Basal Insulin:
The Foundation of Good Control

by Gary Scheiner MS, CDE

When it comes to diabetes management, **basal** insulin is like the assistant principal: he does the bulk of the grunt work, but gets very little respect. Most people can't even spell it correctly (basil? bazal?), and even fewer know what it's used for. And that's a shame, because basal insulin represents the FOUNDATION that intensive insulin therapy is built upon.

Everyone with type-1 diabetes, and almost everyone with type-2 diabetes who takes insulin, requires basal insulin. Unlike its more famous little brother *bolus*, which is the rapid-acting insulin given to cover the carbohydrates in our diet, basal's job is much more mundane: to offset the liver's secretion of glucose into the bloodstream. Everyone's liver does it, mainly in response to the many hormones that are in circulation, such as cortisol, growth hormone, glucagon and epinephrine. A healthy pancreas responds to the liver's release of glucose by secreting a small amount of insulin into the bloodstream every few minutes. This is the *basal* insulin.

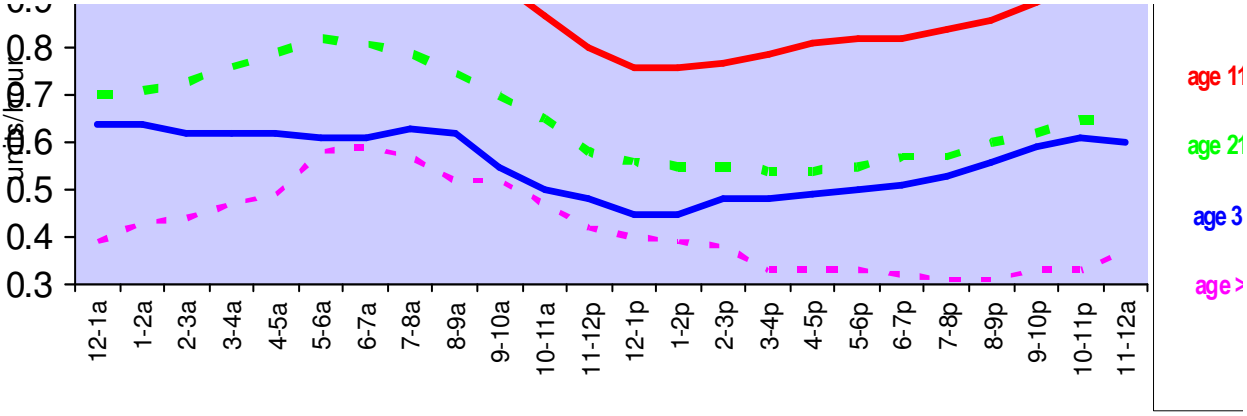
Basal insulin can be supplied in a variety of ways. Intermediate-acting insulin (NPH) can be taken by injection, but it has a dramatic "peak and valley" to its action and usually needs to be injected more than once daily. Long-acting insulins (Lantus and Levemir) offer a relatively peakless insulin presence for approximately 18-24 hours from a single shot. Insulin pumps deliver basal insulin in the form of tiny pulses of rapid-acting insulin every few minutes throughout the day and night. With a pump, the basal insulin level can be adjusted and fine-tuned to closely match the liver's ebb and flow in glucose secretion.

Why is it so important to have basal insulin? Without it, the liver would continue to dump glucose into the bloodstream, and blood sugar levels would rise sharply. Many of the body's cells would starve, and acidic "ketones" would be produced as the cells turn to fat as their primary energy source. Soon, the very high blood sugar and buildup of ketones would lead to diabetic ketoacidosis, and eventually coma and death. Suffice to say that basal insulin is necessary for survival, and the right amount is critical to controlling blood glucose levels.

Meeting Basal Needs

Basal insulin usually makes up approximately 40-50% of a person's total daily insulin requirement. The remainder consists of rapid-acting insulin that is used to cover meals and snacks. Each person's basal insulin pattern and total need is unique, affected by factors such as body size, activity level, stage of growth, hormone levels, and the amount (if any) of internal insulin production from one's own pancreas.

During a person's growth years (prior to age 21), basal insulin requirements tend to be heightened throughout the night. This is due mainly to the production of large amounts of growth hormone. As mentioned earlier, growth hormone stimulates the pancreas to secrete extra glucose. After the growth years, basal insulin tends to be heightened only during a few hours in the early morning. This is commonly referred to as a "dawn effect."



Determining Basal Doses

It is a good idea to fine-tune your basal insulin before settling on specific bolus doses to use at mealtimes. When high or low blood sugars appear, it is difficult to know what to adjust unless the proper basal insulin levels have already been established.

For those taking basal insulin by injection, the goal is to set a dose that maintains a steady blood sugar level overnight. Ideally, the basal insulin should produce no more than a 30 mg/dl (1.8 mmol) change while sleeping – assuming that no food is eaten and no heavy exercise is performed before going to sleep. A consistent rise or drop of more than 30 mg/dl (1.8 mmol) indicates a need to change the basal insulin dosage.

