Guidelines for Insulin Management of Diabetes in School

By Janet Silverstein, MD and Shannon Patrick, ARNP

Introduction

Diabetes affects 1 in every 400–500 persons under 20 years of age. Management of diabetes is essential while the child is at school. The school nurse is an essential member of the child's healthcare team, which also includes the child, parents, teachers, other school personnel, and the diabetes medical team.

What is Type 1 diabetes?

Type 1 diabetes (T1DM) is caused by autoimmune destruction of the beta cells in the pancreatic islets. This autoimmune process is triggered by (poorly defined) factors in genetically susceptible individuals. Symptoms of new-onset or poorly controlled diabetes include weight loss, polyuria, polydipsia, polyphagia, abdominal pain, nausea, vomiting, and blurred vision. Children with T1DM must be treated with subcutaneous insulin, as their pancreas makes little or no insulin.

Several advances over the past decade have revolutionized treatment of diabetes in youth. Evidence has shown that frequent self-monitoring of blood glucose (SMBG) and insulin administration three or more times a day or use of an insulin pump that provides continuous subcutaneous insulin infusion (CSII) can result in improved glycemic control. Further, this improved metabolic control translates to decreased rates of diabetes complications. As a result, there has been a proliferation of new insulins and intensification of diabetes management. The predominant goal of therapy is to achieve and maintain blood glucose (BG) levels as close to normal as is safely possible. In order to achieve this, insulin therapy must be customized to fit the patient's life style. Most diabetes care providers now instruct patients to follow flexible eating patterns and activity and to adjust their insulin doses accordingly, rather than asking them to adhere to a rigid meal plan and insulin dose, as had previously been prescribed. Thus, state-of-the art management of diabetes has both health and lifestyle benefits.

Successful diabetes management requires meticulous attention to the coordination of insulin, carbohydrate intake, and physical activity, as well as frequent SMBG to guide treatment decisions. It is essential that these tasks be performed throughout the day, and as children spend the majority of their day in school, these diabetes-related tasks will need to be performed at school. This article provides information needed by school staff to implement the child's diabetes treatment plan when insulin is involved.

Physiology of Insulin Secretion

Individuals without diabetes normally secrete low levels of insulin to inhibit glucose production from the liver. This insulin output maintains normal glucose levels in the fasting state. Basal insulin secretion normally falls during exercise to allow increased glucose production, reflecting the fact that basal insulin requirements may change with physical activity and in other circumstances in which energy expenditure is altered.

In addition to basal insulin secretion, under normal circumstances a large amount of insulin is secreted to cover meals. Meal-related insulin secretion increases glucose uptake by insulin-sensitive tissues and is responsible for the disposition of ingested carbohydrate, resulting in normal postprandial BG levels. In diabetes, unless injected insulin is matched to the absorption of carbohydrate (in timing and quantity), BG

TABLE 1. PHARMACOKINETIC CHARACTERISTICS OF INSULIN FORMULATIONS (TIME IN HOURS)

Type of Insulin	Onset	Peak	Duration
Long-acting			
Detimir	3-5	10-16	18-24
Glargine	1-2	NA	24
Intermediate-acting			
NPH	1-2	6-10	12-20
	2-4	6-12	12-20
Short-acting			
Regular	0.5-1	2-4	4-8
Rapid-acting			
Lispro/aspart/glulysine			
(Humalog/Novolog/Apidra)	15 minutes	0.5-2	3-4

concentrations will be abnormally high or low after meals.

Modern insulin therapy attempts to normalize glucose metabolism by combining basal and meal-related insulin doses to simulate normal insulin physiology. In ideal insulin replacement therapy, insulin would be delivered at a low constant rate that could be easily adjusted for exercise or other circumstances. Additionally, meal insulin would be given in a form that rapidly increases serum insulin levels severalfold each time carbohydrate is eaten.

Insulin Formulations and Pharmacokinetics

Insulin regimens vary from fixed-dose schedules of two to three daily injections to flexible regimens, including multiple daily injections (MDI) and CSII. The properties of currently available insulin preparations are summarized in Table 1.

