CGM Guide

Continuous Glucose Monitoring

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This educational tool is the result of a joint effort among Taking Control of Your Diabetes (501c3), Steven V. Edelman, M.D., and Timothy S. Bailey, M.D. An unrestricted educational grant was provided by DexCom, Inc. to facilitate the production of this guide.

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Dr. Bailey received his medical degree from the Mount Sinai Medical School. He is a fellow of the American Association of Clinical Endocrinologists and the American College of Physicians. He is also a clinical Assistant Professor at the University of California, San Diego School of Medicine and is active in the education of patients and physicians.

Dr. Bailey has specialized in treating people with diabetes, osteoporosis, thyroid diseases, and lipid and other metabolic disorders with North County Endocrine Medical Group since 1990. He is board-certified in endocrinology, metabolism, and diabetes. He is also a certified physician investigator active in conducting phase II to IV clinical trials. He actively consults for firms that are working to bring the latest technology into patient care.

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CGM Guide

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Table of Contents

Introduction

The purpose of this guide is to help you and other people living with diabetes to use continuous glucose monitoring (CGM) to take control of your diabetes. This important and first-of-its-kind educational initiative is a joint effort of Taking Control of Your Diabetes (501c3), Steven V. Edelman, M.D., and Timothy S. Bailey, M.D. An unrestricted educational grant was provided by DexCom, Inc. to facilitate the production of this guide.

This guide is meant to help you **understand the information provided by your CGM system**—what it means, how to interpret it, and how you can respond to this important information to improve your diabetes control. The guide assumes you are familiar with the system and have started using the system. However, fundamental principles of CGM will be reviewed and highlighted to help you best use the information made available through CGM.

WHAT IS A CONTINUOUS GLUCOSE MONITOR?

A continuous glucose monitoring system is a device that measures glucose levels throughout the day and night. These devices provide measurements every few minutes. The device works by inserting a sensor under the skin (which you can do at home). The sensor takes glucose measurements at frequent intervals. It then transmits these values wirelessly to a handheld, cell phone-sized device that enables you to see glucose values and trends.

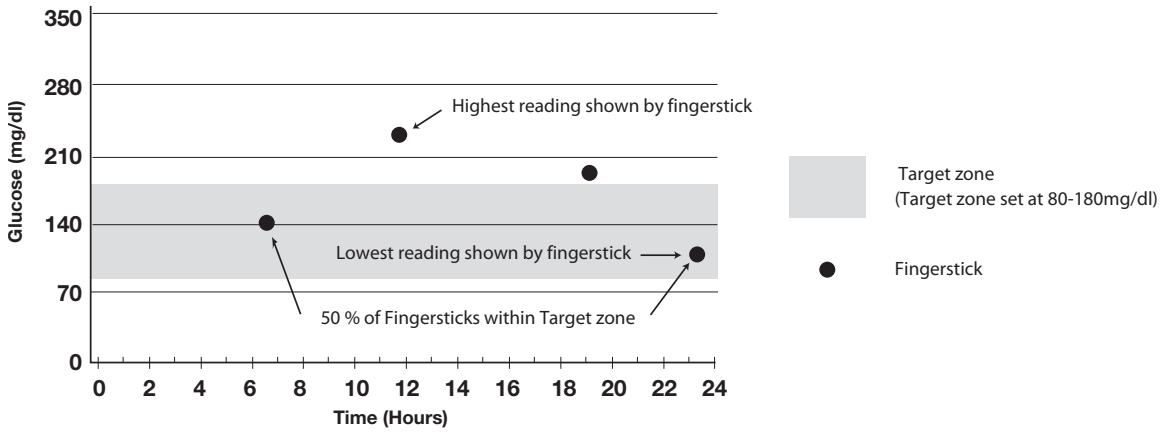
Continuous glucose monitors are not meant to replace traditional blood glucose meters— they work together with fingerstick readings to give you a more complete understanding of what is happening to your glucose levels. You should always confirm your continuous glucose reading with a fingerstick before you take any action (such as taking food or insulin, or waiting to take action). Continuous glucose monitors have been approved for use by the U.S. Food and Drug Administration and are now commercially available.

BENEFITS OF CONTINUOUS GLUCOSE MONITORING (CGM)

The continuous readings that are provided every few minutes create a trend line, which you can use to help understand how insulin, food, exercise, and other variables affect your glucose values. Traditional fingersticks provide a point-in-time glucose value, but do not tell you whether your glucose levels are rising or falling, or how fast these changes are happening.

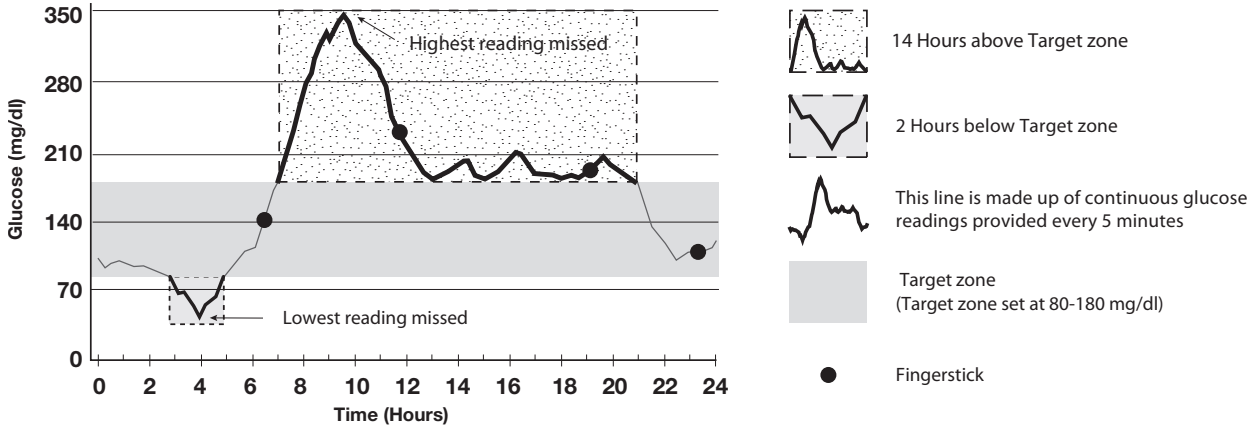
Continuous monitoring allows you to see these trends in glucose, and after confirming with a fingerstick, to make adjustments to your insulin or take other appropriate action. Alert levels can be individually set for both high and low glucose levels, helping you better detect and manage hyper- and hypoglycemia. CGM can help you respond more quickly to changing glucose levels.

Example of Four Fingersticks Taken During 24 Hours



In this graph, 4 fingersticks were taken during a 24-hour period. These point-in-time readings show that half of the readings throughout the day were in the target zone (80-180 mg/dl shaded area in this example) and half were outside the target zone. None of the 4 readings falls below the target zone (potentially dangerous glucose levels). The highest reading shown through fingersticks is 230 mg/dl.

Example of CGM Values Taken During 24 Hours



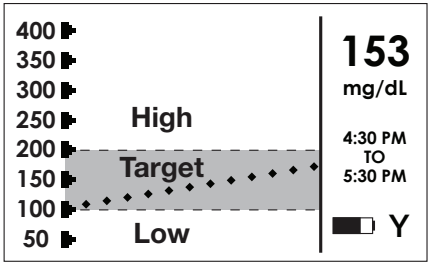
In this graph, continuous monitoring shows substantially more information. Continuous glucose monitoring reveals higher glucose readings (over 330 mg/dl) on this same day as well as lower glucose readings (under 60 mg/dl), compared to the 4 fingersticks. About 16 hours were spent outside of the target zone. A portion of this time outside the target zone was unknown to the person, because fingerstick readings did not show glucose values or trends between these points.

USING AND INTERPRETING CONTINUOUS GLUCOSE MONITORS

Clinical research shows that using continuous glucose monitors can help you spend less time hypoglycemic, less time hyperglycemic, and more time in your target zone. * The following general guidelines can help you to keep your glucose levels in the target range that is appropriate for your diabetes.

Stay in Target – Avoid Highs and Lows

Continuous glucose monitors allow you to set a range of target control, including the high and low levels that are recommended by your caregiver or diabetes care team. You can customize these levels at your doctor's office or at home. Continuous monitoring uses 3 zones: target, high, and low.

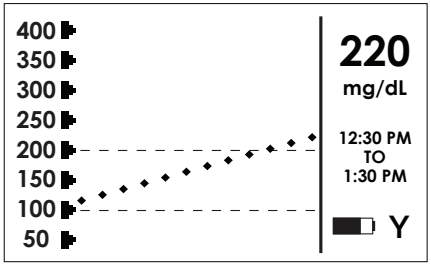


The dashed lines in this graph show a sample target glucose zone of 100 mg/dl (low) to 200 mg/dl (high). When glucose goes above the high target level or below the low target level, the continuous glucose monitor will alert you to let you know you are outside of your target zone. Once you are alerted you have the option to take action early to avoid wide swings in glucose values.

Always Use Your Trend Information with Your Glucose Value

Glucose trends show your glucose levels over a period of time. Both your glucose value and direction that your glucose level is headed are important. From the glucose trend graphs below, you can see that the same glucose value of 220 mg/dl can mean different things, depending on the trend:

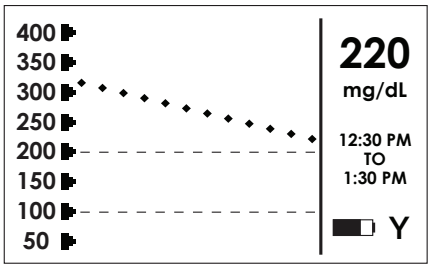
Rising trend



In this graph, the glucose value is above the target zone and is continuing to rise. After confirming the reading of 220 mg/dl with a fingerstick, a rising trend such as this one may prompt you to take additional insulin or begin exercising.

