

CHAPTER 10:

PREVENTING HYPOGLYCEMIA

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The two emergencies that are common to people with diabetes are low blood sugar (“hypoglycemia” or an “insulin reaction”) and ketoacidosis (see Chapter 11). This chapter focuses on hypoglycemia related to insulin pump use. Table 1 reviews the treatment of mild, moderate and severe hypoglycemia. It is assumed that all people/families received education about hypoglycemia at the time of diagnosis.

FREQUENCY

The good news is that almost every study, including one from our Center (5), has reported fewer severe hypoglycemia episodes with pump use compared to injection therapy. In many ways, use of an insulin pump allows the closest replication of non-diabetic basal-bolus insulin secretion. Only one insulin is used in the pump (rapid-acting insulin). Therefore, there is no worry about peaks in activity from various insulins. There is also no worry about inconsistency in peak activity (as occurs with NPH insulin).

DEFINING HYPOGLYCEMIA

The DirecNet Study Group (13) evaluated blood sugar levels in non-diabetic youth, and although several youth had values between 60-70 mg/dl (3.3-3.9 mmol/L), none had values < 60 mg/dl (< 3.2 mmol/L). We thus define **True Hypoglycemia** as a blood sugar < 60 mg/dl (< 3.2 mmol/L). Others have defined **Hypoglycemia** as a blood sugar level < 70 mg/dl (< 3.9 mmol/L). Fortunately, at a level of approximately 70 mg/dl (3.9 mmol/L), the body typically secretes hormones to prevent a further decline in blood sugar. This built-in protection is

sometimes lost in people with diabetes who have too many lows (Hypoglycemia Unawareness).

CAUSES

Although the causes of hypoglycemia are similar to those in people using injection therapy, a few causes seem to be more frequent with insulin pump use:

1. The most frequent cause is **incorrect basal or bolus insulin dosages**. Doing basal checks for different periods of the day (see Chapter 5) helps prevent this error. Checking the accuracy of insulin to carbohydrate (I/C) ratios and the insulin correction factor for high blood sugars is another protective measure (see Chapter 6).
2. A second cause of hypoglycemia is **excessive insulin administration and overlapping of bolus doses**. It is very easy to reach down to the pump and key in another bolus of insulin (in contrast to drawing up and giving a shot). People/families may want to correct a high blood sugar very quickly and they forget that rapid-acting insulin does not peak until after 100 minutes. It is not unusual to download pump data and see that four or five boluses were given in a short period of time prior to a hypoglycemia event. We generally recommend a two hour wait between correction boluses.
3. A third cause is **not accurately estimating the amount of carbs** to be eaten. This is especially true now that we know that a food bolus is best given 15-30 minutes prior to eating. To help prevent an under- or over-estimation of insulin, give only part of the

bolus early (e.g., insulin for high blood sugar correction and for the food that will definitely be eaten). A later bolus can then be given to cover additional food that is eaten. This is an advantage for pumpers over people using shots, as most people are reluctant to take more than one shot with a meal. Waiting to give the entire bolus (or shot) just before or even after a meal results in the insulin peaking after 100 minutes. Blood sugars peak approximately 60 minutes after a meal.

4. A fourth cause of low blood sugar levels relates to having the **wrong pump settings**. The **target blood sugar** may be set too low (e.g., 100 mg/dl [5.5 mmol/L]). It may be that 120 mg/dl (6.7 mmol/L) would be a better target level. The **insulin action curve** may also be set too short. For example, if it is set at two hours, the pump allows a complete second bolus after two hours without subtracting for any insulin on board. Changing the insulin action curve to three hours would then subtract a part of the insulin from the previous bolus.
5. Another cause that pump users/families sometimes worry about is a **pump malfunction** in which the pump gives too much insulin. This rarely happens. The pumps have maximum dosage settings for both basal and bolus doses. These are set by the pump trainer at the Pump Start Visit. Unfortunately, human error is still possible. One girl accidentally put a blood sugar level of 300 mg/dl (16.7 mmol/L) into her carbohydrate screen and then took the insulin dose recommended by the pump for 300 grams of carbs. If the bolus maximum is set correctly the amount of insulin to be given cannot exceed that number, often preventing situations like this. Obviously two heads are better than one, and especially for young children, extra help is always a benefit.
6. A cause that is probably no greater than with injection therapy, but which must be

remembered, relates to the more rapid absorption of the rapid-acting insulins as a result of a **bath, shower or hot tub**. Warm water expands the blood vessels, including those where the insulin is being infused, causing a more rapid uptake of the insulin. A blood sugar check should always be done before exposure to warm water, and a bolus of insulin should not be given prior to a bath, shower, or hot tub. It is important to remember that the hot water in hot tubs will destroy insulin in the pump tubing and infusion cannula.

