

CHAPTER 12:

SPECIFIC ASPECTS OF INSULIN PUMP USE AND TROUBLESHOOTING



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It is true that everyone experiences a learning curve when starting to use an insulin pump. We all have differences in the amount of body fat available and where it is located. We differ in our lifestyle, activities and preferences. These differences guarantee that there will not only be issues that require our attention but that the solution for one person will not always be the best solution for another. Some of the issues that could potentially make a difference on whether you or your child's insulin pump start is a smooth, easy transition or a hard, bumpy one are listed here:

- The kind of infusion set
- Length of cannula
- Length of tubing
- Infusion site choice
- Where pump is worn
- Tape issues (also see Chapter 16)
- Insertion site disconnection
- Air in the tubing
- Forgetting to prime/fill the cannula

INFUSION SETS

Choosing the right infusion set is crucial. Regardless of the insulin pump you are using, there are many types of infusion sets to choose from. Tables 2 and 3 in Chapter 4 provide specific information on several infusion sets. Most infusion sets can be divided into those that insert the cannula at a 90° angle (straight in) or those that insert the cannula at a 30° angle. The cannula is the small tube or catheter inserted under the skin that insulin travels through as it is delivered into the body.

90° Infusion Sets

Infusion sets that are inserted at a 90° angle can be used when there is close to 3/4 inch of pinchable fat under the skin. Many infusion sets have an inserter that makes them a great choice for hard to reach areas and for people with needle fear. It is recommended that you do not pinch when using an inserter to insert a 90° infusion set.

Most of the 90° infusion sets use a Teflon® cannula that is soft and flexible. This allows for a very comfortable infusion set. The downside of these Teflon cannulas is that they can kink. Thin people do seem to have more of a problem with their cannula kinking than persons with sufficient fat tissue under the skin. If kinking is an issue, try a 30° infusion set in that location, or use a metal cannula infusion set. It is not unusual for people to use both types of infusion sets (i.e., a 90° infusion set in areas with enough fat tissue and a 30° infusion set in leaner areas). This maximizes the use of all available infusion site locations, reducing overuse of those sites.

The Sure T® and the Rapid-D® infusion sets have metal cannulas and are inserted at a 90° angle. The metal cannula prevents kinking of the infusion tube. There is no difference in pain compared to a Teflon cannula. They each have a 4-inch “tail” section of tube that separates the infusion site from the disconnection point. This feature is good for a child still in diapers since it allows for more separation between the disconnection point and a potential messy diaper. It can also be a good fit when only one parent is available to do the set insertion on a very young child who is squirmy at insertion time. Even when using an insertion device, it can be difficult to hold a child semi-still while

completing the necessary steps for a successful insert. These infusion sets are very much like a “thumb tack” and can be inserted very quickly.

30° Infusion Sets

Infusion sets that are inserted at a 30° angle work well with very thin people. To insert, you pinch up the fatty tissue and insert into that pinch at a 30° angle. This can help ensure that the muscle is not penetrated. The Paradigm Silhouette infusion set has an inserter called the Sil-serter™. Our experience is that very thin people are able to fine tune the depth of insertion more accurately when they manually insert as opposed to using the inserter. There are some significant advantages to using 30° angled infusion sets. Angled infusion sets are less likely to pop out or kink. Many people find that the 30° infusion sets stay in better with exercise. Unlike the 90° infusion sets, you can see the cannula in the skin through a small tape window. This feature can be reassuring when there is a question as to whether the cannula is in the body or not. 90° infusion sets can pop out or be bent to the side while appearing fine from the outside. It is not uncommon for people to use an angled infusion set in the abdomen and then use a 90° insertable infusion set in a place that it is harder to reach, like the buttocks.

