Randomized clinical trials have definitively shown that achieving near-normoglycemia reduces the risk of diabetes complications in individuals with either type 1 or type 2 diabetes. The Diabetes Control and Complications Trial (DCCT)\(^1\) clearly showed that individuals with type 1 diabetes must strive for an $\text{HbA}_{1c} \leq 7\%$ to effectively reduce their risk of microvascular disease. The U.K. Prospective Diabetes Study (UKPDS)\(^2\) demonstrated that, in type 2 diabetes, an $\text{HbA}_{1c}$ of 7% resulted in a 25–35% reduction in the risk of complications compared to an $\text{HbA}_{1c}$ of 7.9%. The recently published epidemiological analysis of the UKPDS data\(^3\) indicated that the risk of complications in type 2 diabetes continues to decrease in a seemingly linear fashion as the $\text{HbA}_{1c}$ readings drop to 6% or even less.

Even in individuals without diabetes, the risk of cardiovascular disease seems to increase as the $\text{HbA}_{1c}$ rises from the lower to upper limits of the normal range, as very recently demonstrated by Khaw et al.\(^4\) and Barrett-Connor and Wingard.\(^5\) Therefore, our target goals for glycemic control—for both self-monitoring of blood glucose (SM BG) results and $\text{HbA}_{1c}$ values—are steadily being lowered.

It is becoming clear that standard premeal SM BG targets are not sufficient to optimize blood glucose control. In many instances, we must include postprandial monitoring and set postprandial targets if we are to optimize glycemic control.

All individuals with type 1 diabetes and eventually most individuals with type 2 diabetes will require insulin therapy, either alone or (in type 2 diabetes) in combination with at least one insulin-sensitizing oral agent, to reach the emerging tight glycemic targets.

Today, we have a host of advances in insulin therapy and approaches to monitoring the outcomes of that therapy. These include new concepts, such as basal-bolus insulin therapy, new rapid-acting insulin analogs (lispro, aspart), a new long-acting insulin analog (glargine), and new delivery modalities (insulin pumps, insulin pens, and perhaps in the not-too-distant future inhaled insulin).

We also have exciting new means to monitor blood glucose levels. These include new, more effective strips that make collecting a drop of blood easier than ever (i.e., Comfort Curve strips, Roche Diagnostics, Indianapolis, Ind.) and strips that can read blood ketones (Precision Xtra Management System, Abbott Laboratories, Medisense Products, Bedford, Mass.; AtLast and FastTake, LifeScan, Inc., Milpitas, Calif.), off-the-finger testing (FreeStyle, TheraSense, Alameda, Calif.; AtLast and FastTake, LifeScan, Inc., Milpitas, Calif.), and noninvasive glucose monitoring (Glucowatch, Cygnus, Milpitas, Calif.) and continuous glucose monitoring (MiniM ed, Minimed Technologies, Sylmer, Calif.).

Jan Pearson, BAN, RN, CDE, and Richard Bergenstal, MD

Research shows that near-normoglycemia is crucial for preventing complications and improving the health of individuals with diabetes. The majority of people with diabetes need insulin therapy. Just injecting insulin is not enough, however. Patient-centered team care is vital to success. Individuals need to build their self-management skills beginning with the foundation of pattern management and progressing to advanced insulin management. Sliding-scale, or supplemental, insulin therapy can only be fully effective with pattern management as the underlying strategy.
Managing Patterns

With all of these tools, one would think it must be easy to optimize insulin therapy and achieve the desired glycemic targets. In fact, these innovative tools are a terrific starting point, but a key element in achieving success with insulin therapy is for providers to teach and for individuals with diabetes to engage in self-management practices such as pattern management. Pattern management is a systematic approach to help patients identify patterns in their blood glucose readings to determine whether changes are needed to optimize their glucose control.6

Evaluation of the DCCT patients followed at the International Diabetes Center showed that one of the five identified factors associated with a lower HbA1c was not glucose record-keeping alone, but rather whether individuals actually reviewed their glucose records and made self-adjustments based on principles including pattern management.7

Is pattern management outdated now that most individuals using multiple-dose insulin therapy or an insulin pump also use a sliding-scale or supplementary schedule for their bolus (pre-meal) insulin doses? We argue that the more advanced or sophisticated an insulin regimen is, the more important it is to be sure pattern management is a component of that regimen. Sliding-scale, or supplemental, insulin therapy is a method of adjusting insulin to correct the blood glucose at a particular moment in time. This is a quick-fix remedy rather than a problem-solving approach.