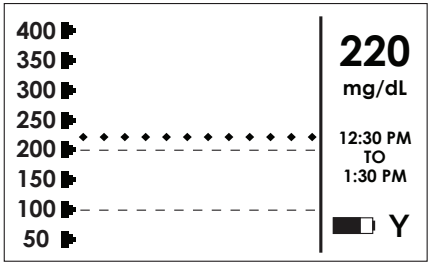
*Source: Garg et al. Improvement in Glycemic Excursions With a Transcutaneous, Real-Time Continuous Glucose Sensor. *Diabetes Care* January 2006.

Falling trend



In this graph, the glucose value falling, and is headed back into the target zone. After confirming the reading of 220 mg/dl with a fingerstick, a falling trend such as this one may prompt you to "watch and wait." If the trend continues to fall rapidly, even if the glucose reading is still within the target zone, it may prompt you to eat some carbohydrates.

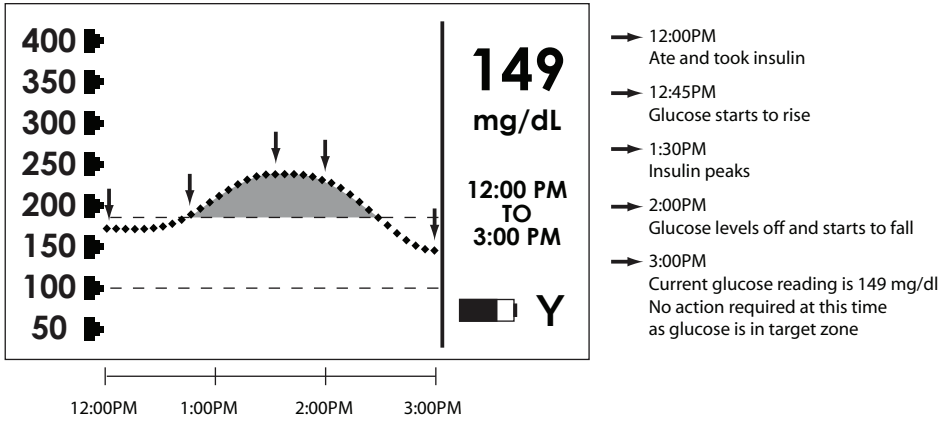
Constant trend



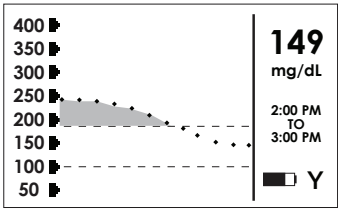
In this graph, the glucose value is above the target zone and is constant. After confirming the reading of 220 mg/dl with a fingerstick, a constant trend such as this one may prompt you to take additional insulin or begin exercising.

Don't Overreact – Understand "Turnaround Time"

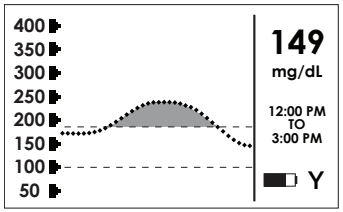
Turnaround time is the time it takes to reverse a trend. There is a delay in the time it takes for insulin even fast-acting insulin to take effect once it is administered. When your glucose trend is going up, if you take insulin, it may still go up for a while before it comes down. When your glucose trend is going down, if you take glucose or other carbohydrates, you may still go down for a while before it comes up. In some cases, it is best to watch and wait before you react to a slowly rising or slowly falling glucose level.



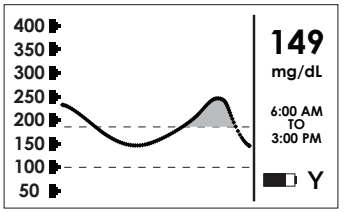
3 Views of the same trend at 3p.m.



1-Hour



3-Hour



9-Hour

These charts are the same trend line shown over different periods of time: 1-hour, 3-hour, and 9-hour. This person ate a meal and took insulin at noon, and soon after you can see their glucose trend starting to rise. Although the trend initially was going up, it began to level off and then went back into the target range (as insulin began acting and bringing the glucose level back down). This turnaround time needed to reverse the trend is shown in the shaded area of the graphs. The 1-hour and 3-hour glucose trend graphs are the best graphs to show that the rise in glucose is leveling off, indicating that a "watch and wait" approach may be appropriate. The 3-hour and 9-hour glucose trend graphs show that the total turnaround time in this example was about 2 hours. The issue of turnaround time is addressed in further detail in the case scenarios in this Guide.

CGM CONSIDERATIONS

When evaluating CGM devices, it's important to recognize that CGM is a relatively new technology that may not work consistently all the time.

SENSOR IRREGULARITY. There may be occasions when the CGM device does not provide glucose data, alerts or trend information. Most often this is because the sensor is experiencing an irregularity in its signal and the receiver has determined that it cannot display an accurate reading.

START-UP PERIOD. When the sensor is first inserted beneath the skin, it requires a start-up period (2-10 hours), plus calibration (entering blood glucose values obtained from your blood glucose meter into the CGM system) before it can begin providing you with continuous glucose information.

CALIBRATION REQUIRED. Most CGM devices require 2-4 fingersticks in addition to the software processing (performed by the receiver) in order to calibrate the system each day.

SUPPLEMENT TO FINGERSTICKS. CGM devices are FDA-approved for "adjunctive" use and are intended to complement, not replace, the glucose values you receive from your blood meter. Diabetes management decisions should not be based solely on CGM readings.

MARGIN OF DIFFERENCE. Even with calibration, the CGM device will generally not provide the exact same glucose value as your blood glucose meter.

REIMBURSEMENT. Health insurance companies may not currently reimburse CGM. At this time, insurance plans may or may not be paying for the device on an individual basis.

How to Get the Most Out of This Guide

This Guide will cover situations that you may encounter while using a continuous glucose monitor. Each example will start off with a real-life situation and the corresponding 1-hour glucose trend graph and, in many cases, the 3-hour glucose trend graph as well. In cases that involve overnight glucose control problems, the 9-hour glucose trend graph will also be shown. After you read the case history, you will be asked a question or series of questions. You should try to answer each question as best you can and then read the explanation of the answer that will follow each question. If you select an incorrect answer, please read the explanation very carefully before you go on to the next question. You will remember and learn more effectively if you approach each case this way.

This guide is meant to simulate and illustrate for you how to interpret the information provided by your CGM device. Our hope is that by the time you finish going through the various case scenarios, you will be able to make more effective and safe decisions regarding your diabetes care.

SECTION I

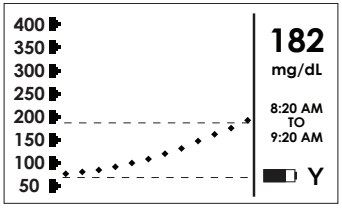
BLOOD GLUCOSE LEVELS ON THE RISE

SCENARIO 1

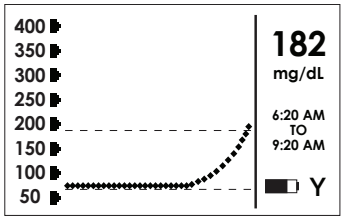
John is a 32-year-old male who has had type 1 diabetes for 20 years. He is currently on 25 units of Lantus at bedtime as his basal insulin and a fast-acting insulin (Apidra), which he takes before meals and for correction boluses. His correction factor is 1:50, which means that one unit of a fast acting insulin like Apidra, Novolog, or Humalog will lower his glucose level about 50 mg/dl. His carbohydrate-to-insulin ratio is 15 to 1, which means that for every 15 grams of carbohydrates consumed he will take one unit of Apidra. John's blood glucose upon awaking was 72 mg/dl, and he ate breakfast at 8a.m. (60 grams of carbohydrates). He took 4 units of Apidra, calculated this way:

60 grams	*Carbohydrates in meal*
÷ 15 grams/unit	*(Carbohydrate-to-insulin ratio)*
= 4 units	***Meal dosage***

At 9:20a.m. the high alert (set at 180 mg/dl and shown by the upper dashed lines in the graphs below) went off. John then did a fingerstick to confirm his glucose level. He then reviewed the 1-hour (figure a) and 3-hour (figure b) glucose trend graphs. Please review the graphs and then answer the following question.



1-Hour *(figure a)*



3-Hour *(figure b)*

QUESTION 1a Options for Treating High Glucose Levels

- ***Which of the option(s) below is the best suggestion for John to follow at 9:20a.m. when his high alert went off? (There may be more than one correct answer)***

  a. Watch and wait (give no additional insulin)
  b. Walk for an hour at a brisk pace
  c. Give a correction dose of 2 to 3 units
  d. Adjust the carbohydrate-to-insulin ratio to 12:1 at breakfast if this scenario repeats itself every morning

EXPLANATION

The correct answers are ***b***, ***c***, and ***d***, depending on the situation. Watching and waiting when the glucose level is rising fairly steeply after a meal usually means that not enough fast-acting insulin was given with that meal. We all know that blood glucose levels are not always the same after meals that we have eaten, even if we have had that same meal numerous times before. There are so many other variables that affect the glucose readings, including stress, exercise, medications, etc. This is why it is important to be able to use a correction dose to account for unexpected elevations in your glucose values. Normally, if you just tested your blood glucose with your blood glucose meter 2 hours after a meal and got a 182 mg/dl reading, you might have been perfectly satisfied. However, the CGM data clearly shows that if nothing is done, the blood glucose levels may continue to rise and stay elevated for hours. One question you might ask is, given that the correction factor is 1:50 and that 2 to 3 units of Apidra (answer ***c***) would drop the blood glucose level 100 to 150 points, if John is only at 182 mg/dl, shouldn't this amount of insulin cause hypoglycemia? The big difference in this situation is that you have the very important trend information that tells you not only that the blood glucose level is 182 mg/dl, but also that it is rising steeply. This really helps you give a more appropriate correction dose and limit the amount of time spent in the hyperglycemic range.