CANNULA LENGTH

You must always take into consideration the amount of body fat in the infusion site locations. Thin people should always choose the shortest cannula available for the infusion set being used. The shortest cannula length for a 90° infusion set is 6 mm. The shortest cannula length for a 30° infusion set is 12 or 13 mm. If an infusion set is inserted too deeply, it can penetrate the muscle. Penetrating the muscle can cause discomfort and bleeding, and increase the chance of kinking a soft, bendable Teflon cannula. If you notice this is happening with a 90° infusion set, try a 30° angled infusion set in that location. If fat under the skin is plentiful and a 90° infusion set is being used, choose a longer cannula length (such as 9 mm). The longer cannula length in a 90° infusion set

decreases the likelihood of the cannula popping out between infusion set changes.

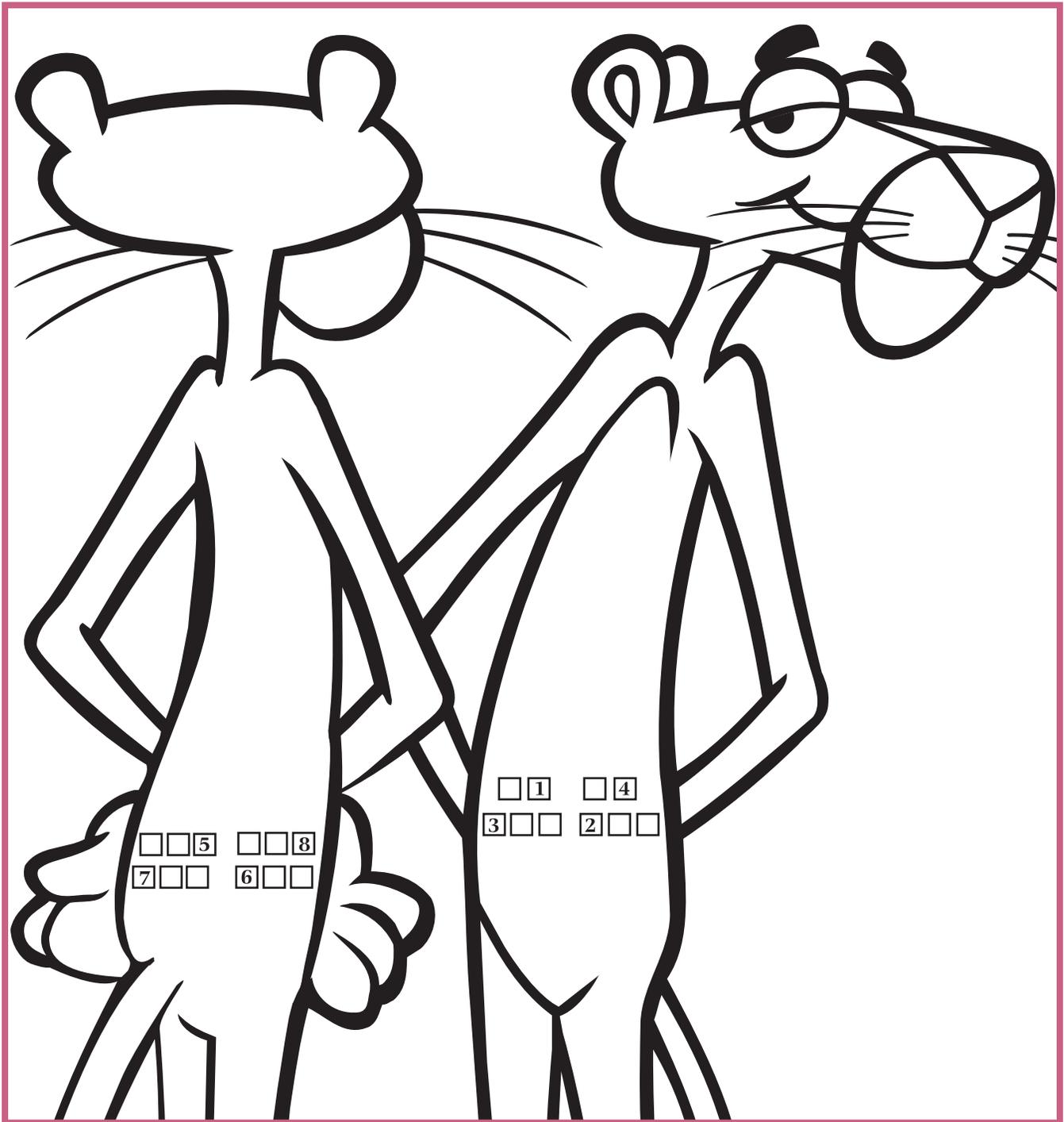
TUBING LENGTH

Infusion sets come with a choice of tubing length, ranging from 23 to 43 inches (57-107 cm). Deciding about tubing length is more for convenience or preference and is not as crucial as choosing the length of the cannula. However, when you know you have a choice in this matter, there are a few things to consider before ordering your or your child's infusion sets. First, it is typical that the taller you are the more comfortable you will feel with longer tubing. Second, when you go to the restroom, you want the tubing to be able to reach from the insertion site to the insulin pump, which most often is attached to the pants waistband and is usually at the floor. Third, you might also want to consider placement of the pump while sleeping when you are deciding what tubing length to use. The place you plan to put the pump when you sleep will affect the length of tubing you need. If you are using long tubing and it is desired to have it shorter, it is fine to roll it in a loose loop and place a piece of medical tape around the loop. Later in this chapter you will learn more options on how you can wear your pump during the day and while sleeping.

INFUSION SET LOCATIONS

