Introduction
As insulin pump therapy increases in popularity, it can no longer be considered an elite or complex method of diabetes management. Pump therapy is another intensive insulin delivery option for people with diabetes, along with multiple daily injections. Moreover, as the number of insulin pump users continues to grow, it is important that diabetes educators have a basic level of knowledge regarding insulin pump therapy.

It is not necessary or practical for all diabetes educators to be certified pump trainers, or even to know the technical operation of all pump models. Manufacturers operate 24-hour customer service telephone hotlines for technical issues and questions, which educators can access as well. However, diabetes educators need to know how to assess and counsel insulin pump users in clinic, and understand the resources available to patients in order for them to be successful with their pumps.

Long-term pump users should be assessed for educational gaps, as they may not have had access to the resources that are now available. They may also have had limited contact with endocrinologists or diabetes education centres, perhaps because they felt the visits were not pump-focused. This population may benefit from re-education regarding insulin pump use.

This article will offer tips for assessing insulin pumpers in clinic and provide resources for further information. This article will highlight only the basics; infusion site issues, physical activity, special situations and continuous glucose monitoring are all topics that require separate articles!

Data assessment:
Basal and bolus insulins
With respect to data assessment, Figure 1 provides an example of a clinic data collection form. Ideally, the pumper should bring their blood glucose (BG) readings from the last 2 weeks with them to their appointment.

All of this data, including BG readings, are available if the pump data is uploaded to a computer. The data can be viewed during the visit, if the clinic is set up to do this. If not, patients can print the data at home and bring it with them to their appointment. Ideally, insulin pump users should upload their pump data at home and evaluate the results at least once per month. Technical support to facilitate this is available from pump manufacturers.

Basal insulin is the “background” insulin needed to meet the body’s physiological needs. It does not cover food at all. Properly set basal rates should allow users to miss meals, sleep in, or fast for 24 hours, while maintaining target BG levels. Figure 2 depicts a basal insulin profile.

When examining a basal insulin profile, take note of how many basal rates there are. Pump settings are individualized, but diabetes educators should be suspicious if there is only 1 basal rate or if there are >4. While some individuals are fine with the same basal rate for 24 hours, more often it means they have not adjusted the insulin rate since starting the pump.

When there are many basal rates, I like to ask pumpers how they came up with their basal rate pattern. Two common answers are “I don’t know,” or they are making frequent changes based on individual BG readings rather than on trends.

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**Figure 1. Clinic assessment sheet**

<table>
<thead>
<tr>
<th>Basal 1 0000 h _____ U/h</th>
<th>Insulin to carbohydrate ratio:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal 2 _____ h _____ U/h</td>
<td>1 U per _____ g carbohydrate</td>
</tr>
<tr>
<td>Basal 3 _____ h _____ U/h</td>
<td>ISF _____ mmol/L glucose/U</td>
</tr>
<tr>
<td>Basal 4 _____ h _____ U/h</td>
<td>Target range _____ mmol/L</td>
</tr>
<tr>
<td>Basal 5 _____ h _____ U/h</td>
<td>TDD _____ U/day</td>
</tr>
<tr>
<td>Total basal insulin _____ U/day</td>
<td>Active insulin _____ h</td>
</tr>
</tbody>
</table>

% of TDD as basal _____

ISF = insulin sensitivity factor
TDD = total daily dose
The standard or active basal pattern should be set based on usual activity levels. Basal rates should be re-evaluated at least yearly in adults and monthly in growing children. Basal insulin adjustments are based on BG pattern management over a 3-4 day period, just as they are with insulin injection therapy.

Basal rate evaluation requires a systematic approach, keeping all variables as constant as possible. The 24-hour period can be broken up into manageable blocks. The place to start is the overnight period. This is the easiest period to evaluate, since there is usually no food eaten. If the fasting BG trend is in range, the overnight basal rate is likely fine. If the fasting BG trend is out of range, then the overnight basal will require adjustment until the morning BG is at target. To see precisely where the BG is out of range, some overnight checking of BG at midnight and 3:00 am is useful. Adjustments to the basal rate are usually made at least 2–3 hrs before the problem time, e.g. if BG is in range at 3:00 am but trending high at 7:00 am, the basal rate should be increased by 3:00 am (Figure 3).

Once the morning BG is in range, the next step is to break the day into manageable blocks of 3–5 hours, where the pumper will delay meals/snacks and evaluate the effect on BG. For more information on evaluating basal rates, refer to the “Recommended reading” list at the end of this article.

If the pumper does not bring their BG records to a clinic appointment, suggest that they record BG levels and boluses for 1 week, and then look for patterns. Entering all BG data into the pump and uploading it on the computer is an even better option. Temporary basal rates can be used to try new basal rates or patterns before changing the active rates.

Calculating the total daily dose of insulin
The total daily dose (TDD) of insulin is a useful piece of information to have. Ask the pumper to
read their TDD for the last 6 days (not including today) and calculate the average. You also need to know what percent of the TDD is basal insulin. The basal insulin should comprise 40–60% of the TDD; if it is outside of that range, something is not right.

