Type 1 Diabetes Management Based on Glucose Intake

www.utmem.edu/endocrinology click "Patients"

(Revised 7/13/2007)

The following is a system of insulin therapy, diet management, and blood glucose monitoring designed to allow the average Type 1 diabetic patient to take responsibility for blood glucose management. This system is based on three basic variables of diabetic control:

A. Basal (long-acting): This insulin is needed to balance the glucose produced by the liver and glucose used by the muscle and brain. The correct insulin dosage should maintain the blood glucose concentration at approximately 100 mg/dl indefinitely if no food is eaten.

B. Meal (short-acting): "Novolog", "Humalog", or "Apidra" insulin taken within 5 minutes of each meal. This insulin dose should be balanced with the amount of carbohydrate or glucose in the meal.

C. Supplemental: Short acting insulin (sliding scale) is also taken twice daily, when the blood glucose is over 100 mg/dl in order to bring the blood glucose back to ~100 mg/dl within 4 to 5 hours.

A. Basal Insulin

Lantus insulin or the subcutaneous insulin pump is usually effective in providing basal blood glucose control. The Lantus dose or pump rate of infusion is adjusted until they balance liver glucose production and glucose utilization by muscle and brain at a blood glucose level of 100 mg/dl. Therefore, when no food is eaten and no short-acting insulin is injected, the blood sugar should remain stable between 70 and 130.

Basal insulin is generally started in a dose based on body weight (0.3 to 0.4 Units/kg body weight/day). Lantus insulin should be given at bedtime and cannot be mixed with any other insulin. It is recommended that the Lantus insulin be adjusted no more often than every three days initially because of its very long duration of action. Changing the Lantus dosage before three days, may lead to irratic blood sugars which are difficult to evaluate. Later, the Lantus can be adjusted daily depending on the level of exercise that day. The subcutaneous pump can be adjusted daily because the full effect of a basal rate change is seen in 4 to 6 hours.

When adjustments are needed, the following schedule can be utilized:

Fasting Blood Glucose	Adjustment of Basal Dose
Less than 50	Decrease by 25%
Less than 70	Decrease by 10%
140-200	Increase by 10%
Greater than 200	Increase by 20%

One way to determine whether the basal insulin dosage is correct, is to eat a small breakfast and take the appropriate short-acting insulin before 7:30 AM. Then skip lunch and monitor the blood glucose every hour between 2:00 PM and 6:00 PM. The blood glucose should stabilize between 80-120 mg/dl.

B. Meal Bolus Insulin

The only component of a meal that usually needs to be covered by short-acting insulin is carbohydrate. There are three simple sugars that make up most of the carbohydrate in food: glucose, fructose, and galactose. Most of the glucose in food is in the form of starch, which is a long chain of glucose molecules linked together. Therefore, starch is 100% glucose. Table sugar is "sucrose" and is made up of one glucose molecule linked to one fructose molecule. Table sugar is, therefore, a disaccharide (two sugars hooked together) and is only 50% glucose. Milk sugar is "lactose" and is another disaccharide made up of one glucose and one galactose molecule. Therefore, milk sugar is also 50% glucose. Blood "sugar" is GLUCOSE, therefore, in order for fructose or galactose to raise the blood "sugar" they must be converted to glucose. Similarly, protein and fat must be converted to glucose in order to raise the blood "sugar". Research studies have shown that fat cannot be converted to glucose and that protein, fructose, and galactose usually are not converted to glucose when eaten as part of a mixed meal. Therefore, all that is required is to take enough insulin to cover the amount of glucose that is in the food. Unfortunately, there are no books that list the amount of glucose in foods, only the total carbohydrate. The solution, therefore, is to convert the total carbohydrate information into glucose.

A subcutaneous injection of short-acting insulin is also not the ideal way to treat a meal. Food is usually totally absorbed into the blood within 2 to 3 hours. The short-acting insulins used today have their peak effect between 1-2 hours and continues to lower the blood glucose for up to 5-6 hours. This means that the food will produce a rapid raise in the blood glucose over the first 2 hours (by 100-150 mg/dl) and then the insulin will rapidly lower the blood glucose between the 4th and 6th hours. Obviously, this can lead to some very large fluctuations in the blood glucose. These fluctuations may be reduced by reducing the amount of glucose in each meal.

A typical short-acting insulin bolus required for a meal is one unit of insulin for every 10 grams of glucose. The carbohydrate composition of most mixed meals is about 70% glucose unless they contain predominately fruit (which contains about 50% fructose) or milk (which is 50% galactose). More detailed meal regimens are given below.

