Technology for Diabetes: 101
Basic Rules of the Road
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Quick Pump Facts!

- Constant insulin supply
- Pager-sized “mini-computer” worn outside the body
- Pump itself is attached to your body by a small cannula inserted into the subcutaneous tissue (under the skin)
Goal

- The goal of insulin pump therapy is to mimic the insulin action of a fully functioning pancreas.

- In those without diabetes, the pancreas makes a constant stream of insulin.
  - It makes extra insulin every time you eat.
How Pumps Work

- The pump automatically delivers a programmed basal (background) dose of insulin.
- The user (child or parent) delivers bolus dose of insulin for meals.
Without Diabetes

- Breakfast
- Lunch
- Dinner
- Bedtime

Blood Insulin Level
Multiple Daily Injections

Rapid-Acting Insulin

Long-Acting Insulin = Lantus, Levemir
Rapid-Acting Insulin = Humalog, Novolog, Apidra

Blood Insulin Level

Breakfast  Lunch  Dinner  Bedtime
Insulin Pumps use only Rapid-Acting Insulins: Humalog, Novolog, Apidra
Basal Rate

- A constant delivery of insulin
  - Rate is pre-programmed by the pump
  - Replaces Long-Acting Insulin

- Basal rate is measured in units per hour (units/hr)
Basal Rate

- Determine your *starting* basal rate, when switching from injections to a pump:
- Take your total daily dose of Lantus/Levemir
  \[= \text{_______ units}\]
- Divide this by 24 (there are 24 hours in a day)
  \[= \text{_______ units/hour}\]
- When using an insulin pump, you may need less insulin than with injections. You may start with 90% (or less) of your total basal.
  - To find 90% of your total basal, multiply the answer above (units/hour) by 0.9
    \[= \text{_______ units/hour}\]
Marcy’s Current Injection Regimen:
15 units of Lantus every night

Converting to basal rate:
15 ÷ 24 = 0.625 units/hour
0.625 x 0.9 = 0.563 units/hour
(or 0.550, 0.560, 0.5)
David’s Current Injection Regimen:
4 units of Levemir in the a.m. and 4 units of Levemir in the p.m.

Converting to basal rate:
4 + 4 = 8 units
8 ÷ 24 = 0.333 units/hour
0.333 x 0.9 = 0.299 units/hour
(or 0.3, 0.25, 0.275)
Basal Rates

- Rates can vary during the day, creating a stairstep effect rather than a flat line.
- Most patients start a pump with only one basal rate.
- Rates are programmed into the pump based on the child’s blood sugar trends.
- Rates remain the same from day to day, but may be altered when needed.
- The basal rate can also be temporarily changed for alterations in schedule, exercise or illness.
Bolus Dose

- A bolus dose of insulin is taken
  - For meals and snacks for carbohydrate coverage
  - Correct elevated blood sugar levels

- Correction for elevated blood sugar should **ALWAYS** be delivered prior to eating

- Some patients prefer to deliver part of the food bolus after the meal
  - Ideally the entire bolus is delivered before the meal

- For best glycemic control:
  - Bolus insulin = 50-60% of total daily insulin
  - Most of bolus should be for carbohydrate coverage, not for elevated blood sugars
Smart Pumps

If turned on, the pump can calculate your bolus based on:

- Blood sugar
- Carbohydrate intake
- Insulin-to-carbohydrate ratio (ICR)
- Insulin sensitivity factor (Blood glucose correction)
- Blood sugar target
- Insulin on Board (IOB) – active insulin still in the body from the last bolus dose
Smart Pumps

- Pump may be pre-programmed with your dosing regimen:
  - Simply enter the blood sugar and the amount of carbs they are about to eat
  - Pump calculates a precise dose, and recommends this
  - User can accept or override the calculated dose
Smart Pumps