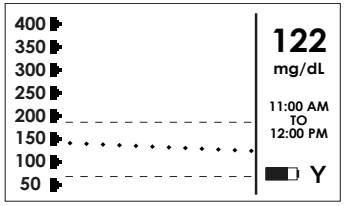
Aerobic exercise for an hour (answer ***b***), especially within 1 to 2 hours from your last injection of a fast-acting insulin such as Apidra, will help to lower your glucose levels. If you have an opportunity to exercise, you would not give any insulin, and would watch to see what happens to your numbers while you exercise. If they do not come down, you can give a correction dose later (with an amount determined by your blood glucose level and trend over time as well).

Answer ***d*** is also correct because if you find that your blood glucose level gets above 180 mg/dl morning after morning, you need to make the long-term adjustment by changing your breakfast carbohydrate-to-insulin ratio. Normally, it is recommended to make small changes slowly and wait several days to see how your adjustment affectes your glucose levels.

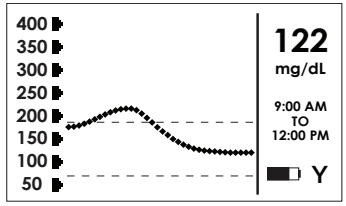
QUESTION 1b Avoiding Post-meal Highs

- ***John gave himself a correction dose of 3 units of Apidra at 9:20a.m. Over the next 90 minutes, his glucose level peaked at 232 mg/dl, but started to trend downward. By noon, it was 122 mg/dl with a flat or level trend. (See 1-hour and 3-hour glucose trend graphs in figures c and d)***

  What could John do differently in the future in order to avoid the same situation of high post-meal glucose values in scenario 1? (More than one answer may be correct)



1-Hour *(figure c)*



3-Hour *(figure d)*

a. Take 2 to 3 extra units on top of his usual 4 units when he eats the same type of breakfast that he ate that day (e.g., only when he eats 60 grams of carbohydrates such as Cheerios with milk)
b. Change the carbohydrate-to-insulin ratio from 15:1 to 12:1 for the breakfast meal
c. Eat only two-thirds of his normal breakfast
d. Change the composition of the breakfast to include fewer refined carbohydrates and more protein and fat

EXPLANATION

Answers ***a***, ***b***, ***c***, and ***d*** could all be correct, depending on the situation. Taking 2 to 3 extra units of a fast- acting insulin (answer ***a***) is a viable option. The correction dose of 2 to 3 units that John gave himself at 9:20a.m. worked well. Thus, the same correction dose could be given at the beginning of the meal, in addition to his calculated initial dose, in order to avoid the high post-breakfast blood glucose level in the first place. If this scenario happens most of the time, answer ***b*** would be appropriate. Changing the carbohydrate-to-insulin ratio is an excellent option if John is going to eat the same type of breakfast on most days. This would work since his post-meal values are typically high when he uses the 15 grams of carbohydrates to 1 unit of fast-acting insulin ratio. Reducing the carbohydrate-to-insulin ratio allows for a higher dose of fast-acting insulin per serving and in this scenario would indicate that John should take 5 units for breakfast instead of 4 units:

60 grams	*Carbohydrates in meal*
÷ 12 grams/unit	*(Insulin ratio)*
= 5 units	***Meal dosage***

If this change does not fix the problem, he could try a 10:1 ratio for breakfast. It is important to look for trends and patterns and not make long-term changes based on one blood glucose result. Lastly, John's carbohydrate-to-insulin ratio of 15:1 may be perfectly adequate at lunch and dinner.

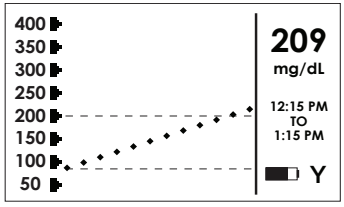
Eating two-thirds of his normal breakfast (answer ***c***) would help his post-meal glucose values. However, if that leaves John hungry after breakfast and leads to snacking and overeating at lunch this would not be the best option. This option would improve or fix the problem, but John would have to make that decision himself. All changes really are up to the individual living with diabetes and his or her diabetes care team.

Changing the composition of the breakfast from a refined carbohydrate meal, such as cold cereal and milk, to one that has more fat and protein (answer ***d***) would reduce post-meal glucose values. One must be aware of his or her limitations for fat if high cholesterol is a problem, or of limitations for protein if kidney problems are present. Normally, a balanced breakfast of carbohydrate, fat, and protein is the best choice; however, personal preferences, living situation, budget, etc., may limit the ideal choices.

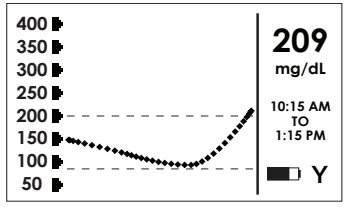
SCENARIO 2

Mary is an 18-year-old college student who has had type 1 diabetes for 3 years. Mary does not do carbohydrate counting, but takes an educated guess on how much fast-acting insulin she needs with meals. Her insulin requirements are usually between 5 and 10 units of Humalog before meals, depending on what and how much she is eating. She uses a correction factor of 1:40 (1 unit of Humalog will normally lower her glucose level 40 mg/dl). She also takes 23 units of Lantus every night before bed.

Mary had a large bowl of tomato soup with a small bag of oyster soup crackers that she bought at a local sandwich shop, and she took 5 units of Humalog with her disposable pen. Before eating at noon, her glucose value was 89 mg/dl. At 1:15p.m. her high alert, which was set at 200 mg/dl, went off. Her sensor reading showed 209 mg/dl (her glucose value went up 120 mg/dl in 65 minutes), which was confirmed with her blood glucose meter. Mary gave herself a correction bolus of 3 units at 1:15p.m. (approximately 75 minutes after her pre-lunch dosage). The 1-hour and 3-hour glucose trend graphs in figures e and f are shown below.

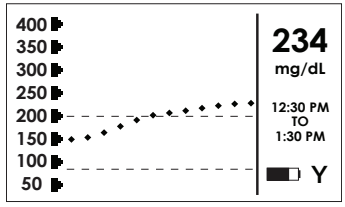


1-Hour ***(figure e)***



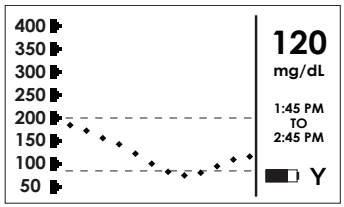
3-Hour ***(figure f)***

At 1:30p.m. Mary looked at her monitor and was frustrated to see that her blood glucose rose to 234 mg/dl. She did a fingerstick to confirm the reading and decided to give herself another correction bolus of 3 more units (see 1-hour display in figure g).

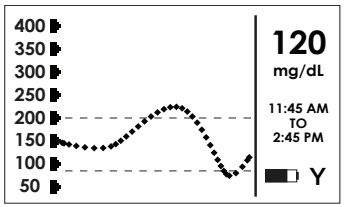


1-Hour ***(figure g)***

Shortly after her second correction bolus at 1:30p.m. Mary's blood glucose values turned the corner and began to fall. At 2:25p.m. her low alert, which was set at 80 mg/dl, went off, and Mary tested herself to confirm. Her blood glucose meter test was 74 mg/dl, and she started to feel slightly shaky. Mary drank a 10-ounce carton of apple juice, and by 2:45p.m. her blood glucose level started to flatten out to 120 mg/dl (see 1-hour and 3-hour glucose trend graphs in figures h and i below).



1-Hour ***(figure h)***



3-Hour ***(figure i)***

QUESTION 2a Causes of a Low Glucose Reaction

- ***Which is the best explanation why Mary had a hypoglycemic reaction at 2:25p.m. that day? (Only one answer is correct.)***

a. Mary took too much insulin at lunchtime to cover her soup
b. Mary gave herself too many correction boluses of insulin too close together in time after her mealtime dose of insulin
c. Mary did not have enough carbohydrates with lunch
d. The insulin Mary was taking was expired and it lost some of its glucose lowering effects or potency

EXPLANATION

The correct answer is ***b***. The situation here is commonly referred to as "stacking the dose" which refers to not waiting long enough after an injection of fast-acting insulin before giving another correction dose. When you have a CGM device and access to a new reading every 5 minutes, you may get anxious or impatient because the blood glucose values are not responding to a correction dose of insulin fast enough. It is important to remember that insulin injected into the subcutaneous tissue takes a long time to be absorbed into the blood stream-this is called "turnaround time." Although the new fast-acting insulins, such as Apidra, Novolog, and Humalog, work much faster than the older regular insulin, there is still a delay and one should wait at least 45 to 60 minutes before deciding on another dose of fast-acting insulin. Mary gave herself too much insulin in a short period of time (lunch bolus of 5 units at noon, 3 more units at 1:15p.m. and a third bolus of 3 more units at 1:30p.m.).

Answers ***a*** and ***c*** are incorrect because Mary did not take enough insulin at lunch. Don't be fooled by a healthy bowl of tomato soup, which probably has a lot of sugar in it. The soup and crackers overpowered her 5 unit pre-meal dose. She definitely had enough carbohydrates. Answer ***d*** is not correct because expired or partially inactive insulin would not have led to hypoglycemia, as it did with Mary. Inactive or partially inactive insulin occurs from being exposed to excessive amounts of heat, light or agitation.

