Insulin Management

To safely use insulin, you not only need to know the proper insulin injection technique, but also you should understand generally how insulin works so you can make at least some basic insulin adjustments and be prepared to deal with possible side effects.

In non-diabetic individuals, an average sized person will produce about 35 units of insulin per day in total. This means that there is a small but continuous supply of insulin secreted by the pancreas 24 hours per day, which turns out to be about ¾ unit of insulin per hour. This totals about 18 units of insulin per day. The other 17 units of insulin are released at mealtimes and with snacks. This would be about 5 units of insulin with each meal and a couple of units of insulin with snacks. The amounts could be larger or smaller based upon meal size.

The whole idea of insulin administration is to try to reproduce the normal function of the pancreas to put enough insulin into the blood stream to keep the blood sugars in a normal range (70-100 mg%) fasting in the morning, and a normal range (80-120 mg%) before meals, and a normal range (120-180 mg%) 1 to 2 hours after meals.

Insulin is a hormone that when injected, begins to start getting absorbed in about 15-20 minutes, achieves its peak level in the bloodstream in about 1 hour and doesn't fully disappear from the bloodstream for approximately 4 to 6 hours. THESE NUMBERS ARE AVERAGES, AND INDIVIDUAL RESULTS CAN VARY SIGNIFICANTLY FROM THIS. The newer, synthetic insulins have quicker onset of action and shorter duration periods. Originally, insulin had to be given to diabetics as 4 or 5 injections around the clock to control blood sugar levels. Obviously, this was very inconvenient and different insulin formulations were developed to slow down the absorption of insulin to make it last longer and reduce the total number of insulin injections that had to be given every 24 hours. This is the reason behind the development of NPH insulin and Lente insulin. These were insulin preparations that had a slower onset of action (1-3 hours), a delayed peak of appearance in the bloodstream (2 to 6 hours) and a longer duration of action (8 to 12 hours). The idea was to take 1 injection of regular insulin mixed with NPH or Lente insulin in the morning at breakfast and a second injection of regular insulin mixed with NPH or Lente insulin in the evening at dinner. This method worked fairly well, but again there is A LOT OF INDIVIDUAL VARIATION in response to these insulin regimens.

In the last 30 years new developments have changed how we use insulin. The insulin pump is a device that you wear on the belt and is attached to a catheter that goes just under your skin on the abdomen. The pump continuously injects a solution of regular insulin into the fat under the skin, and can be programmed to give a bolus of insulin with each meal, much like a normal pancreas. The disadvantages of a pump are that it takes a lot of maintenance, blood sugars typically have to be checked more often, and the insulin is given in the fat under the skin, NOT into the hepatic vein where insulin released from the pancreas first goes. This last point is important because the liver is a primary regulator of blood sugar levels and uses insulin to help it maintain blood sugar levels. When insulin is injected into the fat under the skin, it first goes to the inferior vena cava, then through the heart, then through the lungs, then back to the heart, then to the rest of the body and only a small amount of that then goes to the liver. This

results in sub optimal regulation of blood sugar levels by the liver. Nonetheless, an insulin pump definitely works better than the old formulations of intermediate lasting insulins such as the NPH and Lente insulins.

Newer insulin formulations have become available. The first is an ultra-rapid insulin called Humalog insulin (or Novolog insulin). This insulin is absorbed more rapidly, peaks and dissipates more rapidly than regular insulin. It is somewhat like giving regular insulin directly into a vein. In fact it is MORE like insulin that is released directly into the bloodstream from the normally functioning pancreas than regular insulin would be as it is normally injected. Humalog insulin is given AT mealtime rather than 20-30 minutes before meals like we do with regular insulin. Because it has a shorter duration of action, it appears less likely to cause low blood sugar reactions than does regular insulin. It also appears to have a more predictable time course of action than does regular insulin. For all these reasons, Humalog insulin and the newer ultra-rapid insulin preparations are slowly replacing regular insulin in most diabetic patients.

Another important new formulation of insulin is glargine insulin (or detemir insulin). The first available brand was called Lantus insulin. These insulins are formulated to be long-acting insulins and are “peak-less” insulins. They are meant to be given as an injection once or twice a day and to provide a continuous basal amount of insulin 24 hours a day just like the pancreas supplies in non-diabetic individuals. They work better than the intermediate-acting insulins like NPH and Lente insulins because these intermediate-acting insulins DO have a peak effect in the bloodstream. That is, if you measure insulin levels in people receiving NPH or Lente insulin you will see a gradual rise, a peak, and then a gradual fall in blood insulin levels. This effect tends to make blood sugars go too low during the mid-portion of their duration of action and too high at other times. The newer long-acting insulins really are peak-less when you look at insulin levels after their injection. The insulin gets into the bloodstream within 2-4 hours, has a very steady concentration for 18-24 hours and then gradually falls off. So these newer long-acting insulins do work better for most people compared to what we had before. Again, this means that for most diabetic patients, these insulins are replacing the older NPH and Lente insulins. We see generally better diabetic control and simultaneously fewer hypoglycemic reactions with the newer preparations.