MEAL INSULIN: DOSE ADJUSTMENT

When adjusting the meal dose of short-acting insulin, two goals are utilized:

1. The peak blood glucose should be less than 100 mg/dl ABOVE the starting blood glucose between 1 to 3 hours after the meal (the usual peak time).

2. The blood glucose should return to the same level from which it started, FIVE HOURS after the meal insulin injection. If you do not wish to return to the same point, then the supplemental insulin regimen (described below) must be utilized in order to reach the optimum blood glucose of 70 to 120 mg/dl.

These two goals must be considered together. Some patients will be more sensitive than others to the glucose content of a meal. They may require a limit on the amount of carbohydrate (glucose) that they can eat in one meal in order to prevent the blood sugar from peaking too high. Small, frequent meals may be required if more food is desired. Blood glucose monitoring two hours after meals is usually only required during initial therapy or during pregnancy, but can be done for isolated meals or perhaps once a week on a long term basis in order to reinforce the importance of limiting total carbohydrate (glucose) at a single meal.

DIABETIC DIET MANAGEMENT
FOOD MEASUREMENT

Careful measurement of food amounts is advised during initial therapy so that the most accurate picture of the food's impact on blood glucose can be developed. It is recommended that the patient weighs and measures all food (especially high carbohydrate foods) prior to each meal in order to form a good foundation in estimating food amounts. Patients should use this information in order to calculate insulin dose.

Stage 1: Carbohydrate Counting

To familiarize patients with "carbohydrate or glucose" counting, a diet plan should be established and followed. This diet plan will determine the appropriate amount of carbohydrate in each meal and a predetermined amount of insulin should be taken before each meal. For example, a typical 1800 cal ADA diet will provide 75 grams of total carbohydrate or 50 grams of glucose in breakfast. Therefore, 5 units of regular insulin may be prescribed before each breakfast in order to cover this glucose **(approximately 1 unit for every 10 grams of glucose).** The patient will then have to determine which foods they wish to eat to make up these 50 grams of glucose. Over 3 or 4 days, the blood sugar response to this dosage is evaluated to see if this is the appropriate amount of breakfast insulin. If the pre-lunch blood glucose is consistently over 120 mg/dl then more breakfast insulin should be given. If the pre-lunch blood glucose is less than 75 mg/dl, than less breakfast insulin should be given. Similar adjustments are made for the lunch and supper meals. These insulin adjustments can only be made if the blood glucose is checked prior to each meal and at bedtime.

Carbohydrate amounts can be calculated by several methods:

A. ADA food exchange values (new patients should skip to 'B' and not use exchanges):

Bread or starch exchange = 15 grams carbohydrate
Milk exchange = 12 grams carbohydrate
Fruit exchange = 15 grams carbohydrate
Fat and meat exchanges contain no carbohydrate

Only one-half of the carbohydrate in milk and fruit is glucose while all of the carbohydrate in starch is glucose, therefore:

one starch = two milks = two fruits

The number of starches can be added together and multiplied by 15 to give the total amount of glucose that needs to be covered by insulin. For example, 4 "starch-equivalents" provide 60 grams of glucose and may require 6 units of short-acting insulin.

B. Food labels and Food Composition Tables:

All packaged foods are required to have food composition labels on them. In addition, a book titled **"The Carbohydrate, Fiber, and Sugar Counter"** (by Natow and Heslin, Pocket Books) also includes this information. The ultimate source for this information is the USDA website (Google: **"what's in the foods you eat: find a food").** The three numbers that are needed for this calculation are:

TOTAL CARBOHYDRATE	**Example: 45 grams**
SUGARS	**Example: 20 grams**
FIBER	**Example: 5 grams**

The grams of glucose that should be used to determine insulin dosage are:

'TOTAL CARBOHYDRATE' minus **'1/2 SUGARS'** minus **'FIBER'**

Example: 45 – (20/2) – 5 = 30 grams of glucose per serving

For example, if food 'A' has 45 grams of TOTAL CARBOHYDRATE, 20 grams of SUGAR, and 5 grams of FIBER per serving, then subtract one-half of 20 (that is: 10) and all of the FIBER (that is: 5) from 45. This gives a total of 30 grams of glucose that must be covered per serving. Now the total number of servings must be determined by weighing or measuring the food. If two serving are going to be eaten then a total of 60 grams of glucose must be covered by the meal insulin dose (approximately 6 units of regular would be a typical starting dose, one unit for 10 grams of glucose).

