Type 1 Diabetes Management Based on Glucose Intake
(Revised 2022)

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

A. Basal (long-acting insulin): These insulins are usually injected once daily and are needed to balance the glucose produced by the liver and glucose used by the muscle and brain when you are not eating. The correct insulin dosage should maintain the blood glucose concentration at approximately 100 mg/dl indefinitely **if no food is eaten, no short-acting insulin is taken, or exercise performed**.
Basal Insulins: Pump Basal Rate, Lantus (Basaglar, Toujeo, Semglee, Rezvoglar), Tresiba, Levemir
Novolin N will act as a basal insulin if given in equal doses every 8 hours.

B. Meal (short-acting insulin & "Carb Ratio"): This insulin dose should increase the rate of removal of glucose from the blood after a meal. Food is typically absorbed over one to two hours. Unfortunately, the available "short-acting" insulins act for 4 to 8 hours depending on the dose. This difference produces a mismatch that must be considered when insulin is used to treat dietary carbs. These insulins should typically be injected just before eating.
Short-Acting Insulins: Novolog (Fiasp), Humalog (Lyumjev), Apidra, pump boluses
Fiasp and Lyumjev are quicker and shorter acting forms of Novolog and Humalog, respectively.

C. Correction Factor or Sliding Scale: Short-acting insulin can be taken to correct a high blood glucose back to around 100 mg/dl if no short-acting insulin has been taken within 5 to 6 hours. This situation will typically only happen in the morning and perhaps late afternoon (supper). It will take 5 hours for this correction to take place.

A. Basal Insulin

Basal Insulin should be adjusted every 3 to 7 days in order to maintain "Basal Sugars" (no food ingestion or short-acting insulin taken) between 70 and 130 mg/dl. Basal insulin is generally started at a dose based on body weight (0.3 to 0.4 Units/kg body weight/day). These insulins are usually given at bedtime but they can be administered at other times if necessary. Again, it is recommended that the basal insulin be adjusted no more often than every three days because of its long duration of action. Changing the basal dosage more frequently may lead to erratic blood sugars which are difficult to evaluate. The subcutaneous insulin pump can be adjusted daily because the full effect of a basal rate change is seen within 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 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 it is made up of one glucose molecule linked to one fructose molecule. Table sugar is, therefore, a disaccharide (two sugars linked 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 or databases that list the amount of glucose in foods, only the total carbohydrate. The solution, therefore, is to convert the total carbohydrate information into glucose. It should be noted that **protein can be converted to glucose** and is when there is **no glucose in the meal**. The amount of this conversion cannot be predicted and may not be enough to warrant taking short-acting insulin. However, you may need to take 1 to 3 units of short-acting insulin for a pure **protein-fat meal** if the increase in blood glucose is more than 50 mg/dl.

A subcutaneous injection of short-acting insulin is not the ideal way to treat a meal. **Food** is usually totally absorbed into the blood within **1 to 2 hours**. The short-acting **insulins** used today have their peak effect between 1-2 hours and continue to lower the blood glucose for up to **4 to 8 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 2nd and 8th hours. Obviously, this can lead to some very large fluctuations in the blood glucose. These fluctuations can only be reduced by reducing the amount of glucose in each meal.

A typical short-acting insulin dose 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 and 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 (correction) 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. The typical increase in blood glucose is 4 mg/dl for every gram of food glucose. If your sugar increases more than this amount then you will need to limit the amount of carbohydrate (glucose) that you eat at any one time 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 individual 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. Of course, continuous glucose monitors (CGM) now allow us to follow these glucose changes in real time so we can accurately assess the impact any particular meal-insulin combination.

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 you should weigh and measure all food (especially high carbohydrate foods) prior to each meal in order to form a good foundation in estimating food amounts. You can then use this information in order to calculate the correct insulin dosage.

Stage 1: Carbohydrate Counting

The easiest way to start "carbohydrate or glucose" counting, is to write out a diet plan and then determine the appropriate amount of glucose in each meal. A predetermined amount of insulin can then 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 short-acting insulin can then be taken before each breakfast in order to cover this amount of glucose **(approximately 1 unit for every 10 grams of glucose).** You can then determine which foods you wish to eat in order to make up these 50 grams of glucose. Over 3 or 4 days, the blood sugar response to this dose 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. Of course, a CGM will make these determinations much more precisely. Your personal "Carb-Ratio" can be determined from this data

Carbohydrate Information & Calculations:

Food labels and Food Composition Tables:

All packaged foods are required to have food composition labels on them. The ultimate source for food composition is the USDA website (Search: **"what's in the foods you eat: find a food").** An easy-to-use website and app used to obtain this information is:

https://www.fatsecret.com/calories-nutrition/usda/white-bread

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, food 'A' has 45 grams of TOTAL CARBOHYDRATE, 20 grams of SUGAR, and 5 grams

of FIBER per serving. We assume that all sugars are one-half glucose so subtract one-half of the sugar 20 (that is: 10 grams) and all of the FIBER (that is: 5 grams) from the TOTAL CARBOHYDRATE (that is: 45 grams). 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 short-acting insulin 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 dairy, fruit, berries, 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, that is, the carbohydrate in them cannot be digested.

Stage 2: Carbohydrate Counting with Variable Meals

The next step in using "carb or glucose counting" is to begin varying meal composition. You will then determine the amount of insulin required to cover the glucose in that particular meal using 1 unit for every 10 grams of glucose (or whatever ratio you have determined from your previous experience). Most people repeat many of their meals so that if you keep a record of the insulin given for specific meals, then it will be easy to determine what you need to take the next time.

C. Correction - Short-Acting Insulin ("sliding scale")

"Correction" 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 8 hours in patients with normal insulin sensitivity.** However, some individuals will only have their blood glucose drop 10 mg/dl (insulin resistant) while others will drop 50 mg/dl (ultra-insulin sensitive) with one unit of insulin. Therefore, some trial doses are required. If the pre-meal blood glucose is too low, than insulin is subtracted from the meal dose or additional carbohydrate is given. **One gram of glucose in the food will typically raise the blood glucose by 4 mg/dl.** Therefore, a slice of bread (~12 grams of glucose) will increase the blood glucose by about 48 mg/dl.

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

Calculation of correction:

Take one unit of short-acting insulin for every _?_ mg/dl of blood glucose above 100.

Most patients are started on a dose 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 short-acting 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.

Examples:

1. **Blood Glucose:** — **Correction for normal insulin sensitivity:**

Blood Glucose:	Correction for normal insulin sensitivity:
<50	Eat a carbohydrate snack immediately (15 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 correction 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
Over 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

2. **Blood Glucose:** — **Correction for insulin resistant patients & Type 2:**

Blood Glucose:	Correction for insulin resistant patients & Type 2:
<50	Eat a carbohydrate snack immediately (15 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 correction is needed.
126-150	Add 2 U short-acting insulin
151-175	Add 4 U short-acting insulin
176-200	Add 6 U short-acting insulin
201-250	Add 8 U short-acting insulin
251-300	Add 10 U short-acting insulin
Over 300	Add 12 U short-acting insulin

A short-hand version of this regimen is:
3 units for every 50 mg/dl over 100 up to a maximum of 12 units

3. Ultra-sensitive patients will use 1 unit for every 50 mg/dl over 100 up to a maximum of 6 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: _____

Short-Acting Insulin for Food: _____ Units

Short-Acting Insulin for supplement: _____ Units

Total Short-Acting 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.