QUESTION 2b Avoiding Low Glucose Reactions

- ***How could Mary avoid this situation in the future? (More than one answer may be correct)***

a. Eat her bowl of soup very slowly over a 2-hour period
b. Ask the sandwich shop staff if they have nutritional information about the tomato soup (e.g., the number of carbohydrates) and take the appropriate amount of fast-acting insulin
c. Wait at least 45 to 60 minutes after giving herself an injection of a fast-acting insulin before giving additional insulin
d. Take a higher dose of Lantus at night

EXPLANATION

Answers ***a***, ***b***, and ***c*** are correct, depending on the situation. Answer ***a*** is correct because spreading the carbohydrates consumed over several hours is much gentler on the post-meal glucose levels. The only problem is that it is impractical for most people to eat a little bit of their meal over several hours, especially soup.

Option ***b*** is a good one because if Mary knew how many carbohydrates were in the soup, she would have given a higher and more appropriate insulin dose. This higher dose would have prevented not only the elevated post-meal glucose level, but also the need for a correction dose. Option ***c*** is correct because if Mary had waited 45 to 60 minutes after her first correction bolus at 1:15p.m., she would have seen her blood glucose levels start to fall or flatten out. This observation would have been a red flag for Mary not to give any more insulin, but to watch and wait. The fact that Mary needed some juice was a small price to pay, as she learned quite a bit about stacking her insulin doses too close together. Taking a higher dose of Lantus (answer ***d***), which is a long-acting basal insulin without a peak, would not have helped this situation at all.

SCENARIO 3

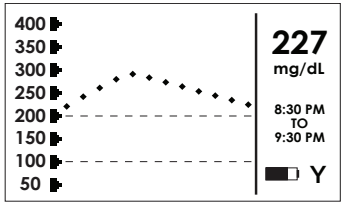
Barbara is a 68-year-old woman who has had type 1 diabetes for 5 years (type 1 diabetes can appear at any age). She is taking Levemir (long-acting basal insulin) twice a day and Novolog with each meal. Her carbohydrate-to-insulin ratio is 12 to 1 and her correction factor is 1:40 (1 unit of insulin will normally bring down her glucose value 40 mg/dl). Barbara also takes 10 units of Symlin before meals.

Barbara ate a late dinner at 8p.m. and at that time her glucose value was 245 mg/dl. She was planning on eating about 70 grams of carbohydrates. Her dose at dinnertime was 3 units as a correction dose for her elevated glucose value at dinnertime, plus 6 units for the number of carbohydrates consumed for dinner (total 9 units):

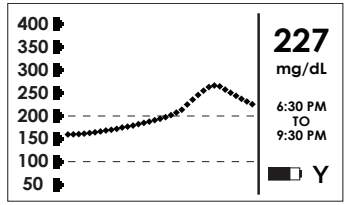
245 mg/dl	*Starting glucose level*
-120 mg/dl	*Target glucose level*
125 mg/dl	***Amount of glucose reduction needed in order to be at target level***
125 mg/dl	*Amount of glucose reduction needed in order to be at target level*
÷ 40 mg/unit	*Correction factor of 40 mg glucose reduction per unit*
3 units	***Correction dosage***
	Plus
70 grams	*Amount of glucose reduction needed in order to be at target level*
÷ 12 grams/unit	*Insulin ratio*
6 units	***Meal dosage***

3 units (correction dosage) + 6 units (meal dosage for carbohydrate to be consumed) = ***9 units total insulin***

At 9:30p.m. Barbara confirmed with a fingerstick that her glucose value was 227 mg/dl. See the 1-hour and 3-hour glucose trend graphs in figures j and k below.



1-Hour ***(figure j)***



3-Hour ***(figure k)***

QUESTION 3a Overcorrecting for High Glucose

- ***Which of the following options would you suggest for Barbara at this time based on the 1-hour and 3-hour glucose trend graphs? Barbara intends to go to bed at 10p.m. (Only one answer is correct)***

  a. Give another correction bolus of 3 units
  b. Watch and wait
  c. Increase the bedtime dose of her basal insulin Levemir by 10%
  d. Give 10 more units of Symlin

EXPLANATION

The best answer is ***b***. Although Barbara's glucose value is still high (227 mg/dl) after dinner, you can clearly see from the 1- and 3-hour displays that the glucose is trending downward. Her glucose value went up after eating to almost 300 mg/dl. This is really not surprising since her glucose value was 240 mg/dl at the time she ate her dinner. If you think about it, her post-meal glucose value went up only about 60 mg/dl after dinner, which is fairly good. The best thing to do is to watch and wait, especially because she is also going to bed soon.

Giving another 3 units (answer ***a***) when her values are trending down could lead to a hypoglycemic reaction after Barbara goes to bed. If Barbara did not have a CGM device, she most likely would have given herself a correction bolus at 9:30p.m, as her post-meal glucose was almost 230 mg/dl. This most likely would lead to nocturnal hypoglycemia, which could be especially dangerous as Barbara has hypoglycemia unawareness.

Hypoglycemia unawareness is a common condition where one does not sense symptoms of their low blood glucose. People with hypoglycemia unawareness can pass out or become seriously disoriented before they develop symptoms that would normally drive them to get something sweet to consume. The chance of having partial or complete hypoglycemia unawareness increases the longer one has diabetes. For example, when first diagnosed with diabetes, one may experience shakiness, sweating, and heart pounding when their glucose value approaches 70 mg/dl. After several years of diabetes, one may only get symptoms of headache and confusion when their glucose value is 50 to 60 mg/dl and none of the other additional symptoms they used to experience when they were first diagnosed. Those with severe and complete hypoglycemia unawareness may pass out or have a seizure as their first sign of hypoglycemia. You can only imagine how dangerous this can be while driving or working with machinery or performing an activity in high places (even walking down the stairs). This is why a CGM device can be so beneficial to managing diabetes and could be lifesaving for some people living with diabetes.

Increasing the dose of Barbara's basal insulin (answer ***c***) at night is not a good suggestion in this situation because this could also lead to hypoglycemia during the night. Normally, we do not treat a high post-meal glucose value by increasing the basal insulin. This is the role of fast-acting insulin. Increasing the basal insulin may also cause havoc for Barbara during the following day.

Taking an additional dose of Symlin (answer ***d***) also is a wrong choice. Symlin is a hormone that is meant to be taken before meals and is approved for type 1 and insulin-using type 2 diabetes. Symlin's main role is to reduce glucose fluctuations and help with weight control.

QUESTION 3b Hypoglycemia Unawareness

- ***What would you suggest the high and low alert limits should be for Barbara, especially considering the fact that she has hypoglycemia unawareness? She experiences symptoms of headache and confusion only when her blood glucose values gets to about 55 mg/dl. (Choose the one best option below for Barbara)***

  a. High alert - 200 mg/dl and Low alert -60 mg/dl
  b. High alert - 180 mg/dl and Low alert -55 mg/dl
  c. High alert - 140 mg/dl and Low alert -70 mg/dl
  d. High alert - 180 mg/dl and Low alert 100 mg/dl

EXPLANATION

The best option for Barbara is to have the low alert at 100 mg/dl (answer ***d***). When you have hypoglycemia unawareness, you want to be alerted of an impending low glucose well before your glucose levels get seriously low. This is why her low alert should be set higher. It is also important to remember that all CGM devices may read 15% or more above or below the real value. A continuous glucose sensor is calibrated with a blood glucose meter value, which may also be 10% to 15% off the true value—making the potential for error even greater. This is why it is always important to test with your blood glucose meter to get a confirmatory measurement before making therapy adjustments. Barbara may get more alerts than someone whose low alert is set at 70 mg/dl. However, safety comes first, which is important since one can have serious brain damage or even die from a seriously low glucose value.

The high alert really does not matter as much as the low alert in someone with hypoglycemia unawareness. However, you also do not want the high alert set too low, as one may be driven to give excessive correction boluses. Answers ***a***, ***b***, and ***c*** are not appropriate because the low alert levels are too low for Barbara's situation. For most people with diabetes without hypoglycemia unawareness, the high alert should be set at 160 to 200 mg/dl and the low alert set at 70 to 80 mg/dl.

SECTION II

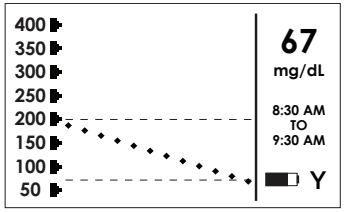
BLOOD GLUCOSE ON THE WAY DOWN

SCENARIO 4

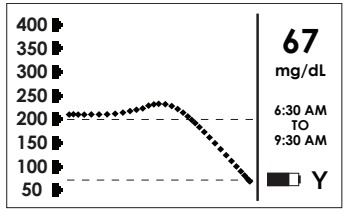
Peter is a 47-year-old graphic artist who has had type 1 diabetes for 8 years. He takes 14 units of Lantus (long-acting basal insulin) each morning plus Humalog (fast-acting insulin) with each meal (choosing a dose according to what he eats).

Last Saturday, Peter went to Denny's for breakfast with some friends. His glucose level prior to eating was 190 mg/dl. He skipped the juice and bread, but at 8a.m. had multiple helpings of eggs, sausage, and bacon. He did not count the carbohydrates in his meal, but took an additional 4 units more than the 6 units of Humalog (10 units total) he usually takes with breakfast because he felt particularly hungry.