Choosing locations on the body where the infusion set can be inserted is a very important part of insulin pump therapy. Insulin is delivered into the site of insertion 24 hours a day for two to three days. If you or your child do not have at least 12 sites or if those sites are not rotated properly, scar tissue can result. If you don't have much “real estate” to begin with, it is important to avoid over-using favorite locations so that the tissues have a chance to return to normal. Locations that have developed scar tissue can take one month to several months to return to a healthy insulin absorbing state.

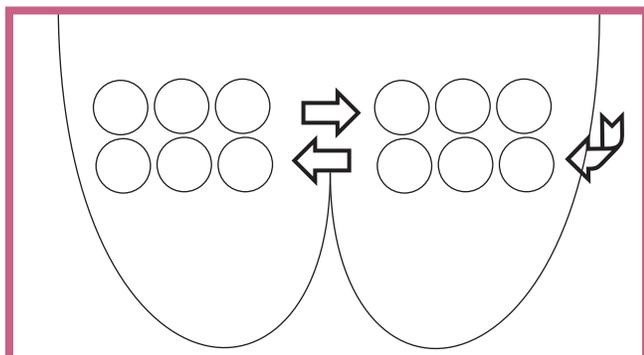
FIGURE 1:
POSSIBLE PUMP SITES



- Eight numbered sites are noted but people/families can rotate and number as they wish.
- Some people also use arm sites for the OmniPod. Others use leg sites (for any pump).
- Some families write the dates in the spaces to keep track of sites used.

FIGURE 2:

SAMPLE TEMPLATE FOR INFUSION SET ROTATION



If it becomes necessary to give over-used sites a rest, great care must be taken to ensure that alternate sites do not develop the same problem. The best way to prevent over-use and potential damage is to start out using as many sites on the body as possible, and to follow a pattern of rotation for those sites. Choosing a site to insert a new infusion set can be the topic of many control battles between the parents and a child using an insulin pump. For these families and everyone else using an insulin pump, there are two suggestions. First, making a “site change template” (see Figure 2) to match your or your child’s body and site locations is a great idea. This can be fun for the young and the old. Some children have brought in colorfully decorated site change templates. Also, many teens and adults have created some nice computer generated site change templates. One was made by a teenager whose desire and talent were leading him into the graphic design field. He made a very professional looking template. Of course, what matters is not that it looks great, but that you have one. So don’t let this intimidate you. Once the template is created, laminate it, and use a wet-erase marker to date the sites as they are used. Second, establish a pattern of rotation. There is really no perfect site change rotation pattern. If the pattern is followed, each site will have maximum rest before it is used again. If you are using an adhesive remover such as Unisolve® or Detachol®, it might be best to choose a rotation

