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Sliding Scale or Sliding Scare: It's All Sliding Nonsense

In Brief

Sliding-scale insulin has a long history and, today, a variety of connotations. With the development of more sophisticated insulin regimens and insulin analogs, it is important to differentiate different types of insulin algorithms from more traditional sliding-scale insulin regimens, which have many disadvantages. For a flexible diabetes regimen to be effective, emphasis must also be given to matching food intake with the appropriate amount of insulin.

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There are certain things in life that are permanent, understood, and acceptable. The sun always rises in the east; during the fall season, tree leaves turn bright colors before falling; and, of course, every April our taxes are due. There are also certainties in medicine: ethanol can be toxic to the liver and other tissues, antibiotics can cure infections, and β -blockers after myocardial infarction reduces the risk of cardiovascular death. Apparently, another widely accepted near-certainty is the entire concept of “sliding-scale insulin.”

Before proceeding, let us state clearly that this discussion will only pertain to outpatient diabetes management. The topic of sliding-scale insulin use for hospitalized patients is equally nonsensical and has been shown to be ineffective.^{1,2}

To be fair, we also need to make sure we are all speaking the same language. What exactly is sliding-scale insulin? It really depends on who you ask. In the 1960s and 1970s, “fractional urine” tests revealed an amount of glycosuria, and then regular insulin could be administered based on a sliding scale. The critical point about this strategy is that the insulin was provided based on a retrospective amount of glycosuria. After the introduction of self-monitoring of blood glucose (SMBG), insulin could be given based on a precise glucose level (precise because the digital read-out could report differences as small as 1 mg/dl).

Unfortunately, even today, many forget that meters only provide good estimates of actual blood glucose, and

sometimes these estimates are far from accurate. The American Diabetes Association's most recent consensus statement on SMBG³ noted that the goal for total error (analytical plus user) should be no more than 10%. However, errors of more than 20% are not unusual. In fact, one of the most important conclusions we are learning from the introduction of continuous glucose monitoring is how poor modern-day SMBG really is.

So, how important is it to make large changes in insulin dose with a blood glucose level of 199 mg/dl versus one of 201 mg/dl when the meter actually can't tell the difference? Nevertheless, this is how most of us practice diabetes care.

Sliding-scale insulin, as currently used by most patients and providers, usually refers to giving insulin based on a single blood glucose level. More often than not, issues such as “lag time” (the amount of time between an insulin injection and the start of a meal) and time of day are not considered when setting the insulin dose. In our experience, most patients do not even differentiate between a before-meal, between-meal, or bedtime blood glucose level when using their sliding scales. Sliding-scale insulin administered retrospectively based on postprandial SMBG results is something we see rarely with most of our patients, although we do still see this often in the inpatient setting.

We now see everything from sliding-scale insulin lispro to sliding-scale regular insulin to sliding-scale NPH. We are still trying to understand the

concept of sliding-scale ultralente insulin. We see it, just like we see sliding-scale 70/30 insulin. It seems more like sliding-scale insulin to us. We are anxiously awaiting our first patients on sliding-scale insulin glargine.

Don't Slide—Supplement

What we are really trying to do is “supplement” for hyperglycemia. Insulin can be divided into three types: prandial (or bolus) insulin, basal insulin, and supplemental insulin. The supplement is part of an algorithm, and it can only be a short-acting insulin (lispro, aspart, or regular) because we are trying to make a correction.

The amount of supplemental insulin needed will vary, depending on the time of day (morning supplements may be greater than bedtime supplements) and the relation to food. Before-meal supplements, after dissipation of the previous prandial insulin, will need to be greater than supplements between meals, when previous insulin may be not only available, but actually peaking. What is clear is that the supplements cannot be the same for all situations.

Before the introduction of insulin lispro, supplementing between-meal blood glucose levels with traditional sliding-scale regimens often resulted in hypoglycemia. For example, let us assume that dinner was eaten at 6:00 p.m., ideally 30 min after an injection of regular insulin. An 8:00 p.m. blood glucose reading of 220 mg/dl might have prompted some patients to inject additional regular insulin. But the regular insulin was only then peaking, so that more than 50% of the insulin dose was still in the subcutaneous depot. Conscientious (and at that time, at least, conscious) patients would look at the sliding scale and inject the appropriate amount of insulin. Of course, the additional regular insulin (not to mention any evening NPH) would drive blood glucose levels down during sleep, resulting in nocturnal hypoglycemia.

