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*Dr. Diana Guthrie reported no potential conflict of interest relevant to this article.*

*Dr. Richard Guthrie reported that he serves as a speaker for Amylin Pharmaceuticals, Eli Lilly, Merck, Novo Nordisk, and sanofi-aventis; and has received research grants from Bidel, GlaxoSmithKline, Macrogenics, Minimed Medtronic, Patton Medical, and Roche. Ms. Hinnen reported that she is a consultant/speaker for Abbott, Amylin Pharmaceuticals, CeQur, Eli Lilly, Pamlab, Roche, and sanofi-aventis.*

*Ms. Childs reported that she is a speaker for Eli Lilly; is a consultant for Becton Dickinson; has served on advisory boards for Mankind Pharma, Novo Nordisk, and Spherix; and has received research grants from Abbott, Amylin Pharmaceuticals, Bidel, GlaxoSmithKline, Macrogenics, Minimed Medtronic, Novo Nordisk, Patton Medical, and Roche.*

# It's time to abandon the sliding scale

Use a system that mimics normal insulin secretion—and the 5 principles of insulin management detailed here—to keep patients' glucose levels on an even keel.

## PRACTICE RECOMMENDATIONS

□ *To prevent wide fluctuations in glucose levels, combine basal insulin coverage with a bolus of insulin given with each meal. (A)*

□ *Use 2-hour postprandial blood glucose levels to adjust doses of rapid-acting insulin. (A)*

□ *Use a basal/bolus regimen for hospitalized patients with insulin-dependent diabetes, adjusted for weight, age, IV glucose amount, meal size, and prehospital insulin regimen. (A)*

### Strength of recommendation (SOR)

- (A)** Good-quality patient-oriented evidence
- (B)** Inconsistent or limited-quality patient-oriented evidence
- (C)** Consensus, usual practice, opinion, disease-oriented evidence, case series

**A**mong the many insulin management systems that have been developed, none has been as widely used as the sliding scale. Despite its acceptance by physicians and patients throughout the world, however, there is little evidence of the sliding scale's efficacy.<sup>1-11</sup>

A number of studies have focused on potential problems associated with the sliding scale, primarily related to the “roller coaster” blood glucose levels that often result. The authors of a recent literature review concluded that fluctuating glucose levels are more harmful physiologically than levels that are continuously elevated, even when the elevation is mild.<sup>12</sup>

In this review, we take a closer look at the failings of the sliding scale system and the advantages of adopting an insulin regimen that more closely resembles a natural physiologic state. To enable you to provide optimal support for patients with insulin-dependent diabetes, we highlight 5 principles of insulin management.

## Premeal glucose levels do not reflect insulin need

In a sliding scale system, insulin administration is based primarily—and in some cases, entirely—on a single point in time. Blood glucose levels are tested before meals and at bedtime or every 6 hours, and the amount of insulin administered at that time is based on the test result.

But a premeal blood glucose level is not an accurate predictor of the insulin needed at that time; it is simply a reflection of the insulin previously administered. Insulin given in response to the current blood glucose, then, may compound a prior dosing error, leading to serious drops or spikes in blood sugar. These wide fluctuations present challenges in both inpatient and outpatient settings, although each uses a different sliding scale system.



Skipping a dose when glucose levels dip below the cutoff point can leave the patient without insulin for hours, resulting in a spike in blood sugar.

### In the hospital, basal insulin is often withheld

In an inpatient setting, an IV insulin protocol is typically used, and patients may be placed on a sliding scale regimen even if their pre-hospital HbA1c was in a satisfactory range. The sliding scale is usually dependent on blood glucose levels obtained by bedside monitoring,<sup>13</sup> tested every 6 hours. Hospitalized patients often receive no basal insulin, and, because rapid-acting insulin lasts only 3 to 4 hours, the results of their glucose tests are based on the intake of short-acting (regular) insulin alone. Short-acting insulin lasts about 6 to 8 hours, depending on dosage.

A sliding scale regimen generally has a cutoff point, below which no insulin is given. But skipping a dose because a patient's glucose levels dip below the cut point can leave him or her without insulin for many hours, resulting in a spike in blood sugar.