His sensor was set to alert at a glucose level below 70 mg/dl. It went off 90 minutes after his meal. He initially thought he had overeaten and that his glucose level was too high. However, his continuous glucose monitor showed a glucose value of 67 mg/dl, and the 1-hour trend was headed sharply down. He tested his blood with his blood glucose meter, and it showed 71 mg/dl. Please look at the 1-hour and the 3-hour glucose trend graphs in figures a and b, shown below:



1-Hour ***(figure a)***



3-Hour ***(figure b)***

QUESTION 4a Possible Causes of Low Glucose Levels

- ***What is the best answer that explains Pete's glucose trend graphs?***

a. He had a stressful drive from home on his way to breakfast
b. He gave himself too much insulin
c. He exercised too much the previous evening
d. The glucose trend graph is probably a mistake due to sensor malfunction

EXPLANATION

The correct answer is ***b***. The meal contained far fewer carbohydrates than Pete realized. He had administered more insulin that he needed (nearly twice his usual dose), leading to a rapid fall in glucose and a low blood glucose alert.

When you eat out, it is easy to miscalculate the quantity of carbohydrates present in food. Even though Peter's glucose level before breakfast was 190 mg/dl, he took far too much fast-acting insulin for a breakfast of mostly protein, and fat and very few, if any, carbohydrates. Continuous monitoring can give you early warning when you make mistakes in unusual situations.

Answer ***a*** is incorrect because stress usually leads to a rise in blood glucoses.

Exercise can work well to help reduce blood glucose levels. Strenuous exercise the previous evening can have continued glucose-lowering effects until the next morning. However, answer ***c*** is unlikely because the drop is too rapid (about 2 mg/dl per minute) so long after the exercise was done. This kind of rapid drop in glucose is more likely to have been caused by the fast-acting insulin he took.

Continuous glucose monitoring is a new technology. As such, all readings should be confirmed by a standard blood glucose meter before you treat yourself. Pete's blood glucose meter confirmed that the sensor reading was accurate, so answer ***d*** is incorrect.

QUESTION 4b Correcting for a Low Glucose Level

- ***Now that Pete has discovered that his glucose levels are on the way down, which of the following options would be most helpful to him? (More than one answer may be correct)***

  a. Keep on eating the same foods he has been eating for breakfast
  b. Have some orange juice and a few glucose tablets
  c. Be more conservative with meal insulin doses in the future
  d. Retest glucose levels to confirm that the readings are correct

EXPLANATION

The correct answers are ***b***, ***c***, and ***d***. He has eaten a meal low in carbohydrates, so continuing these foods (answer ***a***) would offer no short-term benefit to help him avoid or treat hypoglycemia. Additionally, his meal is not a very healthy food choice due to its high saturated fat content.

In the short-term, the best solution would be to provide extra carbohydrates to reverse the decline in glucose levels and prevent hypoglycemia (answer ***b***).

In the future, a less aggressive approach to meal insulin (answer ***c***) would be safer, but precise matching of carbohydrates to insulin (by using his correct carbohydrate-to-insulin ratio) would be optimal. However, this option does not help with his current hypoglycemia.

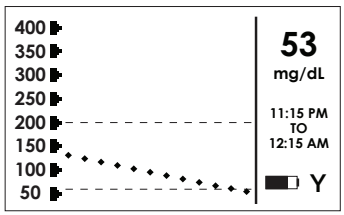
Trends are generally reliable with continuous glucose sensors, and these patterns are unlikely to be caused by a device malfunction. However, it's always safer to confirm glucose readings with a fingerstick and be sure of your numbers. Answer ***d*** is reasonable, but not the most important thing for Pete to do at this moment.

SCENARIO 5

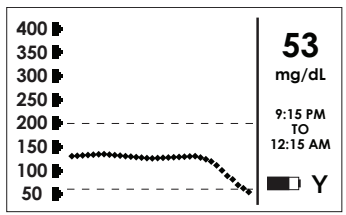
Ruth is a 76-year-old woman with insulin-requiring type 2 diabetes. She has many relatives with diabetes, and when she retired from her job as a banker at age 65, she was diagnosed with diabetes. After taking pills for 5 years, her average blood glucose levels rose to more than 200 mg/dl, and she started taking insulin. She now takes 60 units of Lantus (long-acting basal insulin) at bedtime, 20 units of Apidra (fast- acting insulin) with breakfast, 10 units of Apidra with lunch, and 25 units of Apidra with dinner. She also takes 1000 mg of oral metformin (Glucophage) twice daily. She weighs 169 pounds and is 5 feet, 4 inches in height.

She is as meticulous with her diabetes treatment as she was with her customers' money. Last month, she purchased a continuous glucose monitor and has been using it every day. She set her low blood glucose alert to 60 mg/dl and high glucose alert to 200 mg/dl. Her last A1c value was 6.2%, and she has been able to avoid many complications of diabetes. However, she has macular degeneration (damage to the macula or the eye), and her vision is not as good as it once was.

Ruth went to Napa, California to spend a week tasting wine with her husband. She wrote a few postcards to friends and wrapped the wine she had purchased so it would be ready to give to her son the following day. She went to bed at 11:15p.m. with a glucose level of 128 mg/dl and took her usual 60 units of Lantus. Within 45 minutes of injection, she was awakened by a low glucose alarm. Her monitor read 53 mg/dl and showed a sharp decline in blood glucose. Her 1-hour and 3-hour glucose trend graphs are shown in figures c and d:



1-Hour ***(figure c)***



3-Hour ***(figure d)***

QUESTION 5a Using Different Insulins

- ***What answer do you think is most likely to have caused Ruth's blood glucose level to drop? (Only one answer is correct)***

  a. **Ruth was so preoccupied with wrapping the day's wine purchases for her son's birthday present that she forgot to have her bedtime snack**
  b. **Ruth mistakenly took 60 units of Apidra at bedtime (instead of Lantus)**
  c. **The batteries were low in the receiver which lead to falsely low readings**
  d. **The insulin went "bad" and was working too quickly**

EXPLANATION

The correct answer is ***b***. While this may seem improbable for a woman as careful as Ruth, it happens not infrequently. It may be due in part to all of the newer insulins being clear or colorless and, therefore, difficult to distinguish from one another.

Prior to the introduction of Lantus and Levemir, all clear insulins were faster-acting products. NPH is cloudy and easy to distinguish from clear, short-acting insulin. Currently, there is no consistent way to distinguish commonly used insulins other than by reading the labels, which is difficult for people with limited vision. To minimize the potential for confusion, some doctors suggest using insulin pens for meal therapy and a vial and syringe for long-acting insulin therapy.

Missing a bedtime snack (answer ***a***) can cause problems for people who are taking excessive basal insulin. However, it usually results in a much slower decrease than that seen here, so answer ***a*** is incorrect. However if Ruth drank a great deal of alcohol during her wine tours, it could have made her more vulnerable to hypoglycemia, as drinking alcohol can lower glucose levels.

Answer ***c*** is also incorrect. When the monitor's batteries are low, there is a low battery indicator. The low battery state does not lead to false readings. The monitor is designed to shut off the display of readings in case of suspected inaccuracy of the device.

When insulin is exposed to extreme temperatures or used beyond its expiration date, there is generally a reduced potency. An increased insulin effect has not been seen, so answer ***d*** is incorrect.

QUESTION 5b Options for Treating Low Glucose Levels

- ***Ruth took 4 glucose tablets and woke her husband. What should she do next? (Only one answer is correct)***

a. Call her doctor and ask for further advice
b. Call room service to order some desserts
c. Confirm that her glucose level is really low by a fingerstick test and continue to take glucose tablets and any other available carbohydrates until the continuous monitor shows a glucose level greater than 100 mg/dl and a rising trend
d. Inject herself with 1 mg of Glucagon and call the paramedics immediately

EXPLANATION

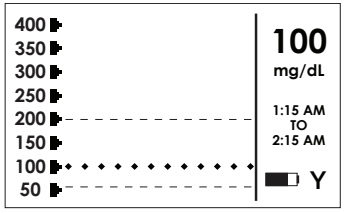
The correct answer is ***c***. Treatment of her accidental mistake is urgent, and quick action is required to avoid severe hypoglycemia. The insulin she took will keep her at risk for hypoglycemia for at least 4 hours, so she should not go back to sleep. Having a continuous monitor will allow her to more closely watch her progress.

Answer ***d*** would be correct if she was unable to take anything by mouth. If she had type 1 diabetes and took this amount of rapid-acting insulin and was not very close to a hospital, taking glucagon and calling the paramedics would not be an unreasonable choice.

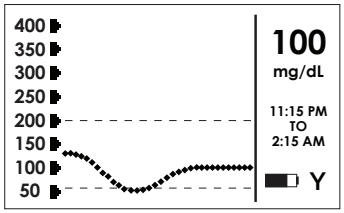
Calling the doctor (answer ***a***) would be a good idea if Ruth didn't know what to do or if she didn't realize her mistake. Anyone on insulin should be educated about accidental dosing and what to do about it without panicking.

Answer ***b*** is unwise for short-term treatment, due to the unpredictable time it may take to get the food. In addition, answer ***b*** has the potential for over treatment (depending on the type and amount of desserts eaten) and could lead to high blood sugar levels. However, ordering a small snack from room service may make all of those glucose tablets more palatable.

Ruth has had a rough night so far. Her initial glucose level when she confirmed it by fingerstick was 68 mg/dl. It has been 2 hours since her low glucose alarm went off. She has not only exhausted her supply of glucose tablets, but she also ate a bagel leftover from lunch and drank the only 2 bottles of regular soda that were in her minibar. Her husband has finally come back with dessert, and it looks fabulous (fresh berries with a Chantilly sauce, chocolate mousse, a banana split, and 2 decaf cappuccinos). Look at her 1-hour and 3-hour glucose trend graphs in figures e and f below and decide what she should do next.