Although this “insulin stacking” is not as much of a problem with insulin lispro or aspart, it still occurs. Patients must always understand how much of the previously injected insulin is still available so that insulin stacking does not result in hypoglycemia.

As a rule, we teach patients that, if they do want to supplement for between-meal glucose levels, the algo-

rithm should be a fraction of what they would usually do. If a 2-h postprandial glucose level is elevated after insulin lispro, we recommend no more than 50% of the usual supplement of insulin lispro.

The problematic issue of between-meal supplements will improve once patients begin wearing continuous glucose sensors. Now, we only look at glucose levels in cross-sections of time. Once we know the *direction* of the glucose levels (the “glycemic slope”) in real time, we will be able to more accurately supplement insulin. We have not yet fully realized the disadvantage we face in not knowing the glycemic slope when determining insulin algorithms.

When to Supplement, When to Adjust

If a supplement schedule is an algorithm for glycemic correction, what about basal insulin? Supplements (as opposed to some of the sliding scales we see) only address short-acting insulins for an acute correction of glycemia. A supplement schedule could also correct premeal hypoglycemia (subtracting insulin compared with the usual dose). The term “adjustment,” on the other hand, refers to the change of a base dose of insulin (prandial, supplemental, or basal) based on a consistent pattern over at least 3 days. The examples are obvious: frequent fasting hyperglycemia means the evening basal insulin needs to be adjusted to a higher dose. Consistent postprandial hypoglycemia means the prandial insulin dose needs to be adjusted downward. This could be achieved by adjusting a base dose of insulin or by using a different insulin-to-carbohydrate ratio.

Even for patients who understand the concept of an insulin algorithm, know how to supplement, and know the appropriate times for adjustments, most (including those on pumps) are still missing an even larger point: that insulin adjustments are necessary based on calorie consumption. The most common scenario involves a patient who is quite knowledgeable about how to make insulin adjustments based on glycemia and who supplements different doses between meals and at bedtime compared to before meals, yet who does not adjust insulin based on the amount of food (especially carbohydrate) anticipated. Some patients are taught this, but many are not. If 6 U insulin lispro is

sufficient to maintain excellent postprandial glucose levels with a 60-g carbohydrate meal, why would one also take the same dose of insulin for a 100-g meal?

Many patients who could learn this are never taught; others are simply unable to comprehend this concept. For those in the latter group, we need to be more creative. We could, for example, advise adding 2 U for a “big meal” or subtracting 2 U for a “small meal.” Some patients do better by taking a constant dose of insulin but adhering to a “carbohydrate target,” either by counting carbohydrates or by using traditional diet exchanges. Having access to a dietitian is crucial, especially for patients who do not understand the concept of an insulin-to-carbohydrate ratio.

Remember the Big Picture

Using insulin algorithms to supplement additional insulin is just one component of a flexible diabetes program. Too often during a typical office or clinic visit, care providers place too much emphasis on insulin as a stand-alone tool, while neglecting to address the other aspects of diabetes therapy.

The fundamental issue is that we must merge eating and exercise recommendations with insulin prescriptions. But many patients do not receive this degree of education. Instead, they are using their sliding scales.

Another option would be to tell patients they need to eat the same quantities of carbohydrate, fat, and protein each day. That way, when we review our patients' insulin doses, each adjustment we make should have a significant impact on glycemia.

This is how diabetes was practiced 40 years ago. And it doesn't work. Giving patients a piece of paper on which is printed their diet (and sliding scale) and telling them that this is what they need to eat at the same time each day is not only unrealistic, but also insulting and doomed to fail. Although most people taking insulin would do better if their schedules, food intake, and exercise were identical from day to day, very few people could or would want to lead such a life. Clearly, diabetes educators need to be better utilized to teach patients how to use the many available diabetes management tools most effectively.

Summary

We see sliding-scale insulin as a relic from years past. Although it still means different things to different people, this debate is about much more than simple semantics. Using insulin supplements and changing insulin doses based on food intake and SMBG is a relatively new concept. We must now move forward with our improved methods of diabetes management and leave the slid-

ing-scale insulin to the medical history books.

References

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