In contrast, pattern management addresses the root cause of the problem. It is the starting point and the foundation for any individual on insulin therapy. It is essential that individuals gain competence in pattern management before the next step of establishing an insulin-to-carbohydrate ratio to cover food intake. Once competence has been established in these two areas, the sliding-scale (supplemental) insulin therapy strategy can be applied, as long as it is linked with pattern management.

Pattern Management in Practice

A pattern is a series of blood glucose readings, taken at the same testing time each day, that are outside of an individual’s target range. Individuals should be taught to look for a pattern of high readings lasting at least 3 days in a row or a pattern of low readings lasting 2 days. If a pattern is seen at a particular time of day, the individual may need to adjust insulin. Equally important, however, is their ability to address the impact of carbohydrate intake, daily schedule, activity, illness, and stress in their problem-solving process to improve glucose control.

When initiating pattern control, individuals are taught to maintain consistency in their schedule, carbohydrate intake, insulin dose, and activity level for a period of time until a base dose is determined. Many people find this frustrating. The tendency is to take immediate action to correct an out-of-target glucose level, versus observing for a few days to see if a glucose pattern emerges. Individuals tend to adjust for a high blood glucose level by taking more insulin or eating less food. If the blood glucose level is low, individuals tend to want to cut back on insulin.

Health care professionals need to emphasize the importance of maintaining consistency while base doses are being established. They need to assure patients that a few blood glucose values above their target may seem alarming but are not a threat in the long term. With pattern management, patients are participating in an experiment to determine their base dose, and the numbers are merely data to be reviewed.

Conversely, should a low blood glucose level occur at the time of an established insulin injection, individuals should be taught to treat the hypoglycemia appropriately and then give the usual insulin dose prescribed for that moment in time. Remember that insulin works in the future, so the meal dose is needed to cover the carbohydrates that will be consumed in that meal. Pattern management drives the individual to identify why a low blood glucose occurred in the first place. If it is a recurring pattern (2 days in a row) and carbohydrate intake, activity level, and schedule are consistent, an adjustment in insulin most likely will be needed.

Pattern management involves five basic steps:

1. Know the target blood glucose range. (Both premeal and postmeal targets should be established.)
2. Gather needed data: blood glucose levels, carbohydrates per meal, insulin doses, activity levels, schedule, physical and emotional stress.
3. Look for patterns.
5. Take action.

Taking action means one of two things. First, it means addressing consistency of schedule, carbohydrate intake, insulin doses, and activity level. If consistency is established and the patterns still persist, then an insulin adjustment is the necessary action. In contrast to the sliding-scale approach of compensating for the blood glucose value of the moment, pattern management focuses on correcting a pattern. Blood glucose readings, or a pattern of readings, are a reflection of insulin taken in the past. To make the correction, an adjustment needs to be made in the insulin dose that was taken before the time of the pattern. Which dose is adjusted depends on the time of the pattern and on the insulin regimen.

For example, blood glucose readings taken before bedtime reflect the action of the short-acting (regular insulin) dose taken before dinner. Therefore, to correct a pattern of bedtime readings outside the target range, one would adjust the short-acting insulin dose taken before dinner.

We have defined important modifications to pattern management when using a rapid-acting insulin analog as the bolus or premeal insulin. Bell et al.8 confirmed the significance of this modification in an illustrative case that emphasized the need for this approach in optimizing control while minimizing hypoglycemia.

Rapid-acting insulin analogs are becoming the preferred approach to covering meals (or significant snacks). They offer more effective control of postprandial blood glucose readings with less hypoglycemia and the added convenience of dosing the insulin with the meal. While lispro insulin was initially felt to be ideal primarily for individuals with type 1 diabetes, we and others9 have found that lispro and now aspart have the same advantages and some additional benefits for those with type 2 diabetes. In highly insulin-resistant individuals with type 2 diabetes, the rapid-acting insulin analogs appear to provide much better meal coverage with a lower overall insulin requirement.

The benefit of more closely matching insulin to carbohydrate intake with the rapid-acting insulin analogs is better postprandial control. Since the postprandial reading is influenced by the rapid-acting insulin analog, one
must set postprandial blood glucose goals, do postprandial glucose testing, and look for postprandial glucose patterns to establish the appropriate mealtime insulin dose or mealtime insulin-to-carbohydrate ratio. With lispro, blood glucose levels should remain steady before and after meals.