Following is an example of TDD analysis:

Megan’s basal rate is 1.50 U/hr × 24 hrs = 36 U/day of basal insulin. For the last week, her TDD has been between 40 and 44 U/day. This means her basal insulin is 85–90% of the TDD and she is only using 4–6 U/day to bolus. What is happening here?

a) Megan is hardly eating any carbohydrates.
b) Megan is using the basal insulin to cover food.
c) Megan is missing most of her meal boluses.

All 3 of the above answers are possible explanations, and none of them are ideal. Since Megan’s glycated hemoglobin (A1C) is 12.9%, we know that (c) is correct. A quick look at the bolus history on her pump reveals that she is missing most of her meal boluses. If her A1C had been in target range, we would know that (a) or (b) was the situation.

Insulin boluses are given to match carbohydrate intake from food, and to correct BG when it is higher than target. Often, when a change is needed, the automatic reaction of pumpers, and even healthcare professionals, is to increase the basal insulin rate; the other rates don’t tend to get increased in proportion. If there is a change in TDD due to growth, weight change, life changes (e.g. puberty, pregnancy, menopause) or a drastic change in routine, the whole picture needs to be examined.

Insulin to carbohydrate ratio is initially calculated as 500 ÷ TDD (450 in children), e.g. if the average TDD is 42 U/day, the carbohydrate ratio is 500 ÷ 42 = 1 U for every 12 g of carbohydrate. If the BG before eating is usually in range, but 2 hours and 4 hours later is high, then the insulin to carbohydrate ratio should be decreased so that the amount of insulin is increased. If missing or delaying food causes low BG levels, then the basal rate at this time is too high.

Many pumpers give meal boluses after eating. Rapid-acting insulin is not really rapid though. It takes 10–15 minutes to start working, and about 60 minutes to peak, so this will always result in high BG levels by the time insulin is given and for some time thereafter. Giving meal boluses before eating can decrease A1C by ~0.7% (1) and also decrease the likelihood of forgetting boluses. Carbohydrate counting is important, but taking insulin is even more important! Four missed meal boluses per week will increase A1C by 1% (2). If the pumper is concerned that they don’t know how much they will eat, they can bolus for an amount of carbohydrate they know they will consume, then bolus for the remainder when they have finished eating.

Large boluses can be given as extended, or square wave, boluses over 15–30 minutes for better absorption. Pumpers doing large boluses may also have better absorption with longer needles if using 90-degree infusion sets. For high-fat meals, combination, or dual wave, boluses can be used (3). This is where some of the bolus (usually 50–70%) is given right away, and the remainder is spread out over a period of time.

The correction factor, or insulin sensitivity factor (ISF), is how much BG will drop with 1 U of rapid-acting insulin. This is initially calculated as 100/TDD, e.g. a person whose TDD is 50 U/day should have an ISF of ~2. Parents often forget to recalculate their ISF when there has been an insulin adjustment for growth. If the BG doesn’t lower to target with corrections, the ISF must be adjusted. If correction boluses are needed constantly, this is a sign that settings need to be re-evaluated.

Today’s insulin pumps all have built-in bolus calculators (e.g. Bolus Wizard™, EZ Carb™, EZ BG™) that calculate meal and correction boluses. Long-term pumpers may not be using these newer features, and should be encouraged to do so. The pump will subtract unused insulin (“insulin on board” or “active insulin”) from corrections. This is a great safety feature to prevent “stacking” of insulin, i.e. giving correction boluses too close together. The bolus calculator settings should be set properly and re-evaluated to be effective. For most adults, target BG should be 6.0 mmol/L, with age-appropriate targets set for children. Active insulin time should be set at 3–4 hours. When pump settings are at the default settings that the pump is shipped with, educators should be suspicious!

Insulin pumpers need to know how to manage high BG levels and prevent diabetic ketoacidosis. This includes checking urine or blood ketones, troubleshooting high BG levels and calculating extra insulin to be administered by syringe for ketones (4). It is also very important to have back-up insulin and a plan for going off the pump (5). Additional information can be found in the “Recommended reading” list below.
Conclusions
Regardless of insulin delivery method their patients are using, it is important that diabetes clinicians be able to provide assistance with insulin adjustment and daily diabetes management. Key assessments that should be undertaken with insulin pump users in a clinic setting include: number of basal rates; fasting BG trend; TDD insulin distribution; bolus habits; frequency of need for corrections; and low BG following missed meals.

References

Recommended reading

New DES Logo
Louise K. LeFebvre RD CDE

The Diabetes Educator Section (DES) has a new logo! The submission was selected by attendees and the DES National Executive at the May 2009 DES Leadership Forum. The winner was Liz Yeung RD CDE who works at the EatRight Ontario call centre in Toronto. The DES Executive presented a pin with the new logo to Liz at the May 2010 Leadership Forum “Meet and Greet” evening.

Liz was asked to share reflections on her design. She writes “there is a reason why you see three and not just one or two maple leaves in the new DES logo. When I reflected about our role as educators to my amusement, many of the aspects that came to mind were trios.” Some of the trios Liz identified are:

• diabetes is a multifaceted disease: the ABCs
• diabetes triangle of diet, medication and activity
• a winning team: the patient and their family, the diabetes care team and the association and researchers that help move us forward in diabetes care
• educators and what we strive to do with our patients: educate, empower and encourage
• number of months of blood glucose levels reflected by glycated hemoglobin levels
• number of teaspoons of sugar in a carbohydrate choice