pattern that includes alternating sides of the body. If enough residue of the adhesive remover is left on the skin, it can keep the tape of the new infusion set from sticking. If deciding where to locate the next infusion site becomes a battle between you and your child, this rotation plan can be made into a written contract and signed by all involved family members. If you look on the site change template and consult the “pattern of rotation” plan, it’s no one’s decision as to where the next site goes. No one is the bad guy!

Body fat can make a big difference when selecting infusion site locations. People can be divided into two categories: the very thin and everyone else. Many children fit into the “very thin” category. There are, of course, many teens and adults that also fit into this “very thin” category. Putting an infusion set into the abdomen of a thin person may be uncomfortable and may not allow good insulin absorption. Choosing the right location and the right infusion set are both essential. A visual guide to follow is when the top of a pinch is close to 3/4 inch (2 cm) wide; it is a good place to try a “straight-in” or 90° infusion set. Pinching the fat is only to make sure there is enough fat in the area. When inserting a 90° infusion set using an insertion device, it is suggested that you do not pinch. The 30° infusion set can work when you have a pinch of approximately 1/2 inch (1.2 cm) across. Work with your doctor or diabetes educator to locate all potential infusion site locations on your body.

There are, of course, some body locations that should be avoided. Insertion sites should be at least two inches (5 cm) from the center of the belly button. Avoid the midline of the body and areas with scar tissue or hard lumps. Most often you should keep infusion sites underneath the ribs and away from the hipbones. Each site should be at least one inch (2.5 cm) from the previous site and from a sensor insertion site when using a continuous glucose monitor (CGM).

The body locations that can be used, in order of popularity with most people, are the abdomen,

legs, buttocks and arms. The abdomen is a very popular site for an infusion set. It is easy to reach, easy to see (with the exception of large breasted women) and is known as the fastest absorbing location. As long as there is enough fat under the skin, the upper abdomen under the ribs, the lower abdomen, and the side “love handle” areas can be used. Some people do not have enough fat in their abdomen, so thankfully this is not the only location we have to insert an infusion set. But, if you have enough fat there, use it!!

The legs are another possible infusion site location. If you are active, it is important not to locate the site in the area of a large muscle, like the quadriceps or hamstring muscles. Insulin infused on top of a large exercising muscle can absorb rapidly resulting in a low blood sugar. The top of the thigh is a location away from large muscles and can be used as an infusion site. This infusion site location is more popular in females than males due to normal fat deposition. It is also a good place for chubby babies. Again, if you have enough fat there, use it!

The buttocks win the prize for the most reliable padding on most people. Thin body shape or not, the buttocks are well padded for the time we might slip on the ice, or the time we need to put an infusion set in. Parents will need to insert the infusion set in younger children's buttocks. Adolescents, teens, and adults can use a mirror to help with the sites that are on the buttocks and more toward their midline. The inserters are a tremendous help when self-inserting in the buttocks. Most people have at least three infusion site locations on each buttock. The top sites should start where the buttocks becomes “cushy.” For most people, this starts at the cleft of the buttocks. To check and see how low a site can be inserted, sit on your hands with your pinky fingers just covered by your buttocks. Leave your hands there as you stand up and look in a mirror. You might be surprised to find that you sit mainly on your legs and the very bottom of your buttocks, leaving many areas available above that point for infusion sites. Once again, if you have fat in this area, use it!

If you or your child has enough fat in the upper arm to pinch 3/4 inch (2 cm), use the arms for infusion sites. The difficulty with this location is securing the 23 to 43 inches of tubing down the back with tape so that the tubing does not get caught on anything, resulting in a dislodged infusion set. This is the main reason why the arm is not a first choice for an infusion site location.