Fixed-Dose Regimens

Intermediate-acting insulins

NPH insulin is intermediate acting because the time course of its effect is intermediate between the long-acting and rapid-acting insulin preparations. NPH is generally mixed with a rapid-acting insulin analogue and given twice daily before breakfast, and either with dinner or at bedtime. When given before breakfast, NPH exhibits a peak effect that occurs approximately in mid-afternoon, which provides the insulin effect needed for disposal of carbohydrate eaten at lunch. Afternoon snacks are often required because of the late peak of this insulin. NPH may be given at bedtime so that its peak action matches the rising insulin requirement observed in the early morning hours in many patients.

Rapid-acting insulin analogues

For decades, the only fast-acting insulin was Regular, or crystalline insulin in solution. Its rapid action allowed use as a meal-related dose. However, the rapid-acting analogues have generally replaced Regular insulin for meal coverage, as the delayed time of onset, late peak, and long duration of action of Regular insulin do not match meal absorption. Regular insulin should be taken thirty to forty-five minutes before eating so that the rise in circulating insulin will match the rise in blood glucose following meals. The rapid-acting insulin analogues have a faster onset and shorter duration of action than Regular insulin, and thus more closely match the rise and fall in blood glucose levels associated with food absorption; these insulins should be taken immediately before eating.

Basal-Bolus Regimens

The basal-bolus insulin regimens are tailored to simulate normal insulin release, with 24-hour basal insulin to decrease glucose output from the liver and bolus insulin to cover meals. These regimens provide more lifestyle flexibility and less frequent hypoglycemia than the fixed-dose regimens but require more attention to the diabetes regimen. The basic elements of basal-bolus therapy for type 1 diabetes include:

- attempts to achieve blood glucose targets that are near normal
- an insulin delivery regimen that simulates normal physiology by combining basal and meal-related doses
- use of frequent SMBG to adjust therapy
- matching carbohydrate intake, physical activity, and insulin doses

Timing of meals can be very flexible when using these regimens, because the insulin level provided by an appropriate basal regimen will maintain BG in the desired range until the next meal. Patients may omit meals, delay meals by several hours, or eat extra meals accompanied by an extra insulin dose.

Basal insulins include glargine (Lantus) and detimir (Levemir). The basal insulins have very little peak action and are, therefore, unable to handle the glycemic load of a meal, making it necessary to use rapid-acting analogues for meal coverage. Lantus is typically given once daily, although twice daily use is increasingly common. Levemir is most often given twice daily.

The carbohydrate content of the meal is responsible for the immediate rise in BG concentration; consequently, the pre-meal insulin dose is based on the amount of carbohydrate ingested during a meal. In very young children and those with variable appetites, lispro, aspart, and glulisine may be given immediately after the meal is eaten — when the amount of ingested carbohydrate is known — thus allowing for more accurate dosing. The mealtime bolus dose is based on the student's pre-meal blood glucose level and the number of grams of carbohydrate eaten, which should be clearly stated in the child's Individual Health Plan (IHP). Most people using MDI or an insulin pump learn to adjust meal doses for variable food intake. The child or parent calculates each meal dose from the planned or actual carbohydrate intake using an insulin-to-carbohydrate ratio. In children and adolescents, insulin to carbohydrate ratios may vary from 1 unit per 25 grams to 1 unit per 5 grams and are adjusted on the basis of 2-hour postprandial BG values. For example, if preprandial BG is in the target range, but postprandial BG is repeatedly high, the insulin-to-carbohydrate ratio should be adjusted.

The meal insulin dose adjustment for BG level is done by means of an insulin algorithm, or "sliding scale" to guide dose adjustments several times a day. The algorithm should be clearly stated in the IHP. These adjustments are made with fast-acting insulin each time insulin is given. Because of the need for mealtime bolus insulin and calculation of bolus insulin dose based on BG levels and food intake, the basal-bolus regimens all require SMBG and insulin injections at lunch and at other times during the school day.

Insulin pump therapy

CSII, or insulin pump therapy, most closely approximates physiologic insulin delivery, with an insulin analogue given in small frequent pulses adjustable over 24 hours, representing basal insulin production, and mealtime boluses given based on mealtime BG levels and carbohydrate intake. Newer pumps are able automatically to calculate the bolus when the BG value

and carbohydrates eaten are entered into the pump program.

CSII has several advantages over the other insulin regimens:

- the use of only rapid-acting insulins may have more consistent and predictable biologic effects
- the basal rate can be quickly adjusted to accommodate different levels of physical activity or basal insulin requirements that vary with time of day
- many patients like the freedom from injections and increased flexibility of insulin pump therapy

It's disadvantages include greater cost, risk of infection at infusion sites, and the risk of ketoacidosis if the insulin infusion is interrupted.