7. Alcohol-related hypoglycemia is also no greater with pump users than with injection therapy. However, it must be remembered that alcohol may block the release of sugar from the liver for up to 12 hours. Low blood sugars may be the result. Food intake and blood sugar checking are essential when consuming alcohol. A temporary basal rate (decreased insulin dose) can be life saving for a pump user who drinks alcohol.

PREVENTION OF HYPOGYCEMIA

Pump-related factors will be addressed in this chapter. As noted earlier, severe hypoglycemia is less frequent for pump users, probably because of several pump features:

- **Variable basal rates**
The accuracy of the basal insulin dose can be finely tuned with an insulin pump. When a daily injection of basal insulin (e.g., Lantus, Levemir) is given, the dosage is the same all day. Pump users can vary the basal rate as often as every 30 minutes. Many diabetes physicians recommend 8 to 12 different basal rates for a person beginning pump therapy, and then make further adjustments as indicated.
- **Blood sugar checking and continuous glucose monitoring (CGM)**
Most diabetes centers require a minimum of four blood sugar checks per day to approve use of insulin pump therapy. With CGMs

becoming more readily available, pump users have the opportunity to see glucose values continuously, as opposed to four snapshots each day. People who are willing to wear a pump are often more willing to wear a CGM. The CGM gives glucose readings every one to five minutes (see Chapters 15-17). The CGM can alarm/vibrate with low glucose levels (and for some monitors, with “pending” low glucose values). It is likely that CGMs will completely eliminate severe hypoglycemia for many people. The use of a CGM could also help in making more accurate adjustments to the variable basal rates.

- **Temporary basal rates**

Basal rates can be decreased for a variable period of time with the “push of a button.” Some people use temporary basal rates to prevent hypoglycemia on a daily basis (see Chapter 5). This is particularly helpful with low blood sugar levels, a sudden decision to exercise or with alcohol intake. In contrast, there is no way to decrease the amount of basal insulin when insulin is taken by injection.

- **Maximum bolus/basal settings and insulin on board**

Pump bolus settings can be set so that a person cannot give an excessive dose of insulin in one bolus. Similarly, a “maximum units per hour” can be set for basal rates (e.g., this would prevent someone from accidentally keying in 3.0 units/hour rather than 0.3 units/hour if the maximum is set for 1.0 units/hour). Also, the “insulin on board” feature calculates and subtracts insulin that is still working from a previous bolus. These safety features are not available for people using injection therapy.

- **Low dose glucagon**

If a person is having difficulty getting the blood sugar levels up with oral carbs (e.g., vomiting with low blood sugar level), a low dose of glucagon can be used. The dose is one unit per year of age up to 15 years. Older people can just use 15 units. The dose can be

repeated every 20 minutes as needed. Also remember that the dosage of glucagon is different for people of different ages when treating severe hypoglycemia (Table 1). All people/families using insulin pump therapy must have glucagon in their home and with them on trips.

TREATMENT OF HYPOGLYCEMIA

The treatment of hypoglycemia is the same for pump users as for people using injection therapy, with one exception. The exception is that the pump can be turned off (preferably with a temporary basal rate of “0” for a set time) or the basal rate decreased for a set time (e.g., for one to two hours). Decreasing or stopping the pump basal rate is very helpful when treating severe or prolonged lows. The basal rate can be restarted at any time if the blood sugars become too high. Using the temporary basal feature prevents high blood sugar levels and ketones as a result of forgetting to turn the pump back on. It is important to remember that the last drop of insulin given will still peak in 100 minutes. The ability to discontinue or decrease insulin with the pump is an obvious advantage over insulin injection therapy.

AVOID OVER-TREATING LOWS

The DCCT found that many people consumed too much sugar/food when feeling low, resulting in high blood sugars. The body gives the message to “eat, eat, eat” and it is hard to resist. The “rule of 15” suggests treatment with 15 grams of carbs, waiting 15 minutes and then repeating the blood sugar check to make sure it has gone up. If not, another 15 grams of carbs can be consumed. If the basal rate was reduced or discontinued, it can be resumed (possibly at 10% to 20% reduction for one or two hours if a prolonged low is expected).