WHERE TO WEAR YOUR PUMP

There are many ways to wear an insulin pump (e.g., using a belt clip, a zipper bag or a harness). The age of the person, activity level, job, comfort level and preference all help determine where to wear the pump.

When a child is on an insulin pump, there are some additional considerations. The questions to ask are:

- Can the child be trusted not to touch the pump buttons?
- Can the child's friends and classmates be trusted not to touch the pump buttons?

For a very young child using a pump, the zipper bag or harness are good options. Both keep the pump under the clothing and in a pouch. This can help with concerns of other children wanting to play with the pump and also protect the pump from harm. When a young child uses a belt clip to hold the pump to the waistband, there is a chance that in a quick rush to use the restroom the pump will take a plunge in the toilet. The zipper bags and harnesses are attached onto their own belts, reducing the chance of a toilet incident.

The zipper bags are also good options for adults whose jobs involve manual labor. The bag will protect the pump from both mechanical and cosmetic harm. People who wear belts often use a zipper bag since it is so easy to get to the pump. They simply feed their belt through the belt loop at the back of the zippered bag. Some belt clips have a hook that helps prevent the pump from being knocked off the belt or

waistband. This can make it hard to pull the belt clip off the waistband when needing to look at the pump screen.

Older children and adults who don't want to have something attached to their clothing have a few "off the beaten path" options. The pump can be clipped to the top of boots that are underneath pants or a skirt. The pump can be put into a baby sock that is pinned or sewn to the inside of a pant leg. People wearing baggy pants may keep their pump in their front pocket. To protect the tubing, a buttonhole can be made in the lining of the front pocket. The tubing can be disconnected and fed through the buttonhole and reconnected to their cannula insertion. The pump can then be kept in the pocket while the tubing is protected under the clothing. There are many pump-wear gadgets that can be used, like bra pouches, thigh bands, shirts and pants with a pump pocket, etc... To explore the many options available, enter **insulin pump accessories** into your online search engine.

Sleeping with a pump can take some adjustment. Of course people who are sound sleepers may not even notice that it is there. For those who have a side of their body that they do not lay on, it is easy to clip the pump to that side of the shorts or pants worn to bed. For restless sleepers, the pump can be placed under the pillow or placed in bed next to the wearer. Inevitably, occasional tangles will occur. If this happens a lot, it would be a great idea to put a piece of medical tape over the tubing, near the infusion site to prevent the site from being pulled out during the night. This will also give the site some extra protection during the day.

TAPE ISSUES (also see Chapter 16)

Keeping the infusion set on is frequently a concern and can be a nuisance for many people. For pump therapy to be successful, the infusion set must stick. It must withstand extreme temperatures for a long period, swimming, bathing, sweating, roughhousing, changing clothes and various other activities. Each infusion set relies on adhesive that keeps the

cannula insertion in place. Adhesives can adhere differently on each person. The reliability of the adhesive can also change over time. For instance, the infusion tape might stick fine in the winter but peel off unexpectedly during the summer. Tape allergies and skin irritation from using adhesives are not common, but they can add another level of troubleshooting. Thankfully, most often there is an answer to whatever adhesive issue is ailing you.

There are various products available to help ensure that the adhesive will last reliably for two to three days. The progression of these site prepping agents in terms of their adhesive-enhancing capabilities is:

Alcohol→IV Prep®→Skin Prep®→Tincture of Benzoin→Mastisol®

If the infusion site falls out with the use of Skin Prep, there are two other products that you can try after alcohol has been applied to clean the site. These products are Tincture of Benzoin and Mastisol. Of these two, Mastisol enhances the adhesive the most and usually causes less irritation. Once the right prepping product is found to ensure a lasting adhesion, another problem may be created: getting the infusion tape off!