If only total carbohydrate is known then some adjustment can be made to convert to glucose. If the food is a starch (bread, potato, pasta, rice, corn, peas, cereals, cakes, cookies, etc), then just use the total carbohydrate. If the food is a dairy product, fruit, or candy then this number should be cut in half. Remember that many green vegetables, meat, fish, and nuts are "freebies". That is, they do not need to be included in these calculations because they do not contain any significant amount of absorbable glucose. If you are confused as to what type of food you have, then consult a diabetes exchange booklet that lists the foods by "type" or ask your dietitian.

Stage 2: Carbohydrate Counting with Variable Meals

The next step in using "carb or glucose counting" is to allow variable meal intake and determine the amount of insulin required to cover the desired carbohydrate. The patient decides how much food they wish to eat. They then calculate the amount of glucose in that food (using food composition books, labels, or diabetic exchanges) and multiply the carbohydrate by the prescribed short-acting insulin dosage (e.g. 1 unit for every 10 grams glucose) to determine the total meal insulin dosage.

Example: (from example above)
(30 grams of glucose) X (1 unit insulin/10 grams glucose) = 3 units of regular insulin

C. Supplemental Short-Acting Insulin (sliding scale)

Supplemental short-acting insulin is usually taken twice daily (before breakfast and before dinner) and is given in a dose sufficient to return the blood glucose to between 70 and 130 mg/dl. One unit of short-acting insulin given subcutaneously will typically lower the blood glucose 25 mg/dl over 4 to 5 hours. However, some individuals will only have their blood glucose drop 10 mg/dl while others will drop 50 mg/dl with one unit of insulin. Therefore, some trial doses are required. If the starting blood glucose is too low, than insulin is subtracted from the meal dose or additional carbohydrate is given.

SUPPLEMENTAL INSULIN SHOULD ONLY BE TAKEN IF IT HAS BEEN AT LEAST FIVE HOURS SINCE THE LAST INJECTION OF SHORT-ACTING INSULIN

Calculation of supplement:

Take one unit of regular insulin for every ? mg/dl of blood glucose above 100.

Most patients are started on a dosage of one unit of short-acting insulin for each 25 mg/dl of blood glucose above 100. The amount of insulin should never be rounded "up", always "down". For example, at 149 mg/dl, only 1 extra unit should be taken, while at 151 mg/dl two extra units should be added. The

maximum supplemental regular insulin is usually 12 units for a blood glucose greater than 400 mg/dl. Assessment of the accuracy of the supplemental dose can best be done by giving a dose of short-acting insulin for an elevated blood glucose and monitoring the response to that dose without food for 5 to 7 hours.

Example:

Blood Glucose:	**Adiustment:**
<50	Eat a carbohydrate snack immediately (15-30 grams). Take the full meal insulin dose after eating the whole meal.
50-70	Subtract 2 units from the meal insulin and take after eating the meal. If no meal is planned, eat a small snack (15 grams carbohydrate).
71-125	No Adjustment is needed.
126-150	Add 1 U short-acting insulin
151-175	Add 2 U short-acting insulin
176-200	Add 3 U short-acting insulin
201-250	Add 4 U short-acting insulin
251-300	Add 6 U short-acting insulin
301-350	Add 8 U short-acting insulin
351-400	Add 10 U short-acting insulin
>400	Add 12 U short-acting insulin, check urine ketones

A short-hand version of this regimen is:

2 units for every 50 mg/dl over 100 up to a maximum of 12 units

Practice:

Time: 7:40 AM Blood Glucose: 186 mg/dl

Breakfast:	**per serving:**					
Food:	**Carbs**	**Sugars**	**Fiber**	**Glucose**	**Servings**	**Total Gluc**
1 cup DelMonte Lite fruit cocktail	_____	_____	_____	_____	_____	_____
8 oz skim milk	_____	_____	_____	_____	_____	_____
½ cup Quaker Oats	_____	_____	_____	_____	_____	_____
3 strips of bacon	_____	_____	_____	_____	_____	_____
2 egg beaters	_____	_____	_____	_____	_____	_____

Total Glucose for meal: _____

Humalog Insulin for Food: _____ Units

Humalog Insulin for supplement: _____ Units

Total Humalog Insulin: _____ Units

Hughes TA, Atchison J, Elliott SK, Hazelrig JB, Boshell BR: Effect of Food Composition on Glycemic Responses in IDDM. **American Journal of Clinical Nutrition** 49:658-666, 1988.