1-Hour *(figure e)*



3-Hour *(figure f)*

QUESTION 5c Treatment Following a Low Glucose Value

- ***What should Ruth do now? (Choose the one best answer)***

a. Decide not to eat the desserts and go to sleep, as she was confident her glucose was not going to drop further
b. Have a decaf cappuccino and watch the monitor closely for another hour before doing anything else
c. Continue eating, but more slowly
d. Give 10 units of Apidra to prevent rebound hyperglycemia

EXPLANATION

Answer ***b*** is the best option, since she has reversed the falling glucose trend and has a glucose level high enough to be reasonably safe. Remember, she has type 2 diabetes, and because of the associated insulin resistance, overdoses of insulin are less catastrophic (as compared to such a high dose of Apidra in a thin person with type 1 diabetes).

Answer ***a*** is incorrect, as although Apidra is a fast-acting insulin, it is remains active for 4-5 hours, and she is not out of the woods yet with regard to hypoglycemia risk.

Answer ***c*** would be what she should do if glucose levels begin to trend downward again.

Answer ***d*** would be unwise as the time frame during which she is at risk for hypoglycemia has not passed. Most likely, Ruth's glucose levels will not be in the normal range in the morning due to over treatment of her lows with food. However, this is preferable to hypoglycemia.

QUESTION 5d Adjusting Your Target Range

- ***What setting change on her CGM receiver should Ruth consider? (Choose the one best answer)***

a. Raise the high glucose alert to 250 mg/dl
b. Raise the low glucose alert to 100 mg/dl
c. Call the manufacturer of the company to change the fixed low warning of 55 mg/dl
d. Turn off the audible alarms

EXPLANATION

Answer ***b*** is the correct answer. Raising the threshold for a low alarm can improve safety, as it gives you more time to anticipate a potential low. Although the alarm on the device may annoy you, the increase in safety from hypoglycemia can be worth it (particularly if you have hypoglycemia unawareness).

Raising the high glucose alert in Ruth would offer no benefit (it is already somewhat high at 200 mg/dl), so answer ***a*** is incorrect.

Answer ***c*** is incorrect because the low glucose alarm warning (set at 55 mg/dl) cannot be altered. This option would also be unwise because of safety concerns.

Answer ***d*** would be unwise as the audible alerts might be very helpful to Ruth, particularly during the night.

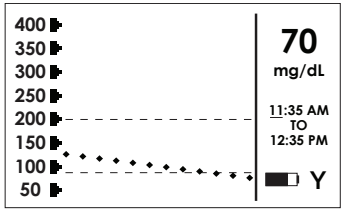
SCENARIO 6

Skip is a 25-year old construction worker who has had type 1 diabetes for 15 years. He is 6 feet 2 inches tall and weighs 200 pounds. He takes Levemir (long-acting basal insulin)—20 units each morning and 14 units each evening. He snacks frequently during the day and at bedtime and takes Novolog (fast- acting insulin) with each meal (usually 6 units with breakfast, 2 units with lunch, and 8 units with dinner). Most of his morning glucose levels are 60-105 mg/dl. He avoids checking glucose levels at work because his hands are usually dirty. He thinks that he can feel most of his low blood glucoses.

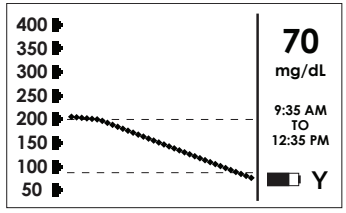
Skip is a newlywed and was told by his wife that he sometimes wakes her up, thrashing about at night and other times is hard to awaken. She works at an endocrinologist's office and has heard about a new device that monitors glucose levels continuously. She convinced her husband to wear a continuous glucose monitor to work last week.

Throughout the week, Skip has complained that the glucose monitoring device is sending "low" alarms frequently at work. His low glucose alert is set at 80 mg/dl. It usually happens when he is working particularly hard. The alarm resolves when he snacks.

On Thursday, he skipped his lunch so that he could complete a critical part of the electrical work that his boss really wanted done. When his sensor alarmed at 12:30p.m. with a low of 75 mg/dl he simply ignored the alert and went on working. However, when it went off again a few minutes later, he looked at the 1-hour trend graph (figure g) and saw a steep decline in glucose. He then reviewed the 3-hour glucose trend graph (figure h) more closely.



1-Hour ***(figure g)***



3-Hour ***(figure h)***

QUESTION 6 Skipping or delaying meals

- ***What is the <u>least</u> appropriate choice(s) for Skip? (There may be more than one <u>inappropriate</u> answer)***

  a. **Stop work and ask his coworker to cover for him, take a fingerstick to confirm glucose level, and start eating a snack immediately**
  b. **Consider reducing his morning Levemir dose**
  c. **Silence the alert and continue working twice as hard because he should be able to finish the job within another hour**
  d. **Reduce the lunchtime Novolog dose when he eats lunch**

EXPLANATION

The correct answer is ***c*** —he should not continue working because if glucose levels decline steadily, his glucose could be as low as 25 mg/dl within an hour. With the trend information from the continuous glucose monitor, you can predict the future more accurately. While Skip frequently measured glucose levels in the 70's at work, this day was different since he had skipped lunch and could see the steady decline in glucose values.

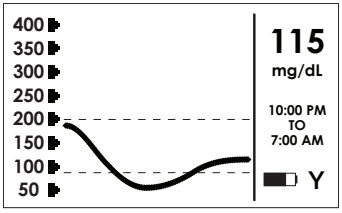
Answers ***a***, ***b***, and ***d*** are all appropriate for Skip. The time to treat a low is before any symptoms occur, at the time when it can first be predicted. With continuous glucose monitoring, it is possible to see patterns (such as the trend in the figure above) that single-point fingerstick testing cannot reveal. In this way, severe hypoglycemia can be anticipated and prevented. Once he has confirmed the reading with a fingerstick, stopping work and eating will accomplish this. If Skip decides to eat a full lunch, he should probably reduce the insulin dose taken at lunch.

Answer ***b*** is very important to consider. Skip is taking nearly 70% of his total daily dose (TDD) of insulin as Levemir (basal or long-acting). (The TDD is computed by dividing the 34 units of Levemir by the approximately 50 units TDD of insulin administered daily). Typically, basal insulin is approximately 50% of TDD and may be less in very active people.

This illustrates how continuous glucose monitoring not only helps to warn you of impending lows and highs, but also may tip you off to the big picture and help to suggest changes in insulin dosing. Skip and his caregiver decided to reduce his morning Levemir dose to 18 units.

SCENARIO 7

Skip hates to eat at night, so he does not have a bedtime snack. Skip reviews the 9-hour glucose trend graph (figure i) again the following morning at breakfast with his wife.



9-Hour ***(figure i)***

QUESTION 7 Changes in Insulin Therapy

- ***Which of the following is the most important for Skip to consider:***

a. Skip may be taking too much Levemir at night
b. Skip may be taking too much Novolog at dinner
c. This is probably as good as Skip can hope to do with his overnight control
d. Skip should have a bedtime snack

EXPLANATION

Answer ***a*** is the most important issue for Skip to consider. We saw how Skip was having problems during the day with excessive basal insulin. Night is another time where people are vulnerable to hypoglycemia. Reducing the Levemir dose to 12 units in the evening would be a good first step to level out the overnight blood sugars and prevent them from dropping. However, Skip can use the overnight 9-hour glucose trend graphs to monitor his glucose levels when he makes a change in insulin dosage.

Answer ***b*** is unlikely because Novolog would not cause a low this many hours from dinnertime.

Answer ***c*** is false. If injections fail to optimize overnight control, insulin pumps can allow Skip to customize his overnight insulin doses until this problem is corrected. Answer ***d*** (a bedtime snack) can be of some help, but Skip would prefer to avoid it.

In each of these cases, continuous glucose monitoring is useful for both understanding what is going on and monitoring the effects of any changes in therapy.

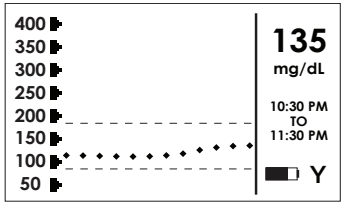
SECTION III

BLOOD GLUCOSE LEVELS DURING THE NIGHT

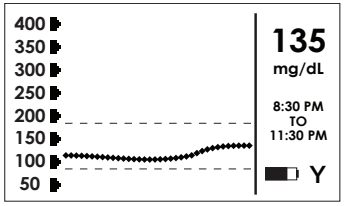
SCENARIO 8

Harry is a 51-year-old car mechanic who has had type 1 diabetes for 36 years. He is currently taking 20 units of Lantus at night as his basal insulin, plus a fast-acting insulin before meals and for correction doses. He calculates his pre-meal doses based primarily on his past experience of eating the same types and amounts of food (carbohydrate counting is a relatively new concept, and he was well into his habits before this method of calculating the insulin dose came into vogue). His correction factor is 1:40 (1 unit of a fast-acting insulin will lower his glucose value about 40 mg/dl) unless his glucose value is above 250 mg/dl. In that case, his correction factor is 1:30.

Harry commonly eats dinner fairly late around 8:30 or 9p.m., and dinner is his largest meal of the day. On one occasion, Harry had a large pasta dinner at 9p.m. and he took 10 units of a fast-acting insulin. His glucose value before dinner was 112 mg/dl. He went to bed at 11:30p.m. with a glucose value of 135 mg/dl. Please see the 1-hour and 3-hour glucose trend graphs in figures a and b below.



