Optimizing Insulin Therapy

Calculating Insulin to Carbohydrate Ratios and Correction/Sensitivity Factors

Introduction

Diabetes management, and particularly self-management, has come a long way. Unfortunately, many healthcare professionals, as well as patients, continue to practice outdated approaches. These approaches limit the patient's flexibility in meal planning, and prevent them from achieving optimal blood glucose control. A person with diabetes that takes a combination of long and short acting insulin, or utilizes an insulin pump, has the best opportunity to select the foods that they enjoy, and still achieve their blood glucose targets. This module will help you to learn how to help your patients to select the foods that they enjoy, and adjust their insulin accordingly, to help improve blood glucose control, as well as enhance their quality of life.

Identifying Carbohydrates

The first step in basic diabetes education is to identify which food groups contain carbohydrates. When people think of diabetes, very often they just think of bread and pasta products, and of high sugar foods such as candy and cake. It is a common mistake that patients are not aware of the carbohydrate content of foods deemed healthy such as skim milk and fruit. The following table includes the food categories that contain carbohydrates (1):

Breads & Starches	Bread, Rice, Cereal, Pasta, Tortillas, Bagels, Rolls, Pita Bread etc. *Whole grain products do contain carbohydrates so also need to be counted
Fruit	All types of Fruit Fruit Juice * Fruit contains a natural sugar called Fructose so every type of fruit has carbohydrates
Milk	All types of Milk (Skim, 1%, Whole) Yogurt Ice-Cream *Milk contains a natural sugar called Lactose, so most dairy products contain carbohydrates
Starchy Vegetables	Corn Potatoes Beans / Legumes / Lentils
Processed Foods & Desserts	Candy Cakes Cookies Soda Chips

It is important for a person with diabetes to realize that they DO NOT need to avoid all of the foods listed above. Many of the foods are very healthy, and contain essential nutrients. The key is to identify which foods have carbohydrates, and then count the grams of carbohydrate consumed at each meal, so they can adjust their insulin accordingly.

To count the grams of carbohydrate at each meal, label reading is key. In order to calculate the grams of total carbohydrate when looking on a food label, the patient must look at both the Total Carbohydrates and also the Serving Size. If they are eating more than the suggested serving, they must multiple the total carbohydrates by the serving size that they actually consume. It is not necessary to look at the sugar on the food label. This is just a small piece of the big picture. All of the carbohydrates eventually turn to sugar, so the Total Carbohydrates in the product will always be greater than (or at least the same as) the sugar content. You will never see a food label that shows MORE sugar than total carbohydrates. If a product has more than 5 grams of fiber in it, it is recommended for a patient that is taking insulin to subtract the fiber from the Total Carbohydrates when they are calculating how much insulin they need.

The Concept of Basal-Bolus Therapy

There are various types of insulin used to help with blood glucose control. The types that we will focus on are those that allow for the most precise control of blood glucose while offering the most flexibility in food choice and timing of meals.

Many patients use a combination of long-acting insulin and rapid-acting insulin. The types of long acting insulin include insulin glargine (brand name LANTUS®) and insulin detemir (brand name Levemir ®). These are recombinant human insulin analogs that result in a relatively constant concentration/time profile over 24 hours with no pronounced peak (2,3). Long-acting insulin provides a continuous level of insulin, mimicking the slow, steady (basal) secretion of insulin provided by the normal pancreas. Most people who take long acting insulin also take a fast-acting (also known as rapid-acting insulin), or bolus, insulin. Taking a long-acting basal insulin and a fast-acting bolus insulin is called "basal-bolus therapy." Basal-bolus therapy helps people with diabetes control blood glucose both during the day and at mealtime.

The rapid-acting types of insulin include: Insulin Glulisine (Apidra®), Insulin Lispro (Humalog®) and Insulin Aspart (Novolog®). Humalog®, NovoLog® and Apidra® begin working within about 15 minutes of bolus, peak 60 to 90 minutes later and have a duration of therapeutic activity of approximately four hours (4). Rapid-acting analogues are essentially equal in terms of pharmacodynamics and pharmacokinetics. Most patients experience that these types of insulin work strongly in their body for the first 2 hours, and the remaining 2 hours are more of a tail effect.

The Basics of Adjusting Rapid-Acting Insulin

The amount of long acting insulin a patient takes is usually consistent from day to day, and is prescribed by their physician or other member of their diabetes care team. The amount of rapid acting insulin a patient takes should be continuously adjusted by the patient, on a meal-to-meal basis, and should be based on their current blood glucose, and also on the amount of carbohydrates that they plan to eat. Many healthcare professionals use a sliding scale approach to help their patients to adjust their rapid acting insulin. A sliding scale gives the patients a range for how much insulin they should take, based on their current blood glucose. This approach does not provide them with a way to adjust the insulin based on the carbohydrate content of the meal.