If you have a child on the insulin pump or if you have sensitive skin, it is important to be aware that removing the adhesive of the infusion set can hurt more than inserting an infusion set. Have no fear! There are products to help with that as well. Two products that help remove the adhesive of an infusion set are Detachol® and Uni-Solve®. These products can be rubbed on the top and outside of the infusion set to start loosening the adhesive. Then, while lifting up the edge of the tape, rub the product between the skin and the adhesive to break the adhesion. This will help the tape peel off. When using these products, make sure their residue is completely removed so the next infusion set will stick. Removing the infusion set right before a bath or shower can help remove the residue and clean the old site as well as the next infusion site.

Adults and children who are physically active should consider placing an extra piece of tape on their tubing. A small piece of non-irritating roll tape can be placed over the tubing a half inch from the infusion set adhesive. If the tube gets caught on something or pulled, this extra piece of tape is like a shock absorber and may prevent the infusion set from being pulled out. Since this tape will have to be removed each time the pump is disconnected, there is no reason to use adhesive-enhancing products for this tape.

Allergies and sensitivities to the infusion set and the infusion set tape are not very common, but they can occur. If a pump user notices itching with a red rash in the area of the infusion set tape, a product can be applied to provide a barrier between the skin and the tape. Skin Prep, a product mentioned previously, or Bard® Barrier can be used. Of these two products, Bard Barrier provides more protection. Another way of dealing with skin irritation is to apply a dressing tape (such as Tegaderm® or IV3000®) to the skin first and then insert the infusion set through the dressing tape. This method prevents the problematic adhesive from touching the skin.

Allergies to the infusion set material, like the cannula, are very rare. If such a problem were to occur, the area of insertion would show a localized reaction. Switching to a different infusion set is the best plan of action for an infusion set allergy.

DISCONNECTING

Life necessitates that people using an insulin pump disconnect their tubing from their insertion site for one reason or another. This is easy to do with the quick release feature available on almost all infusion sets. When disconnecting, the insertion cannula stays in place while the tubing and the insulin pump are removed. Most infusion sets have a cap that can be placed over the cannula insertion when disconnecting to keep the site clean and protected. Everyone will disconnect with baths or showers simply because there is nothing to clip the pump to and who wants to wash their hair with one hand while holding their pump in

the other? It is also recommended that insulin pumps not be submerged in water, even the waterproof pumps. This will be discussed in more detail later.

Due to sports and activities, children and young adults seem to disconnect more frequently than older adults. When you or your child are participating in contact sports, it is highly recommended that you disconnect during the activity. Children and teens are also more likely to disconnect for activities such as physical education in school, rock climbing, or going to a playground or an indoor gym. Many water activities, such as swimming, water skiing, snorkeling and scuba diving, require the pump user to disconnect from their insulin pump. It is recommended that people disconnect for water activities even when using a waterproof pump. There are two main reasons for this. First, depending on the activity, you might have to take up scuba diving to find your pump if it gets separated from you during the activity. Second, waterproof insulin pumps are only waterproof in the absence of hairline cracks. Since many pump wearers do not diligently check their pump for cracks on a daily basis, when given a choice it is safest not to submerge the pump.

One of the tricks with disconnecting from the pump is to make sure you do not become insulin deficient. Insulin is needed even when exercising, just usually in a smaller amount. This is discussed in the Exercise Chapter (Chapter 9).

Since each person is different in the length of time they can safely be disconnected, a little trial and error is needed to learn how to accommodate these situations. When learning to adjust your insulin, you should check your or your child's blood sugar before disconnecting, within an hour after disconnection, when reconnecting, and approximately an hour and a half later. Checking at these times will allow you to see your or your child's blood sugar pattern while being disconnected for that particular exercise or activity. After seeing the pattern, you can more accurately match it to an insulin adjustment for exercise.

There are a few patterns you could see:

- The blood sugar might stay at an acceptable level at each of these blood sugar checks. If so, thank your lucky stars, and remember that things can change over time.
- You might see that things go well during the disconnection and even when reconnecting; however, the blood sugar level is high later. If this is the pattern, just give a small amount of insulin as a bolus when you reconnect to replace a portion of the insulin that was missed. You would do the same thing if your blood sugar was a little high when reconnecting.