Insulin Therapy in Type 2 Diabetes

Youth with type 2 diabetes often require insulin therapy. The specific regimen varies between patients, or from time to time in the same patient. Some adolescents early in the course of type 2 diabetes may be well controlled with a single daily injection of glargine insulin; others may require an MDI regimen that is virtually identical to that used for type 1 diabetes.

School Protocols

Diabetes management in the school setting includes BG testing, insulin administration, and recognition and treatment of acute complications, including hypoglycemia and ketonuria. The child should have an IHP in place each year, updated throughout the school year if his diabetes regimen changes. This plan should reflect the child's current insulin and blood glucose testing regimen and ability to participate in self-care. This should be accompanied by a formal 504 plan. Sample management plans are available online and as an appendix in the excellent downloadable manual "Helping the Student With Diabetes Succeed," both available on the National Diabetes Education Programs (NDEP) website http://ndep.nih.gov/. The American Diabetes Association also has a downloadable sample 504 plan and treatment recommendations for children in the school setting at www.diabetes.org.

Insulin Administration

Insulin is administered in the school setting according to the child's IHP for: meal coverage, treatment of hyperglycemia, and treatment of urinary ketones. The IHP will specify the individualized dosage and schedule for insulin administration, including the insulin-to-carbohydrate ratios for meals and snacks and a correction dosage (sliding scale) to treat hyperglycemia. The insulin dose will vary based on blood glucose readings, food availability/preference, and physical activity level. The nurse should contact the child's parents or diabetes care team if insulin must be given for ketonuria.

Opened vials of insulin will retain potency for 30 days when left at room temperature but will keep for 3 months if refrigerated. Unopened vials of insulin should be stored in the refrigerator and will remain good until the expiration date noted on the insulin box. All diabetes supplies, including insulin, should be supplied to the school by the child's parents and accommodations for storage of the medication should be thoroughly discussed.

Blood Glucose Monitoring

The child with type 1 diabetes will need to check BG levels before meals and any time there are symptoms of hypoglycemia. Some children might also need to check BG levels 2 hours after meals, and before or after physical activity, especially if they have a history of exercise-induced hypoglycemia or if they are not certain of the effect of exercise on their BG levels. Many children need to know pre- and postexercise BG levels in order to adjust insulin doses or determine if they need to snack before physical education class or other exercise. Most older children will be able to do such testing independently, but the younger child may need help.

Hypoglycemia

The student with diabetes should be allowed immediate access to testing and treatment supplies, and be allowed to test when he or she is having symptoms of hypoglycemia. If the child is unable to test, treatment of suspected hypoglycemia should be given immediately, even in the absence of confirmatory BG readings.

Hypoglycemia occurs with inadequate food intake, increased energy expenditure, or excessive insulin dose. Symptoms may mimic those of anxiety, with flushing, sweating, palpitations, and tremor, resulting from release of catecholamines in an effort to increase BG levels. If sugar is not given early, there will be insufficient glucose delivered to the brain (neuroglycopenia), with resulting symptoms of personality change, including uncharacteristic introverted or aggressive behavior, which can progress to coma or even seizures if left untreated. Although symptoms of hypoglycemia vary from person to person, they generally remain consistent for an individual.

Treatment includes immediate administration of 15 grams of rapidly-absorbed glucose in the form of glucose tablets, juice, regular soda, honey, or hard candies. The child should re-test BG levels after 10–15 minutes and repeat the treatment if the BG is less than 70 mg/dL or the target set by the child's Individual Healthcare Plan. Once the BG has normalized, a snack may be needed depending on the child's anticipated activity level, time to the next meal or snack, and insulin regimen.

Glucose gel or gel cake icing can be placed into the buccal mucosa, where it will be absorbed, if the child is not responsive or is unable to swallow juice. If the child is completely unconscious or having a seizure, an injection of glucagon will be necessary. **Glucagon is a safe medication, even in large doses.** The injection can be given anywhere an insulin injection can be given. The child should be turned to the side, as glucagon can cause vomiting. If it is necessary to use glucagon, both the parent and emergency medical services should be called.

The occurrence of hypoglycemia may be reduced by decreasing the insulin dose

on days of increased activity, testing before and after exercise, and snacking before activity if the child's BG levels drop significantly with exercise.