Insulin injection is simple, but good injection techniques lead to fewer problems and more predictable results. The first thing to remember is that when you draw up an injection of insulin into a syringe, you should first inject an amount of air into the insulin vial that is equal to the amount of insulin that you are about to draw out. For instance, if you are going to draw out 8 units of insulin, first you draw up 8 units of air, wipe the top of the insulin vial with an alcohol prep, and then insert the needle and inject the 8 units of air into the insulin vial. Then turn the vial over and withdraw the insulin into the syringe. Make sure you do not get any air bubbles in the insulin syringe. If you do, flick the syringe with your finger to force the bubble to the top of the syringe, squirt it back into the insulin vial, and re-draw out the correct amount of insulin.

The reason you inject the air into the insulin vial first is so that you do not create a

vacuum in the insulin vial. If you just drew out insulin all the time, as the bottle gets closer to empty, a partial vacuum forms in the air space. This will make it harder to draw out the insulin, and insulin can even be sucked back into the insulin vial after its drawn out. Injecting air first eliminates these problems.

Hold the insulin syringe like you would a pencil. Pinch the skin with your other hand. Doing this will bring up the skin and the fat, and push the muscle down. The idea is to inject the insulin into the fat just underneath the skin. When you pinch the skin it is taunt right where you are doing the pinching between your fingers. Injecting right there is going to be more uncomfortable and could cause bleeding. Instead, do the following. Mentally draw a line between your two fingers that are pinching your skin. Now draw a second line that is perpendicular to and bisects the first line. Travel down that perpendicular line about 2-3 inches. THAT is where you are going to inject. That area is lifted off the muscle, it is soft, and the place where you want to inject. Clean that area with a little bit of alcohol from the alcohol prep, let it dry a few seconds, and plunge the insulin needle all the way in to the hub of the needle. Inject the insulin and then pull the syringe and needle straight out. When you do the insulin injection, you want to make sure you are going straight in and straight out with the needle. It should be perpendicular to the plane of the skin. This will minimize any pain with the injection, and will minimize the chance of bleeding at the injection site. Over time you want to rotate where you do your insulin injections. Injecting at the same spot all the time will cause lipohypertrophy (a lump of fat deposit) at the site of injections. It will look like you are growing an extra small breast on your abdomen.

Another option for insulin injections are “insulin pens.” These are pre-filled syringes that have a mechanism on the syringe that allows you to dial a dose of insulin in units and then just do the injection. They are a great convenience item for people who have to carry insulin around with them for mid-day and evening shots. Of course, these pens are significantly more expensive to use than insulin injections with the older vial and insulin syringe method. And the insulin pens don’t allow for mixing insulins if you take more than one type of insulin at a time.

Now that you know how to give yourself an insulin injection, lets talk about sliding scales of insulin and how you adjust insulin. “Sliding scale” is a term that is used to refer to the process of varying your insulin by a pre-set amount depending upon what your blood sugar is at any particular instant. A typical sliding scale might say the following:

For a blood sugar reading of < 50, give 4 units of insulin
For a blood sugar reading of 51 to 110, give 5 units of insulin
For a blood sugar reading of 111 to 150, give 6 units of insulin
For a blood sugar reading of 151 to 200, give 7 units of insulin
For a blood sugar reading of 201 to 300, give 8 units of insulin
For a blood sugar reading of 301 to 400, give 9 units of insulin
For a blood sugar reading of > 400, give 10 units of insulin and call the doctor.

So under this scenario, if you check your blood sugar before lunch and it is 172, you

would use the sliding scale to give yourself 7 units of insulin at lunch. Sliding scales are good to have, because everyone's response to insulin is going to be a little bit different based upon their particular circumstances. Knowing how your body responds to a given dose of insulin is valuable information when your are trying to compensate for a particular blood sugar reading.

However, it is not as easy as it looks. First of all, your blood sugar is going to rise after you eat a meal and start absorbing the carbohydrates consumed with the meal. If you eat more carbohydrates, or carbohydrates that are simple sugars, your blood sugar will tend to go up faster and higher. The blood sugar reading you took before the meal will tell you where you are starting out from, but it does not tell you where you are going to wind up. It turns out that 15 grams of carbohydrate (1 carbohydrate exchange) can raise your blood sugar level as much as 50 to 80 mg%. This means that if your normal blood sugar before lunch is 100 to 115 mg%, and you normally take 4 units of Humalog insulin at lunch, and you normally eat 3 carbohydrate exchanges for lunch, and your normal after lunch blood sugar is 140 mg%, then if your before lunch blood sugar today is 172 mg%, and you eat 3 carbohydrate exchanges for lunch, if you take 5 units of Humalog insulin at lunch, you could expect to see your after lunch blood sugar around 140 mg%.