The target for 2 h after a meal is to have a blood glucose excursion or rise of only 20–40 mg/dl. So, if the premeal target is 80–140 mg/dl, this would equate to a 2-h postprandial reading of <160–180 mg/dl. We prefer to use the target of only a 20–40 mg/dl rise after meals because it allows individuals to evaluate whether the basic premeal dose—without supplementation—was correct, regardless of the premeal blood glucose reading. If the 2-h postprandial readings are consistently greater than the target (a rise of 20–40 mg/dl over the premeal reading) or if one is using an additional insulin supplement (premeal >160–180 mg/dl), then an increase in the premeal insulin dose is needed.

The examples in Tables 1–3 translate these strategies into practice.

In Table 1, we see an excellent intensive regimen—multiple-dose therapy with 50/50 basal-bolus distribution. The regimen provides lifestyle flexibility as well as an opportunity to improve glycemic control. Despite this, the principles of pattern management and sliding-scale (supplemental) therapies have not been applied, and the opportunity to maximize control is lost.

Table 2 demonstrates the implementation of a sliding-scale (supplemental) approach. An insulin-to-carbohydrate ratio has been determined, and supplements are being used. The results are a definite improvement in bedtime blood glucose values, with the exception of one concerning the low level of 51 mg/dl.

In Table 3, efforts were made to identify why the predinner blood glucose values were elevated. First, the lunch dose of lispro was evaluated. The dose was considered appropriate because all lunch pre- and postprandial excursions were within the 20–40 mg/dl range. Another question to ask is whether there is a significant snack before dinner. The answer in this case was no. As a result, the morning ultralente dose was increased to address the elevated blood glucose levels before dinner. Day 9 and 10 demonstrate the response to the change and the benefit of “correcting” the problem. What we have seen demonstrated in this example is the best of both worlds—the application of both pattern management and sliding-scale (supplemental) insulin therapies.

Outpatient and Inpatient Applicability

The strategy of pattern management not only enhances the use of insulin in the outpatient setting, but also is an essential component of effective inpatient insulin management.

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<th>Table 1. Intensive Insulin Regimen Without Applying Pattern Management or Sliding-Scale (Supplemental) Therapy</th>
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Target BG range: 80–140 mg/dl. Values in bold are out of range.

Regimen: 10 units LP/12 units UL before breakfast; 8 units LP before lunch; 10 units LP before dinner; and 16 units N at bedtime.

BG, blood glucose level; LP, lispro; N, NPH; UL, ultralente.

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<th>Table 2. Intensive Insulin Regimen With Sliding-Scale (Supplemental) Insulin Therapy</th>
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Target BG range: 80–140 mg/dl. Values in bold are out of range.

Regimen: 2 units LP/CHO; 10 units UL before breakfast; and 16 units N at bedtime.

Supplemental dose: 1 unit/30 mg/dl above target range.

BG, blood glucose level; CHO, carbohydrate; LP, lispro; N, NPH; UL, ultralente.
al. studied the glycemic control and sliding-scale insulin use in 171 adult medical inpatients with diabetes. They concluded that "although sliding-scale insulin regimens are prescribed for the majority of inpatients with diabetes, they appear to provide no benefit..." An editorial by Swain in response was titled "Action Without Benefit: The Sliding Scale of Insulin Use" and emphasized that a sliding scale as the sole approach to insulin delivery was not helpful and in fact was detrimental in many instances. In response to both of these articles, the International Diabetes Center wrote a letter titled "The Insulin Sliding Scale is Not Dead," which described an approach to using a standardized format for incorporating patients' usual insulin regimen and a modest sliding scale at meals with daily adjustments in the insulin orders based on pattern management. This approach of combining pattern management and a sliding scale in the hospital has proven very effective in optimizing glycemic control while minimizing hypoglycemia.

**Summary**

To achieve the aggressive glycemic goal of an HbA1c under 7% (and, as more data emerge, perhaps the goal will even be <6%) in all patients with diabetes, most will require insulin therapy. Patient-centered team care is vital. In a sports event, the winning team is likely to be the one with both a strong offense and a sound defense. In diabetes management, success is most likely achieved when individuals are armed with a strong offense (sliding-scale insulin) and a sound defense (pattern management).

**References**


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