**■ Standing orders: One size does not "fit" all.** Failure to individualize the insulin protocol is another problem with the use of sliding scales in an inpatient setting.<sup>7</sup> Typically the sliding scale protocol is preprinted on standing orders, which are the same for all patients who require insulin and are under

the care of a particular physician. Rarely are the orders adjusted for factors such as age, weight, IV glucose intake, time of day, size of the upcoming meal (or absence of food, at midnight), or type of diabetes. Outcomes studies of a sliding scale protocol in a hospital setting found that its use did not consistently achieve the desired results.<sup>7</sup>

### Outpatient sliding scale fails to normalize blood glucose levels

Unlike the sliding scale regimen commonly used in hospitals, outpatient protocols often incorporate basal insulin. But that fact alone is not enough to eliminate the peaks and dips in blood glucose levels associated with this approach.

The dose of basal insulin—a long-acting or twice-a-day intermediate-acting insulin—is sometimes given on a sliding scale. More commonly, the sliding scale is used to determine the dose of rapid- or short-acting insulin administered prior to meals, based on the preprandial blood glucose reading and/or the expected caloric or carbohydrate intake. The wide fluctuations and excessive spikes in blood glucose levels associated with sliding scale management may cause reactive oxi-



**Help patients achieve better glucose control**

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**>**  
 A premeal blood glucose reading is a reflection of the insulin given previously, not a predictor of the insulin needed at that time.

dative stress—a trigger for vascular damage, especially in patients with type 2 diabetes.<sup>14,15</sup>

**CASE ▶** Louis C, an 8-year-old boy diagnosed with type 1 diabetes at age 4, was under the care of a pediatric endocrinologist, who used a “pattern” insulin management system to achieve blood glucose control. Louis was maintained on a 4-dose-per-day schedule: Rapid-acting insulin was administered before each meal (with the dosage adjusted based on the pattern of postprandial glucose values over the last 2 or 3 days and by his expected caloric intake and activity level) and a basal insulin given once a day. His HbA1c was 7.2%. He rarely experienced even mild hypoglycemia.

When his family relocated, Louis was taken to another specialist—a pediatric endocrinologist at a medical school affiliated with a children’s hospital. This physician thought that pattern management was out of date, and insisted that sliding scale was the only acceptable approach.

Thus, Louis was put on a regimen of intermediate-acting insulin before breakfast and at bedtime and rapid-acting insulin, given on a sliding scale, at mealtimes. The rapid-acting insulin was withheld if his blood glucose level was  $\leq 100$  mg/dL; one unit was administered if his level was 101-150 mg/dL, 2 units for

a reading of 151-200 mg/dL, and so on. Within 3 months, Louis’ HbA1c had risen to 9.8%, and he developed significant hypoglycemia, especially in the afternoon and during the night. Louis’ mother reported that he was tired all the time and wondered if it was because his blood glucose levels were “on a roller coaster.”

### **Adjust—don’t skip—insulin doses**

The best medical care aims to reproduce the physiologic state to the extent possible. For patients with insulin-dependent diabetes, that means receiving 24-hour basal insulin coverage, as well as a bolus of insulin with each meal, to mimic normal insulin secretion.<sup>16,17</sup>

Pharmacodynamically, short-acting insulin lasts 6 to 8 hours. It should be given every 6 hours, in 4 equal doses, without ever skipping a dose. Rapid-acting insulin, too, should never be skipped. Because food or caloric intake requires insulin at the time of ingestion to facilitate glucose transport across the cell membrane, rapid-acting insulin should be administered before each meal (in 3 daily doses if the patient is also taking a long-acting or intermediate-acting insulin, or 6 times a day if used without basal insulin).

## **5 principles of insulin management**

These principles can be used in the hospital for professional education and in the outpatient setting for patient education:

1. **Advise health care professionals (and patients) not to skip insulin doses.** To avoid high blood glucose levels caused by low or missed doses, stress the importance of administering short-acting insulin every 6 hours, in 4 equal doses, or rapid-acting insulin before each meal with a long-acting basal insulin.
2. **Teach providers and patients that on an outpatient basis,** routine daily regimens should reflect the pattern of postprandial blood glucose levels over the previous 2 or 3 days.
3. **Explain that rapid-acting insulin doses should be based primarily on the amount to be eaten,** rather than on premeal glucose levels (although abnormally elevated or depressed levels may require a correction).
4. **Set parameters for glucose levels** and instruct patients to call (or to administer a correction dose) if the value falls above or below a predetermined range.
5. **Consider providing insulin-dependent patients** (or their parents, school nurse, or hospital staff) with an algorithm that uses a basal insulin dose and premeal rapid-acting insulin doses, adjusted for caloric or carbohydrate intake. Examples of insulin algorithms, which can help keep problems and telephone calls to a minimum, are available for both type 1 and type 2 diabetes from the Texas Diabetes Council at [http://www.tdctoolkit.org/algorithms\\_and\\_guidelines.asp](http://www.tdctoolkit.org/algorithms_and_guidelines.asp).

## Calculating a correction dose

If a patient's blood glucose level rises above a predetermined value, he or she may need an insulin bolus to bring it down. Calculating the supplemental dose is a 2-step process: First, an insulin sensitivity factor (ISF) is calculated; then, the desired blood glucose level is subtracted from the actual blood glucose reading and divided by the ISF.

### Step 1:

Divide 1700 by the total daily dose (eg, 50 units)

$$\frac{1700}{50} = 34 \text{ (ISF)}$$

### Step 2:

Subtract the desired blood glucose level (110 mg/dL) from the actual blood glucose reading (eg, 240 mg/dL) and divide by the ISF

$$\frac{240 - 110}{34} = 3.8 \text{ additional units}$$

**Commentary:** For an adult of average size,\* an additional 3.8 (or 4) units of rapid-acting insulin should bring the patient's blood glucose level down to 110 mg/dL. If the elevated blood glucose level occurs at this same time on subsequent days, it is an indication that the dose at the previous meal should be increased.

\*An insulin-sensitive child might require less insulin, and an overweight adult might require more. When in doubt, give half of the calculated correction dose and repeat in an hour, if needed.

Rapid-acting insulin is essentially out of the system by the time of the next preprandial blood glucose test. Therefore, premeal levels mainly measure the action of the basal (long- or intermediate-acting) insulin. The package inserts for rapid-acting insulin state that a 2-hour *postprandial* blood glucose level should be used to adjust the next dose of rapid-acting insulin.<sup>18,19</sup> (See "5 principles of insulin management" on page 268.)

### A closer look at pattern management

Measuring—and recording—both fasting and 1- or 2-hour postprandial blood glucose levels over a 2- to 3-day period is the first step in pattern management. The patient's insulin intake is determined by the pattern of these values, with adjustments made for anticipated need. Here's how it works in an outpatient setting:

- In the morning, the patient receives short- or rapid-acting insulin; the number of units is determined by his or her previous after-breakfast blood glucose levels, with adjustments depending on the caloric intake expected at breakfast and any deviation in the patient's normal activity level to follow.

- At noon, the short- or rapid-acting insulin is adjusted for the size of the lunch and the patient's recorded blood glucose levels 1 to 2 hours after lunch.
- At suppertime, the amount of insulin depends on the meal and the patient's previous after-supper blood glucose levels.
- At bedtime, intermediate- or long-acting insulin is administered in an amount adjusted according to the patient's fasting and/or premeal blood glucose levels. If the values are elevated because of extra eating or decreased activity, a correction dose (See "Calculating a correction dose" above) may be needed to restore his or her blood sugar to within an acceptable range.<sup>20</sup>

■ **Other factors that may influence blood glucose levels** include the injection site (insulin is absorbed faster when administered in the abdomen vs the leg); the type, or combination, of insulin used, ie, long-acting basal insulin vs intermediate-acting vs (or combined with) short- or rapid-acting insulin; and lifestyle (sedentary, active, very active, or suddenly becoming very active), which also affects the absorption of insulin.<sup>21</sup>

CONTINUED



Following an algorithm that combines a basal insulin dose with variable dosing of premeal rapid-acting insulin results in less hypoglycemia than a sliding scale system.

**CASE ▶** After 5 months, Louis and his family returned to their former home. But by then, Louis had an HbA1c of 10.2%. On the advice of the pediatric endocrinologist who had treated him initially, Louis was put back on a pattern management system, using both rapid- and long-acting insulin. Three months

later, his HbA1c was down to 7.6%—close to its previous level—and he no longer had problems with hypoglycemia. **JFP**

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