The truth is that insulin works differently in each person's body. So, the best approach for optimized blood glucose control is to help your patients to calculate an individualized Insulin to Carbohydrate Ratio and to calculate their own Sensitivity or Correction Factor.   Once the patients know these ratios, there is less guesswork needed when correcting for a high blood glucose, or adjusting insulin for meals, and the process becomes a lot more precise.

Calculating Correction or Sensitivity Factors

There are 2 ways to calculate a patient's sensitivity factor. You can start with this basic calculation, and then use the method below to make sure it is accurate.

Rule of 1800

Add up the total amount of insulin the patient takes during the day, taking into consideration both the long acting and rapid acting insulin (this is called the Total Daily Dosage or TDD). Divide this number into 1800, and you will get the point drop per unit of rapid acting insulin (5). For example, if someone's total daily dose is 50 units of insulin, divide 1800 by 50 = 36 mg/dl drop per unit of insulin. So the Correction or Sensitivity factor is 1 unit of Insulin: 36 mg/dl.   This means that for each 36mg/dl that this person is above their target blood glucose, they need 1 unit of insulin for correction.

<u>To assess if this calculation is right, you can have your patients follow these steps:</u>

This is an actual handout used for patient education:

Step #1 – Test your sensitivity factor at a time when your blood glucose is high (and it needs to be at least 2 hours after meals, and 3 hours after the last time you took insulin). But don't do this at a time that your blood glucose is above 300, because your body may become resistant to the insulin when your blood glucose is in this range, so it's not a good indication of how your body would response in other circumstances. So ideally, you will do this test when your blood glucose is around 200mg/dl. If you wake up in the morning with a high blood glucose, this may also be a good time to do this test.

Step #2 - Take 1 unit of the rapid acting insulin, and **DO NOT EAT**. Wait 1.5 - 2 hours, and test your blood glucose again.

Step #3 – Take your starting blood glucose, and from that number, subtract the resulting blood glucose 2 hours later. The difference that you come up with is the amount that 1 unit of insulin decreases your blood glucose.

Examples

- ✓ If you started with a blood glucose of 200, and 2 hours later your blood glucose was 130, this means that 1 unit of insulin decreased your blood glucose by 70 mg/dl.
- ✓ If you started with a blood glucose of 170, and 2 hours later your blood glucose was 120, this means that 1 unit of insulin decreased your blood glucose by 50 mg/dl.

It is recommended that you do this test a few times, at various times of the day. Your sensitivity factor may vary based on the time of the day.

Once you figure out how many mg/dl 1 unit decreases your blood glucose, you will easily be able to calculate how much insulin you need at meal times, or between meals, to correct your blood glucose back to target. Your target will be set for you by your doctor or diabetes educator. Any time your blood glucose is above target, you can use this correction or sensitivity factor to calculate how much insulin you need to return to your target blood glucose.

How to Determine an Insulin to Carbohydrate Ratio

As we've already discussed, insulin works differently in each person's body. That means that the amount of insulin that you need to cover your food varies from person to person. This is called an insulin to carbohydrate ratio, and means that 1 unit of insulin covers x grams of total carbohydrate, or 1: X.

There are 2 ways to calculate a patient's insulin:carbohydrate ratio. You can start with this basic calculation, and then use the method below to make sure it is accurate.

Rule of 500

Add up the total amount of insulin the patient takes during the day, taking into consideration both the long acting and rapid acting insulin (this is called the Total Daily Dosage or TDD). Divide this number into 500, and you will get an approximate for the grams of total carbohydrate that will be covered by 1 unit of insulin (5). For example, if someone's total daily dose is 50 units of insulin, divide 500 by 50 = 10 grams of total carbohydrate. So the Insulin to Carbohydrate ratio is 1 unit of Insulin:10 grams of Total Carbohydrate. This means that for each 10 grams of total carbohydrates that this person eats, they need to take 1 unit of insulin.

To assess if this calculation is right, you can have your patients follow these steps:

This is an actual handout used for patient education:

Step #1 – You can identify your insulin: carbohydrate ratio at a meal where you are entering into the meal with a good blood glucose. This means that you do not need any insulin for correction, because you are starting the meal with a good blood glucose. So, you will just need enough insulin to cover the carbohydrates in that particular meal.

Step #2 – Identify how many carbohydrates are in the meal that you are about to eat by carefully counting the carbohydrates. It is a good idea to eat something 'pre-packaged' with a nutrition label, such as a frozen dinner, so you can be sure about the carbohydrate count.

Step #3 – Take the number of units that you feel is appropriate. This may have been recommended to you by your doctor using a sliding-scale approach, or by using the Rule of 500 calculation.

