers and Preschool Children 0–6 years	100–180	110–200	<8.5 (but >7.5)
School age, 6–12 years	90–180	100–180	<8
Adolescents	90–130	90–150	<7.5
	Goals should be individualized and lower goals may be reasonable based on benefit-risk assessment.	Post-meal blood sugar levels should be measured when there is a disparity between pre-meal levels and A1C.	A lower goal of <7.0% is reasonable if it can be achieved without excessive hypoglycemia.

such processes can markedly deteriorate glucose control. Other causes of hyperglycemia include missing insulin dosages (either inadvertently or on purpose), insulin pump malfunction, and severe stress (physical and psychological). Certain medications can cause acute hyperglycemia.

All instances of hyperglycemia need to be recognized and treated quickly. If not, it is possible that an episode could lead to severe hyperglycemia and progress into the serious condition referred to as diabetic ketoacidosis. Severe hyperglycemia and diabetic ketoacidosis are due to insulin deficiency (Kaufman & Halvorson, 1999b). In the face of insulin deficiency, glucose cannot enter the cells and the cells are effectively starving. As a result, glycogen, protein and fat stores are broken down, further elevating the blood glucose level and leading to ketoacid (ketone) formation. Initially, ketones are present in the urine, but as their production increases, they build up in the blood stream. As shown in Table 3, symptoms progress from excessive urination, dehydration, nausea and abdominal pain, to vomiting, deep breathing (to blow off ketones with respiratory effort), electrolyte disturbance (total body potassium depletion and severe acidosis), and finally to decreased consciousness. Diabetic ketoacidosis remains a leading cause of morbidity and mortality in childhood diabetes (Umpierrez et al., 2002).

By measuring hemoglobin A1C levels at quarterly intervals, healthcare providers, patients and families can assess whether hyper-

glycemia is rare or frequent, mild or severe (Kaufman & Halvorson, 1999a). Target levels by age for A1C for children with Type 1 diabetes are given in Table 2. The A1C is almost like a diabetes “report card.” A1C values have been shown to correlate with the average blood glucose level, and also with long-term complications of diabetes.

### Symptoms and Treatment of Hyperglycemia

Acute hyperglycemia can affect how the student with diabetes feels and functions at the time of the glucose elevation (Cox et al., 2005). The common symptoms of an acute elevation of blood sugar and diabetic ketoacidosis are given in Table 3.

School nurses, teachers and other personnel who interact with the student who has diabetes need to be able to detect and manage an acute episode of hyperglycemia in a timely fashion (Kaufman, 2002). The treatment for an individual patient may vary and should be outlined in the Diabetes Medical Management Plan developed by the student’s health care team and provided to the school nurse.

The National Diabetes Education Program’s (NDEP) handbook, *Helping the Student with Diabetes Succeed: A Guide for School Personnel*, contains a sample Diabetes Medical Management Plan and a “Quick Reference Emergency Plan for Hyperglycemia.” School nurses can order a free copy of the guide by calling 1-800-438-5383 or by downloading these sections of the guide from the NDEP website at <http://www.>

[ndep.nih.gov/resources/school.htm](http://ndep.nih.gov/resources/school.htm). The guide is copyright-free and school nurses are encouraged to photocopy and distribute the forms and information in the guide to school personnel, parents and the student’s healthcare providers.

The mainstay of treatment of hyperglycemia is to give supplemental insulin (short- or rapid-acting) according to the

**TABLE 3. COMMON SYMPTOMS OF HYPERGLYCEMIA AND DIABETIC KETOACIDOSIS**

#### Hyperglycemia

- Increased urination, thirst, and hunger
- Loss of appetite and nausea
- Blurry vision
- Fatigue, malaise and headache
- Dry mouth

#### Diabetic ketoacidosis

- Abdominal pain
- Nausea and/or vomiting
- Dry mouth, extreme thirst and dehydration
- Fruity or acetone breath
- Heavy breathing and shortness of breath
- Electrolyte disturbance with worsening ketoacidosis
- Mental status changes, with depressed level of consciousness

dosage schedule outlined in the child's Diabetes Medical Management Plan. If an insulin pump is in use, it should be checked to determine whether it is functioning. Until then, the supplemental dosage of insulin should be administered with a syringe.

In children with Type 2 diabetes, hyperglycemia can be treated by hydration: drinking water or non-glucose-containing fluids, and by withholding food. While it is difficult to give additional doses of oral glucose-lowering medications to acutely lower the blood glucose level, it is important to assure that hyperglycemia is not due to non-adherence with the diabetes regimen. If hyperglycemia is recurrent and frequent, a child with Type 2 diabetes might require additional medications or be considered a candidate for insulin therapy.

Frequent monitoring of the glucose level is required to be sure that it starts to decrease to the target range. Repeating at 2-hour or shorter intervals should assure that the treatment plan is succeeding. Hydration is critical. The child should attempt to drink water or sugar-free drinks and modify food intake. Urine should be checked for ketones if there is nausea or vomiting, or if this is prescribed in the Diabetes Medical Management Plan.

If there is no nausea or vomiting and ketones are not present, increasing physi-

cal activity might help reduce the blood glucose level. Otherwise, if ketones are present in the urine, and the blood glucose level is above a predetermined level outlined in the Diabetes Medical Management Plan (usually >250 or 300 mg/dL), exercise should be avoided.

The treatment of severe hyperglycemia is outlined in Table 4.

Children and youth spend most of the day in school or in after-school programs. Thus, school personnel must be knowledgeable about the cause and treatment of hyperglycemia. School nurses in particular play a critical role, by ensuring that students with diabetes have the opportunity to measure blood glucose and ketone levels and giving supplemental doses of insulin, while they demonstrate competence to correct dehydration, recognize impending diabetic ketoacidosis, and follow their Diabetes Medical Management Plan. With prompt recognition and proper treatment of hyperglycemia, the student with diabetes should be able to be optimally healthy. 🍷

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## TABLE 4. MANAGEMENT OF SEVERE HYPERGLYCEMIA OR DIABETIC KETOACIDOSIS

Refer to the student's Diabetes Medical Management Plan.

Monitor blood glucose and ketone levels frequently—at a minimum of every 2 hours, and perhaps as often as every 30-60 minutes.

Inject a corrective dose of rapid- or short-acting insulin.

Attempt oral hydration with water or electrolyte-containing fluids. Replacement of fluids should take precedence over trying to give food.

Call parents or the health care provider if:

- child is ill, vomiting, lethargic or having trouble breathing
- blood glucose stays elevated
- moderate to severe ketones do not clear

Parents and care givers may consider treatment of nausea and vomiting with anti-nausea suppositories [such as promethazine hydrochloride (Phenergan)]. These agents must be given with extreme caution so as to not mask an acute abdomen or worsening ketosis.