When disconnecting for a day in the water, you can disconnect and then reconnect every hour to hour and a half and give a portion of the missed basal rate as a bolus. Some people decide to go back on a long acting insulin such as Lantus or Levemir for a full day at the beach or water park. This is an option. However, a fair amount of control is lost when doing this. With an insulin pump, you can more easily and spontaneously adjust your basal insulin if the exercise decreases the blood sugar level more than expected. You can't adjust the long-acting insulin once it is given.

AIR IN THE TUBING

Air bubbles in tubing create dead space (i.e., areas that have no insulin). When air gets into the tubing, it can affect the consistent and accurate delivery of insulin. Air injected into the body from the cannula insertion placed in the fatty tissue layer will not cause harm. It can, however, affect the blood sugar level. Unfortunately most insulin pump wearers do not routinely check their infusion tubing for air bubbles. A good routine for checking for air bubbles is to quickly scan the infusion tubing first thing in the morning and again before bed. Depending on the size of the bubble, it may or may not affect the blood sugar level. If it is determined that the bubble needs to be removed, the process is very simple, but may take a few minutes (see below).

There are several situations that can cause air in the infusion tubing, and then there are a fair amount of “how did that air get in there” mysteries:

- One of the most common reasons for air in the infusion tubing is the temperature of the insulin when the reservoir is filled. As cold insulin warms up to room temperature, it releases gas. So if a reservoir is filled with insulin straight out of the refrigerator, air bubbles will result.
- Changing altitude also can increase the chance of finding air bubbles. It is wise to pay extra attention to the tubing during air travel and when in the mountains.
- Young, active children will sometimes have more air bubbles than adults. It is thought that the “bouncy” nature of their play can increase air bubbles.
- Air bubbles can enter the reservoir during the preparation of a new infusion set. If the reservoir is pinched at the o-rings at the top of the plunger, the seal between the o-rings and the reservoir's sides can be compromised, introducing air.
- Occasionally there will be mystery bubbles. Don't let these bother you too much. Just make sure you take appropriate action to remove them.

One inch (2.5 cm) of air in the infusion tube is equal to 0.50 unit of insulin. Depending on the insulin requirement of the person wearing the pump, this may be equal to going a long time without insulin or only a short time. For instance, if the person wearing the insulin pump's basal rate is 1.0 unit per hour and they have one inch of dead air space in their infusion tube, they will miss approximately 30 minutes of their basal insulin. Losing more than 20 minutes of insulin due to an air bubble is too long. The bubble should be removed.

The first and most important action to take when getting a bubble out of the infusion tubing is to

disconnect the tubing from the cannula insertion. Almost all insulin pumps have a Prime or Fill Tubing function. This is the function used to remove air bubbles as opposed to using a normal bolus. That way the insulin pump doesn't record the insulin infused to get the bubble out as insulin that entered the body to lower the blood sugar level. It would not be included in the insulin on board calculation. Once the bubble has been pushed out using the Prime or Fill Tubing function and the Prime has stopped, the tubing must be reconnected to the cannula insertion.

FORGETTING TO PRIME/FILL THE CANNULA

A common mistake is to forget to prime (fill) the cannula. Insulin pumps with infusion tubing will require two separate primes: one for the infusion tubing, and one for the cannula. The infusion tubing and cannula must both be filled before

the pump is used. Once the infusion set is inserted, the needle that is used to introduce the soft Teflon cannula is removed. If insulin has not been infused, the removal of the needle leaves an air space in the cannula. The cannula prime fills this space so that when the insulin pump delivers insulin, it is delivered into the body as opposed to being used to fill up that space. This is the very last step in changing the infusion set and is sometimes forgotten.

SUMMARY

All people are different. Some may prefer a particular cannula or tubing. Good site rotation is important for everyone. Finding the optimal methods of insulin infusion and correctly troubleshooting the problems that arise will help to achieve maximum benefits from insulin pump therapy.