HYPOGLYCEMIA UNAWARENESS

As mentioned above, some people (usually those having frequent low blood sugars) lose the ability to recognize the common symptoms

associated with hypoglycemia. For someone who has hypoglycemia unawareness, the protective hormones (epinephrine [adrenaline], glucagon and others) become depleted after repeated low blood sugars. These hormones cause the usual early warning symptoms of hypoglycemia. The treatment in the past has been to back off on maintaining tight (good) glycemic control. Now that CGM is a reality, all people with hypoglycemia unawareness should use a CGM. The CGM alarms for low glucose and pending low glucose can be extremely helpful in preventing repeated low blood sugar episodes and therefore in regaining the symptoms associated.

SPECIAL CIRCUMSTANCES

Insulin pumps also have advantages over injection therapy in preventing lows in several special circumstances. These include exercise, surgery, travel and special meals.

Exercise: During exercise, insulin needs are decreased and this can be closely matched with insulin pumps to prevent hypoglycemia. The same is generally not true for injection therapy (particularly with sporadic exercise, see Chapter 9).

Surgery: The basal rate or a temporary basal rate is usually all that is needed to cover insulin needs during surgery. With no peak insulin activity and no food intake, the chance for lows is greatly reduced.

Travel: There is often much jostling of injected insulin doses with time changes, which can result in lows. However, with the pump, when crossing time zones, only the time needs to be changed on the pump as the new destination is reached.

Special meals: With special meals (e.g., high fat) the insulin pump allows special insulin bolus combinations. This may help to reduce lows immediately or several hours after meals.

SUMMARY

Severe hypoglycemia occurs less frequently in insulin pump users than in people using insulin injection therapy. There are many potential advantages of pumps which help prevent hypoglycemia. Each person/family must learn all they can and do the extra work and thinking ahead in order to use all the advantages of the insulin pump.

DEFINITIONS

Hypoglycemia unawareness: A condition in which a blood sugar level is found to be < 70 mg/dl (< 3.9 mmol/L) but the person has not had symptoms of hypoglycemia.

Low dose glucagon: Using a low dose of the usual glucagon to treat a prolonged low blood sugar not responding to oral carbs. The usual dose is 1 unit per year of age up to 15 units, which is the adult dose.