Many sliding scales of insulin are written (and used) without good knowledge of how an individual responds to carbohydrate exchanges at mealtimes. And we are all slightly different. Furthermore, many sliding scales vary the insulin dose too much, and are constructed with too much gain in the sliding scale (The sliding scale ranges from giving no insulin to giving very large doses of insulin). The fallacy here is that people are trying to treat the blood sugar level that was just tested ***instead of*** giving insulin to control the blood sugar rise that is expected to occur after eating the meal. If on the other hand, through trial and error, you have developed a good knowledge of how your body responds to doses of insulin, this is an invaluable tool to use to help adjust your insulin when the need arises. Careful record keeping and minimizing the variables that can occur before and after mealtimes can make this happen.

What do I mean by "minimizing the variables?" Here are a few of those variables. If you exercise much more vigorously than normal anytime during the prior 24 hours, that exercise you did will have an impact to lower your blood sugar more than you would otherwise expect in response to any action you take. This difference can be profound. If you have been ill, the opposite situation may occur. If you take your insulin shot in your arm, it will act slower than if you take your insulin shot in your leg, and if you take your insulin shot in your leg, it will act slower than if you take your insulin shot in your abdomen. The greater amount of insulin you take in any one shot, the longer it will take to get fully absorbed and the longer it will last. If you eat a bigger meal than usual, the slower it will be in absorbing, and the blood sugar response will be slower and longer. If you eat a normal sized meal, but is has more fat in it than usual, the slower it will be in absorbing, and the blood sugar response will be slower and longer. If you eat just a simple sugar (like table sugar) or a quickly absorbed carbohydrate like pasta on an empty stomach, the quicker it will be absorbed, the higher the blood sugar will go. If you drink a glass of apple juice instead of eating the whole fresh apple (which contains

fiber), the quicker it will be absorbed, the higher the blood sugar will go. Insulin taken in the morning at breakfast will act like it's a little less potent than the insulin you take at night (this is due to what is known as the "dawn phenomenon." In the early hours of the morning the body releases growth hormone and cortisol in larger quantities, which antagonize the effects of insulin. Therefore blood sugars tend to run a little bit higher). One other problem that can occur is the Somoygi effect. Dr. Somoygi in Japan described a phenomenon whereby patients who are overdosed with insulin have their blood sugar drop too low too rapidly. They may or may not feel symptoms of hypoglycemia. Their body in turn overcorrects for this low blood sugar level by releasing adrenalin and other hormones that make the blood sugar level rise again. It rises more than it should and stays high longer than it should. Depending on circumstances, if the individual is not checking their blood sugars frequently enough, all they see is that their blood sugar is running higher than what is normal. They mistakenly think they need MORE insulin, when in fact just the opposite is true. Unless recognized and treated by lowering the dose of insulin, the diabetic control invariable gets worse. All of these issues are just ***some*** of the variables that insulin-requiring diabetics have to cope with on a daily basis.

The biggest problem that I see with people using sliding scales, particularly those people who use insulin pumps and do carbohydrate counting, is that it gives people a false sense of security. They think that their sliding scale can handle all the possible situations and all the variables simultaneously! So I see these people who will skip meals, skip snacks, and then eat a whole pizza followed by ice cream, or some other ridiculous combination of fat and carbohydrate. Their response is, "Well, I count carbohydrates. And I know I'm eating more carbohydrates with this meal. My sliding scale tells me that I just need to increase my insulin bolus by X amount and that will take care of the extra carbohydrate and calories. Right?" Who do they think they are fooling? Only themselves. Time and again I see people with diabetes in moderate control who are put on an insulin pump. It's considered "superior medicine" and "better management." Only it turns out that the patient's expectation changes to, "Now that I'm on an insulin pump, I can do what I want, and the pump will take care of me. I can skip a meal. I can eat a double, or triple serving of mashed potatoes. I just need to adjust the mealtime bolus and everything will be fine." The end result is that when the patient comes in to see me, I see wider blood sugar fluctuations than ever, and the glycosylated hemoglobulin level doesn't go down, it actually rises. The patient has been changed to an insulin pump and now they are on a much more expensive regimen, its much more time-consuming, their diabetes control has deteriorated, and they are worse off! Unfortunately, this occurs much more commonly than people like to admit.

The PROPER way to use this technology is to use it to help MINIMIZE all the variables and vagaries of taking multiple insulin shots throughout the day to control the diabetes. You minimize the variables by doing the SAME amount of exercise EVERY day. You eat the same number of carbohydrate exchanges for breakfast one day to the next. You eat the same number of carbohydrate exchanges for lunch one day to the next. You eat the same number of carbohydrate exchanges for dinner one day to the next. You ALWAYS have a bedtime snack. You try to keep your insulin doses constant from one breakfast to

the next to the next. The same is true for lunch and dinner. You have tried to minimize as many variables that affect your blood sugar levels throughout the day as possible. Then, and only then, based upon your review of repeated blood sugar patterns that you see, you adjust your insulin to try to lower your blood sugar readings that tend to run too high, and/or you lower your insulin to try to raise your blood sugar readings that tend to run too low. You don't make insulin changes more frequently than once every 3-4 days, so that your body can acclimate to a given new dose of insulin, and you again start to run blood sugar patterns that you can use to make further insulin adjustments. When people with diabetes follow this method, I often see ***significant*** improvements in diabetic control over time.

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