Ketonuria

Ketones are caused by fat breakdown, which normally occurs during fasting or during the stress of illness, as stress hormones cause lipolysis. Children with diabetes will develop ketosis if they omit insulin injections. Untreated ketosis results in nausea, vomiting, abdominal pain, rapid deep breathing, dehydration, lethargy, and ultimately, ketoacidosis.

Ketones should be tested according to the child's IHP, but should always be tested whenever the child displays any of the symptoms noted above, whenever the BG level is greater than 300 mg/dL (or greater than 240mg/dL in a child on CSII therapy), or if the child has signs of a systemic illness, such as fever and, especially, vomiting, even if the blood glucose is normal. The presence of moderate or large ketones will require extra dosing of insulin to reverse ketosis. If the child is on an insulin pump, it also may be necessary to change the insertion set and give a subcutaneous injection of a rapid-acting insulin, since it is likely that there is a problem with insulin infusion into the site. It should be noted that problems with insertion sites cannot always be detected by their appearance. If ketones are present, the child's parent and/or medical team should be contacted for advice on treatment. If the child is not vomiting, liberal fluid intake will help prevent dehydration and increase urinary excretion of ketones. The child should be allowed free access to water and a bathroom.

Responsibilities of the Child, Parent and School Personnel

Child

Responsibilities for the student depend on the age of the child. The child in elementary school may not be able to check blood glucose levels independently and will always need to be supervised. Many students in middle school and high school may be very responsible and knowledgeable about their diabetes care and may be able to do blood glucose checks independently.

Older students, depending on their age and level of maturity, may be able to determine insulin dose and administer insulin. All students should be responsible for appropriately discarding supplies used for insulin administration. The child's ability to perform diabetes-related tasks responsibly and independently should be noted on the IHP.

Parent

The parent of the child with diabetes must be responsible for providing the signed IHP (or Diabetes Medical Management Plan) to the school nurse and for meeting with the school health team to discuss the specifics and implementation of the IHP. An annual meeting to put a 504 plan into effect will clarify both parent and school expectations with regard to the student's diabetes management. This includes discussing timing of scheduled insulin administration and indications for giving additional insulin. The parent should explain the insulin-to-carbohydrate ratio and correction factor and provide the nurse with a chart detailing the dosing. Treatment of hypoglycemia should be clear. Location of insulin and related supplies should be noted.

The parent should also give signed permission for the school personnel and the child's healthcare team to share information regarding the student's diabetes. It is, furthermore, the parent's responsibility to inform the school of any changes in the child's diabetes regimen.

The school should attempt to provide the parent with the carbohydrate content of the foods served in the cafeteria for the week and share that information with the school nurse. If children bring their lunch to school, the parents should provide the carbohydrate content for these foods to the school nurse to allow for accurate determination of the carbohydrate-to-insulin ratio.

The *parent* is responsible for providing and maintaining all diabetes supplies, including those necessary for insulin administration. These supplies should be stored in a safe place in the school and be available when the child is participating in extracurricular activities.

School Personnel

The school nurse is the school professional who has the responsibility for assuring that children with diabetes are adequately cared for, according to their IHPs. As such, the nurse must understand the student's IHP, and is expected to arrange and participate in the child's 504 plan. The nurse is expected to perform the diabetes care tasks outlined in the student's medical plan, and to document the timing and dose of all insulin given to the student. The nurse also is responsible for clarifying insulin regimens with the parents or the child's diabetes care team if there is any uncertainty about insulin dosing. The storage of insulin and other diabetes supplies will be under the supervision of the school nurse. The setting in which the insulin is given will be determined by the school nurse, in conjunction with the parent.

Conclusion

Diabetes care has become complex and is likely to become even more so with emerging technologies, including continuous glucose sensors and increasing capabilities of insulin pumps.

As the student's advocate, the nurse is expected to encourage independence in insulin administration, consistent with the student's level of maturity and skill. If a school nurse is not available at the school, the nurse assigned to the school on a part-time basis is responsible for training, assessing the competence, and then monitoring the performance of trained diabetes personnel in carrying out the prescribed healthcare procedures.

ABOUT THE AUTHORS

Janet Silverstein, MD is a member of the National Diabetes Education Program's Work Group for Children and Adolescents' With Diabetes and Professor and Chief, Pediatric Endocrinology, University of Florida, Gainesville, FL

Shannon Patrick, ARNP is a