REFERENCES

13. DirecNet Study Group, *J Pediatr* 144; 770, 2004.

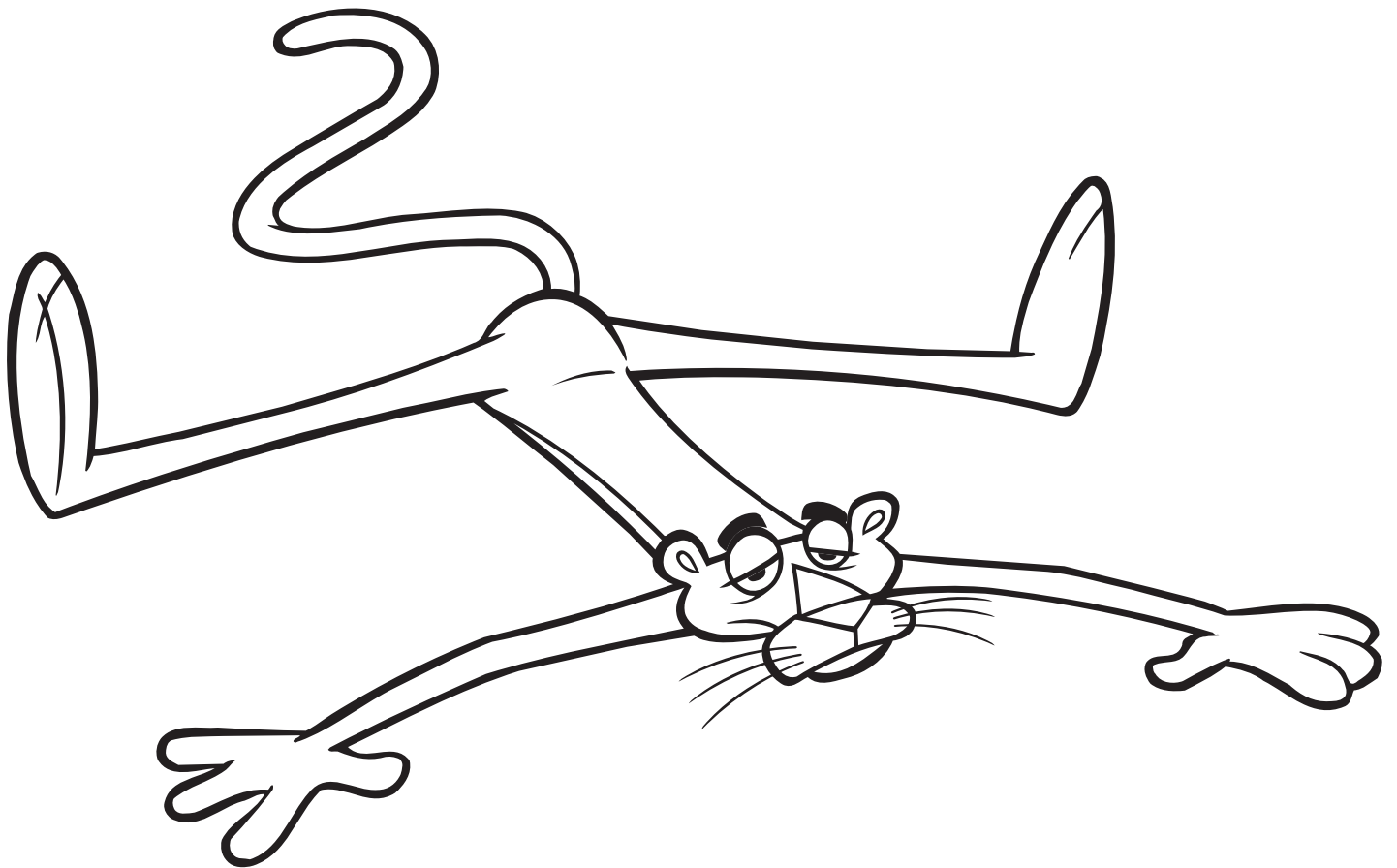


TABLE 1:

HYPOGLYCEMIA: TREATMENT OF LOW BLOOD SUGAR (BS)

Always check blood sugar level!

SEVERITY:	MILD	MODERATE	SEVERE
ALERTNESS:	<ul style="list-style-type: none"> Alert 	<ul style="list-style-type: none"> Not alert Unable to drink safely (choking risk) Needs help from another person 	<ul style="list-style-type: none"> Unresponsive Loss of consciousness Seizure Needs constant adult help (move to position of safety) Give nothing by mouth (extreme choking risk)
SYMPTOMS:	<ul style="list-style-type: none"> Mood changes Shaky Hungry Fatigue, weak Pale Sweaty 	<ul style="list-style-type: none"> Lack of focus Headache Confused Disoriented 'Out of Control' (biting, kicking) Can't self-treat 	<ul style="list-style-type: none"> Loss of consciousness Seizure
ACTIONS TO TAKE:	<ul style="list-style-type: none"> Check BS Give 2-8 oz sugary fluid (amount age dependent) Recheck BS in 10-15 minutes <ul style="list-style-type: none"> BS < 70 mg/dl (< 3.9 mmol/L) repeat sugary fluid and recheck in 10-20 minutes BS > 70 mg/dl (> 3.9 mmol/L) give a solid snack 	<ul style="list-style-type: none"> Place in position of safety Check BS If on insulin pump, may disconnect or suspend until fully recovered from low blood sugar (awake and alert) Give Insta-Glucose or cake decorating gel – put between gums and cheek and rub in Look for person to wake up' Recheck BS in 10-20 minutes Once alert: follow actions in 'Mild' column (Can use low dose glucagon, [1 unit per year of age], if very disoriented or out of control) 	<ul style="list-style-type: none"> Place in position of safety Check BS If on insulin pump, disconnect or suspend until fully recovered from low blood sugar (awake and alert) Glucagon (can be given with an insulin syringe): <ul style="list-style-type: none"> Below 5 years: 30 units (0.3cc) 5-16 years: 50 units (0.5cc) Over 16 years: 100 units (1.0cc) (all of dose) If giving 50 or 100 unit doses may use syringe in box and inject through clothing. Check BS every 10-15 min. until >70 mg/dl (> 3.9 mmol/L) If no response, call 911 Check BS every hour for four to five hours High risk for more lows over the next 24 hours (need to increase food intake and decrease insulin doses)
RECOVERY TIME:	10-20 minutes	20-45 minutes	Effects can last 2-12 hours Call RN / MD



**IF YOU ARE NOT FEELING WELL,
CHECK YOUR KETONES.**