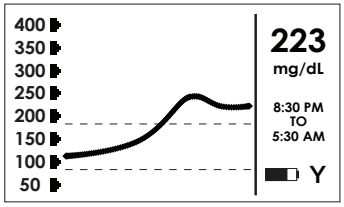
1-Hour ***(figure a)***



3-Hour ***(figure b)***

As you can see, his 1-hour and 3-hour displays show excellent post-dinner and bedtime glucose values. However, the problem arises in the middle of the night a few hours after going to bed. Harry would commonly wake up with an elevated glucose value at approximately 2 to 4a.m., as his high alert would go off. He would give himself a correction dose of fast-acting insulin and go back to bed, as he did in this case.

Please see the 9-hour glucose trend graph (figure c) that was available upon awaking the next morning at 5:30a.m.



9-Hour ***(figure c)***

QUESTION 8a Nocturnal Hyperglycemia– First Culprit

- ***Which of the following choices might explain why Harry's blood glucose levels are rising in the middle of the night? (There may be more than one correct answer)***

  a. Harry is getting up in the middle of the night and snacking on Oreos, chips or other foods
  b. Harry needs more long-acting basal insulin at bedtime
  c. Harry may have a condition called diabetic gastroparesis
  d. Harry needs more fast-acting insulin with dinner

EXPLANATION

The best answer is ***c*** although options ***a*** and ***b*** could also explain the high blood glucoses in the middle of the night. Harry mostly likely has diabetic gastroparesis, a condition where the muscular contractions of the stomach are not normal. Gastroparesis is a form of neuropathy (nerve damage). Normally, the nervous system stimulates the muscles of the stomach to contract in a coordinated fashion after eating. These contractions keep the food that is being digested moving down the gastrointestinal tract. When you have gastroparesis, a large meal will just sit in the stomach for a prolonged period of time, giving symptoms of fullness and bloating. The blood glucose does not go up after eating, since the food must leave the stomach and go into the small intestine before the nutrients are absorbed into the blood stream. It is typical with gastroparesis to have surprisingly normal or low blood glucose 1 to 2 hours after eating a large meal, but to then see glucose levels rise excessively high several hours later.

Snacking in the middle of the night (answer ***a***) will also give you this pattern. Another possible scenario is that there is not enough long-acting basal insulin at night (answer ***b***); however, this scenario occurs only when Harry eats a large meal late and is not likely the problem. Answer ***d*** is not correct because if he did not take enough fast-acting insulin with dinner, his 2-hour blood glucose level would have been much higher than what it was.

QUESTION 8b Correcting This Condition

- ***Which of the following are viable options to help prevent this scenario (adequate glucose values at bedtime but elevated values in the middle of the night) from occurring on a regular basis?***
  (More than one answer may be correct)

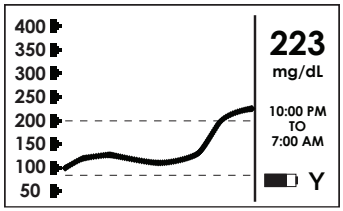
  a. Harry should avoid eating late at night
  b. Harry should avoid eating large, heavy meals
  c. Harry should see his caregiver about tests for gastroparesis and for medication that may improve gastroparesis
  d. Harry's wife should lock the pantry at night, so he cannot snack in the middle of the night

EXPLANATION

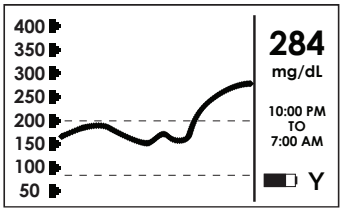
Answers ***a***, ***b***, and ***c*** are all correct. Gastroparesis is a form of neuropathy, and there are several medications that are used to treat moderate-to-severe gastroparesis. A good gastroenterologist can order stomach motility tests to confirm the diagnosis. He/she will also be familiar with the medications commonly used to treat gastroparesis. One of the best non-pharmacologic (without using drugs) ways to treat this situation is to eat earlier and not to overeat. Large, heavy meals will stretch the stomach walls and make the symptoms of gastroparesis worse. Most people with mild gastroparesis can manage their condition by changing their eating habits.

SCENARIO 9

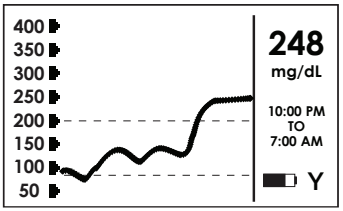
Mary is a 19-year-old college student who has been living with diabetes for less than a year. She is on an insulin pump with the basal rate set at 0.6 units per hour for 24 hours (A basal rate is a constant amount of insulin delivered throughout the day and night by an insulin pump in very small increments. The basal rate maintains blood glucose values in the normal range between meals, overnight, and during periods of fasting). Mary's correction factor is 1:50 and her carbohydrate-to-fast-acting insulin ratio is 15:1. She commonly goes to bed with a good blood glucose level, but it is high upon awakening in the morning. She has dinner at 6p.m. on most nights and does not snack after dinner. She usually goes to bed around 11p.m. Please see her 9-hour glucose trend graphs in figures d, e, and f from the previous three nights.



9-Hour ***(figure d)***



9-Hour ***(figure e)***



9-Hour ***(figure f)***

QUESTION 9a Nocturnal Hyperglycemia – Second Culprit

- ***Which option below best explains what is happening with Mary overnight? (Only one answer is correct)***

a. Mary is experiencing the Somogyi reaction (rebound hyperglycemia as a result of a hypoglycemic reaction)
b. Mary's insulin pump is malfunctioning
c. Mary is experiencing the Dawn Phenomenon, which is early morning resistance to insulin
d. Mary has gastroparesis

EXPLANATION

Option ***c*** is the correct answer. The Dawn Phenomenon is a well-characterized problem that is common in people with diabetes. First, it is important to describe what happens to non diabetic individuals overnight. People without diabetes commonly need more insulin in the early hours of the morning to keep the their blood glucose levels from rising. This need for more insulin is thought to be due to natural circadian (natural biological cycle of the body) elevations in anti-insulin hormones such as the growth hormone. If you do not have diabetes, the pancreas merely secretes a little more insulin during this time period, which is normally between the hours of 3 and 7a.m. However, if your pancreas does not secrete enough insulin because you have diabetes, your glucose levels will go up during this time unless your compensate for it.

Answer ***a*** is not correct. The Somogyi reaction is a situation where there is rebound hyperglycemia after one has a hypoglycemic reaction. When one has a hypoglycemic reaction, there is sometimes a natural physiologic response to protect you from extremely low glucose values by secreting hormones such as epinephrine (also called adrenalin) and glucagon that raise the glucose levels. As you can see from the 9-hour displays, Mary is not getting into the hypoglycemic range, so this option is not correct.

There is no reason why the pump would malfunction at such a specific time period, so answer ***b*** is not correct.

Gastroparesis, as described in the previous scenario, would not take 9 hours to cause hyperglycemia, so answer ***d*** is not correct. Mary eats dinner at 6p.m. and the glucose values do not go up until around 3a.m. Gastroparesis usually causes a delay in post-meal glucose elevations of about 2 to 4 hours.

QUESTION 9b Preventing This Phenomenon

- ***Which of the options below might help to prevent this situation causing elevated sugar levels in the early morning? (There is one best answer)***

a. Have Mary take an injection of NPH insulin at bedtime
b. Program a second basal rate into Mary's pump where the rate is increased by 30% to 0.8 units/hour, starting at 3a.m. until 7a.m.
c. Have Mary do 30 to 45 minutes of aerobic exercise starting at 3a.m.
d. Have Mary change her normal sleep hours, so that she goes to bed much later than 11p.m.

EXPLANATION

Option ***b*** is the best answer. One advantage of insulin pump therapy is that you can have more than one basal rate throughout the day and night. A basal rate is a constant amount of insulin delivered throughout the day by an insulin pump in very small increments, and is used to maintain the baseline metabolism of the body (without food or exercise). You can adjust your basal rate according to your activities, including exercise, and whether you experience the Dawn Phenomenon. Having an increased basal rate during the time of the Dawn Phenomenon is normally very effective at preventing the rise in glucose in the early morning hours.

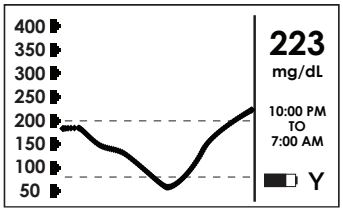
Giving NPH at bedtime (answer ***a***) would also help the situation, however, the timing of NPH insulin is not as precise as increasing the basal rate on an insulin pump. In addition, adding intermediate-acting insulin such as NPH at night to a patient on a pump adds unnecessary complexity to the insulin regimen. Changing Mary's sleep habits (answer ***d***) or exercising in the middle of the night (answer ***c***) are very unreasonable options.

SCENARIO 10

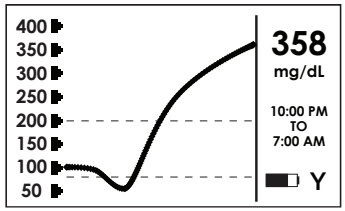
Antonio is a 42-year-old, overweight Latino who has insulin-requiring type 2 diabetes. Both of his parents have type 2 diabetes, as well as one of his 3 sisters and two paternal uncles. He was diagnosed 6 years ago and was on oral medications only until last year, when he was put on a basal-bolus regimen because of elevated A1c levels above 9%.