To determine whether or not your overnight basal insulin dose is set correctly, try the following:

1. Take your usual doses of dinnertime rapid-acting insulin and basal/long-acting insulin.
2. Have a fairly healthy dinner; avoid large amounts of fat. High-fat food will cause a prolonged blood sugar rise and will affect the test results. Do not have any calories after dinner.
3. If you normally exercise in the evening, go ahead and do so, but keep the intensity and duration modest. Very heavy exercise may cause the blood sugar to drop several hours later.
4. At least 4 hours after dinner, perform a bedtime blood sugar check. As long as your blood sugar is above 80 mg/dl (4.4 mmol) and below 250 mg/dl (14 mmol), do not take any food or rapid-acting insulin and proceed with the test. If you are below 80 (4.4), take a snack and try the test another night. If you are above 250 (14), give a correction dose of rapid-acting insulin and try again another night.
5. Check your blood sugar once in the middle of the night and again when you first wake up the next day. The middle-of-the-night reading is needed to rule out a potential "rebound" from low blood sugar.

If your blood sugar remains within 30 mg/dl (1.7 mmol) from bedtime to wake-up, your basal dose is probably OK. If it rises more than 30mg/dl (1.7 mmol), talk to your doctor about increasing your basal insulin dose by 10%, and then repeat the test. If it is dropping by more than 30 mg/dl (1.7 mmol), ask about decreasing your basal insulin by 10%, and repeat the test. Continue adjusting and repeating the test until your blood sugar holds reasonably steady through the night.

For example, if your bedtime reading was 185 (10.3) and your wake-up reading was 122 (6.8), your basal insulin dose is too high since the blood sugar dropped by 63 mg/dl

(3.5 mmol) while you slept. Had your bedtime blood sugar been closer to normal, you would have experienced hypoglycemia during the night. Reduce the basal insulin dose by 10%, and run the test again the following night. Had it risen from 87 (4.9) to 160 (8.9) – a rise of 73 (4.0) – an increase in the basal insulin would be in order. If your bedtime reading was 95 (5.2) and you woke up 107 (6.0) without dropping low in the middle of the night, the basal insulin dose would appear to be set correctly.

Pump therapy is unique because it offers the ability to adjust the rate of basal insulin delivery hourly, if needed, to match the liver's normal 24-hour pattern of glucose secretion.

To test your pump's basal rates, the rules are similar to those for testing injected basal insulin: wait at least 4 hours after your last bolus and meal/snack (to give carbs and boluses time to finish working), and make sure the meal (or snack) eaten before the test is not high in fat. You must stay connected to the pump continuously during the test, and go about your normal daily activities. However, heavy exercise should be avoided during the fasting phase of the test. Testing should not be performed during an illness or onset of menses, following hypoglycemia, or if the blood sugar is greater than 250 (14.0) at the beginning of the test.

To start the test:

- Check your blood sugar about four hours since the last bolus
- If the blood sugar is above 250 (14.0), bolus for the high blood sugar and cancel the test
- If below 80 (4.4), eat to bring your blood sugar up and cancel the test
- If the blood sugar is not too high or too low, proceed with the test
- Check your blood sugar every hour or two until you next usual mealtime

(a complete set of basal testing guidelines can be found at http://www.integrateddiabetes.com/p_basaltest.shtml)

If your blood sugar drops by more than 30 mg/dl (1.7 mmol) during the test period, the basal rate is probably too high. If it rises by more than 30 (1.7), the rate may be too low. The basal rate should be adjusted in increments of .05 to .2 units/hr based on your usual settings and the magnitude of the rise or drop that took place. The next day, re-test to see whether the adjustment produces a steady blood sugar level. Continue to adjust and re-test until steady levels are obtained.

In terms of timing, basal rates are usually changed one or two hours prior to an observed rise or fall in the blood sugar, since the rapid-acting insulin infused by the pump takes about an hour to peak. For example, if your blood sugar rises between 3 am and 7 am, you would increase the basal rate between 2 am and 6 am.

Unlike testing injected basal insulin, pump basal rates should be tested at all phases of the day. Skip breakfast (no calories or boluses until lunchtime) to test the morning basal rates. Skip lunch (eat breakfast, then no boluses or calories until dinnertime) to test the afternoon rates. And delay dinner (eat lunch, then no calories or boluses until near bedtime) to test the evening rates.

Give Basal A Little Respect…

Having the right basal program and setting the right doses is important for anyone who uses insulin. Receiving too much basal insulin, or receiving large amounts at the wrong times, can result in frequent (and perhaps severe) hypoglycemia, not to mention weight gain. Receiving too little basal insulin will cause blood sugars to climb and make it very difficult

to determine the right doses of rapid acting insulin. Although Insulin pumps allow the greatest degree of precision and flexibility in setting basal insulin levels, the benefits are only for those who take the time to test and properly adjust their settings.

Once you have determined your appropriate basal settings, the pattern (when you peak, when you valley) should stay with you for a lifetime. However, the *magnitude* of the settings may change as you grow, age, or gain/lose weight. Repeat testing may be necessary if you undergo significant lifestyle changes, or if you start seeing patterns of consistent high or low blood sugars.

Fine-tuning basal insulin doses can be complex. Don't hesitate to reach out to a member of your health care team who specializes in this sort of thing. Or give me a call… I'd love to help!

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