Step #4 – Test your blood glucose 2 hours after you finish your meal. It should be 140mg/dl or less. If your blood glucose 2 hours after the meal is within range that means that the amount of insulin you took was accurate.

Step #5 – To calculate your insulin: carbohydrate ratio, divide the Total Carbohydrates in the Meal by the # of Units of insulin that you took.

Examples:

- ✓ If the meal had 45 grams of carbohydrate, and you took 3 units of insulin, that means that you took 1 unit of insulin, for 15 grams of carbohydrate (or 1:15).
- ✓ If the meal had 60 grams of total carbohydrate, and you took 6 units of insulin, that means that you took 1 unit of insulin for every 10 grams of carbohydrate (or 1:10).

Step #6 – If your blood glucose 2 hours after the meal was too high or too low, you can still calculate the insulin: carbohydrate ratio as described above, but you know right away that you need to alter the numbers that are being using, to make them lower or higher based on your blood glucose response. For example, if you used 1:15, and your blood glucose was too high after the meal, next time use 1:14.

It is recommended that you do this test a few times, at various times of the day. Your Insulin to Carbohydrate Ratio may vary based on the time of the day. Some people use a different Insulin to Carbohydrate Ratio at each meal.

<u>Pulling it all Together – Optimizing your Blood Glucose Control</u>

Once a patient has calculated their Insulin: Carbohydrate ratio, and Sensitivity or Correction Factor, they have the ability to eat what they would like, when they would like, and alter the insulin they take to accommodate their food choices.

The steps they would take are as follows:

1. At the start of each meal, test their blood glucose, and determine if they need any insulin towards correction, to get their blood glucose to the target that has been provided to them by their physician (usually 100-120). They will use the Sensitivity Factor to calculate how much insulin they need for correction.

2. Next, they should count the carbohydrates in the meal, and using their Insulin: Carbohydrate ratio, figure out how much insulin they need to cover the Total Carbohydrates in the meal they are about to eat.

3. Finally, add the units of insulin needed for correction to the units of insulin needed to cover the total carbohydrates in the meal. That is the total amount of insulin needed for this particular scenario.

The Importance of Tracking

Many factors can affect a patient's insulin to carbohydrate ratio, such as the presence of insulin resistance, how much long-acting insulin they are taking, body weight, activity level, fiber and fat content of diet, as well as many other considerations (6).

Asking patients to keep a detailed log will help the healthcare provider to assess if the ratios being used are correct. Often, dietitians/diabetes educators prefer to start by having patients keep a detailed food record in which they attempt to eat fairly consistently; then test blood glucose before and 2- hours after meals, carefully recording the carbohydrate content of the meals, the insulin doses, and the pre-meal and post-meal glucose readings. This data enables the diabetes team to retrospectively calculate the current regimen, to determine the current insulin-to-carbohydrate ratio; then adjust the ratio upward or downward, according to the patients individual needs (6).

This is an example of a comprehensive log:

Time	Current Blood Glucose	Food to be consumed	Grams of Carbs	Insulin for Correction (1 : 50)	Insulin to cover Carbs (1 : 15)	Total # of units delivered	Blood Glucose 2 hours later
9am	160	2 slices toast	30	1	2	3	120

Insulin Pump Therapy

Delivering insulin through an insulin pump has many advantages. For the purposes of this module, I will speak of the advantages as related to Insulin to Carbohydrate Ratios and Sensitivity Factors.

Many people were trained how to count their carbohydrates using the Exchange System, which rounds the grams of carbohydrates, instead of counting the exact grams. Coupled with this, insulin to carbohydrate ratios and sensitivity factors are often rounded to keep the math simple for the patient.

An insulin pump has the ability to store multiple insulin to carbohydrate ratios and multiple sensitivity factors. The first advantage is that the insulin pump does not round. So if an I:C of 1:15 does not work, the patient can change this ratio to 1:14, and get slightly more insulin. If this does not work, the patient can again decrease the I:C to 1:13. These very small incremental changes are much easier to make and to track using an insulin pump. Another advantage is that a patient can calculate and then store various I:C and SF for each meal during the day. Again, if a patient was expected to remember each ratio for the specific time of the day, and do the precise calculation, they would likely end up rounding and sticking with just one ratio. An insulin pump will utilize the exact ratios that have been programmed for the time of the day.

When using an insulin pump, patients simply need to enter their blood glucose into the pump, followed by the total grams of carbohydrate that they will consume. The more precise they are with the carbohydrate count, the more precise delivery of insulin they will receive. For this reason, rounding numbers is not necessary or recommended. It is a good idea to get an accurate carbohydrate count. Using ratios that have been programmed into the pump for I:C and SF, the pump will calculate for the patient how much insulin they need, and will also take into consideration any active insulin they still have in their system, or insulin on board. This will help to prevent them from stacking insulin too closely together.