Antonio is currently on 35 units of Levemir as his basal insulin, given at bedtime, and 10 to 15 units of Novolog before meals. After starting insulin his A1c came down to the 6.5% - 7.3% range. However, he is experiencing problems with morning hyperglycemia on a consistent basis. He also has been complaining of nightmares and night sweats. His high and low alerts are set at 200 mg/dl and 60 mg/dl, respectively.

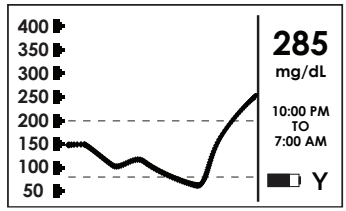
Antonio has dinner at 7p.m. each night and recently has stopped eating anything before bedtime as he is trying to lose weight. His bedtime is normally at 11:30p.m., which is when he takes his 35 units of Levemir. See his 9-hour glucose trend graphs in figures g, h, and i over the previous three nights.



9-Hour ***(figure g)***



9-Hour ***(figure h)***



9-Hour ***(figure i)***

QUESTION 10a Nocturnal Hyperglycemia – Third Culprit

- ***Which of the following options best explains why Antonio is awakening with an elevated glucose value? (Only one answer is correct)***

  a. **Antonio is experiencing the Somogyi reaction (rebound hyperglycemia as a result of a hypoglycemic reaction)**
  b. **Antonio is experiencing the Dawn Phenomenon (early morning resistance to insulin) Antonio is not on enough of his basal insulin, Levemir**
  c. **Antonio is eating dinner too late in the evening**

EXPLANATION

Answer ***a*** is the correct answer. The Somogyi reaction is a situation where there is rebound hyperglycemia after one has a hypoglycemic reaction. When you have a hypoglycemic reaction, there is sometimes a natural physiologic response to protect you from extremely low glucose values by secreting hormones that raise the glucose levels such as epinephrine (also called adrenalin) and glucagon. You can see from the 9-hour displays that Antonio is getting hypoglycemic every night. Night sweats and nightmares are common symptoms of nocturnal hypoglycemia, which were present with Antonio. After he bottoms out, his glucose value climbs excessively high due to the anti-insulin hormones. On one of the nights, his low alarm woke him up, and he ate 15 Oreo cookies in response (second 9-hour glucose trend graph in figure h above).

The Dawn Phenomenon (answer ***b***) may also contribute to his problem, but hypoglycemia is the obvious diagnosis according to 9-hour glucose trend graphs above. Please see scenario 9 above for an explanation of the Dawn Phenomenon.

It looks like Antonio is getting too much Levemir at bedtime, especially since he stopped eating after dinner snacks. Answer ***c*** is definitely not a correct answer. Answer ***d*** is not correct because 7p.m. is not too late for dinner.

QUESTION 10b Preventing This Early Morning Hyperglycemia

- ***Which of the following options would help prevent Antonio's problem of awaking with an elevated glucose value in the morning after having nocturnal hypoglycemia? (More than one option may be correct)***

a. Reduce his dose of Levemir at bedtime
b. Reduce his dose of Novolog at dinnertime
c. Have Antonio drink 8 ounces of juice instead of a handful of Oreo cookies when he gets low
d. Have Antonio eat a large snack just before bedtime

EXPLANATION

Answer ***a*** is the best option; however, answer ***d*** would also be somewhat effective. Reducing the dose of Levemir would be the best first option to try. A reduction of 5% to 10% is reasonable; however, Antonio's caregiver should make the ultimate decision. Eating a large snack at bedtime (answer ***d***) will help prevent the low glucose value, but Antonio is trying to lose weight and there would be a risk of hypoglycemia if he could not get a snack on certain nights.

Antonio's dose of pre-dinner Novolog (answer ***b***) seems to be adequate as his post-dinner numbers are in the 150 to 200 mg/dl range. Novolog is a fast-acting insulin and is pretty much out of his system within 5 to 6 hours and would not have any strength to cause hypoglycemia at 3a.m., 8 hours after the time of injection.

Antonio does need education on how to treat his hypoglycemic reactions. Eating 15 Oreo cookies consumes a ton of calories (over 700) and because they contain fat, the absorption is not as fast as carbohydrates alone (such as juice or glucose tabs). Drinking 8 ounces of juice (answer ***c***) would help limit the rise in blood glucose after having a hypoglycemic reaction, but it would not prevent the problem from occurring in the first place.

Summary

We hope that these examples were helpful to you in understanding how you may use the new technology of continuous glucose monitoring to help you take control of your diabetes. At first glance, you will see more happening with your glucose levels than you may have expected. However, the extra information will actually fill in the gaps and give you a better understanding of your diabetes. Proper setting and use of the alerts and alarms can allow you to achieve lower target glucose goals more safely.

We are interested in your experiences. Please send us your stories of how continuous glucose monitoring has affected your diabetes treatment, your A1c, and other aspects of your life.

You can send these to: ***Taking Control of Your Diabetes***

1110 Camino Del Mar, Suite B

Del Mar, CA 92104

or

info@tcoyd.org

Glossary

Fingerstick – A method of blood glucose testing that uses a small drop of blood, which is obtained by poking or "sticking" a fingertip. A blood drop can be drawn from an alternative site, but fingertips are the most common.

Insulin – Insulin is a hormone secreted by the pancreas, and is essential to management of blood glucose levels. Fast acting insulins (brand names Apidra, Humalog and Novolog) are typically effective between 30 minutes and 3 hours after being taken; long acting insulins (brand names Lantus and Levemir) are typically effective between 12-24 hours after being taken. Insulin is taken most often through injection, insulin pump or insulin pen.

Hyperglycemia – High glucose levels. Normal glucose level are generally 80-120 mg/dl, however, for people with diabetes the target zone or target levels of glucose control are often higher. The high target zone varies from person to person and should be agreed upon by the healthcare provider; in continuous monitoring a high target zone limit might be set between 140-200 mg/dl to minimize the time spent high.

Hypoglycemia – Low glucose levels. Normal glucose level are generally 80-120 mg/dl, however, for people with diabetes the target zone or target levels of glucose control are often higher. The low target zone varies from person to person and should be agreed upon by the healthcare provider; in continuous monitoring a low target zone limit might be set between 70-100 mg/dl to minimize the time spent low.

Hypoglycemia unawareness – A condition where a person with diabetes does not sense their low blood glucose values. People with hypoglycemia unawareness can pass out or become seriously disoriented before they develop symptoms that would normally drive them to get something sweet to consume. The chance of having partial or complete hypoglycemia unawareness increases the longer one has diabetes.

Nocturnal hypoglycemia – Hypoglycemia, or low glucose levels, that occur at night or when one is sleeping.

Target zone – These are the high and low boundaries (the ideal minimum and maximum) of glucose control for a person with diabetes. Continuous glucose monitoring can help people with diabetes to increase the amount of time spent in the target zone, and reduce the excursions outside the target zone.

mg/dl – milligrams per deciliter. mg/dl is the standard measure of blood glucose used in the US.

Dawn phenomenon – A rise in blood glucose levels that typically happens between 3 and 7a.m. People with and without diabetes commonly need more insulin in the early hours of the morning to keep their blood glucose levels from rising. If your pancreas does not secrete enough insulin because you have diabetes, your glucose levels will go up during this time, causing the Dawn phenomenon.

Somogyi reaction – The Somogyi reaction is a situation where you experience rebound hyperglycemia (high glucose levels) after you have a hypoglycemic reaction. When you have a hypoglycemic reaction, there is a natural physiologic response of your body to protect you from extremely low glucose values by secreting hormones such as epinephrine (also called adrenalin) and glucagons. These hormones cause a steep rise in glucose levels, resulting in "rebound" high glucose levels.

Rebound hyperglycemia – Same as Somogyi reaction.

Gastroparesis – Gastroparesis is a form of neuropathy or nerve damage. Diabetic gastroparesis is a condition where the muscular contractions of the stomach are not normal, since the nerves in the stomach are damaged. These damaged nerves prevent the body from sensing the amount of food in the stomach. This slows down the digestion of food and can cause unexpected glucose levels.

Macular degeneration – Damage to the macula (part of the retina of the eye) that can cause impairment or loss of vision.

Pancreas – An organ in the endocrine system of the body that is responsible for the production of insulin.

Correction factor – A term commonly used in insulin pump therapy that represents the amount of insulin needed to lower glucose levels by a specific amount. For example, a correction factor of 1:60 means that one unit of insulin will lower glucose levels by about 60 mg/dl. The correction factor varies from person to person, and even in the same person, can vary throughout the day.

Carbohydrate-to-insulin ratio – A term commonly used in insulin pump therapy that represents the amount of carbohydrates you can eat for each unit of insulin taken. For example, a carbohydrate-to-insulin ratio of 12 to 1 means one unit of insulin is needed for each 12 grams of carbohydrates consumed. This ratio varies from person to person, and even in the same person, can vary throughout the day.

Carbohydrate counting – A term commonly used in insulin pump therapy. Many people that use an insulin pump calculate their insulin dosage for meals and snacks by counting the number of carbohydrates in the food, and giving an insulin dose accordingly.

Basal rate – A term commonly used in insulin pump therapy. The basal rate is the insulin taken that will maintain blood glucose levels in the normal range between meals, overnight, and during periods of fasting.

Bolus – A term commonly used in insulin pump therapy. A bolus is an on-demand dose of insulin given to balance the carbohydrates consumed in a meal or snack, or an on-demand dose given to correct an elevated glucose level.

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This educational tool is the result of a joint effort among Taking Control of Your Diabetes (501c3), Steven V. Edelman, M.D., and Timothy S. Bailey, M.D. An unrestricted educational grant was provided by DexCom, Inc. to facilitate the production of this guide.