- The pump can be programmed to have different patterns throughout the day or week
  - Basal and/or bolus dosing patterns
- People who may benefit from this are:
  - Athletes
  - Children who live in different households
  - Changes in routine (school day versus weekend)
<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Model</th>
<th>Reservoir Type</th>
<th>Basal Increment</th>
<th>Basal Increases and Maximum</th>
<th>Bolus Duration for 1 Unit</th>
<th>Memory, Features</th>
<th>Battery Life</th>
<th>Battery Type</th>
<th>Use With Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tandem Diabetes Care</td>
<td>t:sling Insulin Pump</td>
<td>300 units Disposable Cartridge with Micro-Delivery Technology™</td>
<td>0.001 at programmed rates ≥ 0.1 units/hr</td>
<td>0.05 to 25 units in 0.01-unit increments, with option for additional 25 unit bolus.</td>
<td>~30 seconds</td>
<td>Non-volatile memory with 90-day history (up to 11,000 events). 25% smaller than comparable pumps. Touch screen makes it simple to learn and use. Advanced Micro-Delivery Technology™ delivers insulin in the smallest increments available. Can be integrated with CGM (Dexcom).</td>
<td>7 days between charges</td>
<td>Built in rechargeable lithium polymer battery. Can be charged via wall, car, or USB outlets without interrupting insulin delivery.</td>
<td>Watertight (IPX7); 3ft. for up to 30 minutes</td>
</tr>
<tr>
<td>Animas Corporation (U.S. &amp; Canada)</td>
<td>OneTouch Ping Glucose Management System</td>
<td>2.0 mL</td>
<td>0.025 unit</td>
<td></td>
<td>1 to 2 seconds</td>
<td>Non-volatile: 500 boluses, 270 basals, 120 daily totals, 60 alarms, 60 primes, 900 blood glucose levels. Software Download: Pump data downloads in less than 10 minutes for OneTouch Ping. Can be integrated with CGM (Dexcom).</td>
<td>5 to 7 weeks with lithium</td>
<td>(1) AA lithium or AA alkaline (1.5 volt)</td>
<td>Pump: 12 feet for 24 hours (Meter-Remote must not be exposed to water)</td>
</tr>
<tr>
<td>Insulet Corporation</td>
<td>OmniPod Insulin Management System</td>
<td>Holds 200 units of insulin; Reservoir integrated into Pod</td>
<td>0.05 unit</td>
<td>0.05, 0.1, 0.5, 1.0, or 5.0 unit increments, using a maximum of 20 steps</td>
<td>40 seconds</td>
<td>No tubing required. System includes a disposable Pod that is worn for 72 hours and a PDM that wirelessly controls the Pod’s functions. Pod integrates the infusion set, cannula, and automated inserter. PDM includes a built-in FreeStyle blood glucose meter, contains a food library with more than 1,800 common foods and their nutrition information, and stores 90 days of data (up to 5,400 records).</td>
<td>PDM: 3 weeks</td>
<td>Two AAA alkaline</td>
<td>Pod is waterproof to a depth of 25 feet for up to 60 minutes (IPX8), so there’s no need to disconnect from the Pod for swimming or bathing.</td>
</tr>
<tr>
<td>Medtronic</td>
<td>MiniMed Paradigm Real-Time Revel™ 523</td>
<td>Holds 176 Units of insulin; Disposable shock-resistant plastic</td>
<td>0.025</td>
<td>0.025, 0.05, 0.1 up to 25 units</td>
<td>40 seconds</td>
<td>Can be integrated with CGM (Enlite). Threshold suspend feature available. 1:1 insulin to carb ratio. Approximately 90 days of data (prime, bolus, daily totals, alarms and programming)</td>
<td>3 weeks</td>
<td>One AAA alkaline; readily available</td>
<td>Watertight (IPX7)</td>
</tr>
<tr>
<td>Medtronic</td>
<td>MiniMed Paradigm Real-Time Revel™ 723</td>
<td>Holds 300 Units of insulin; Disposable shock-resistant plastic</td>
<td></td>
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</tbody>
</table>
Reservoir

- Insulin is put in a reservoir or cartridge
  - Reservoir is then placed inside the pump
  - Omnipod – Reservoir is housed inside the pod
- The reservoir can hold up to 200-300 units depending on the pump
- All reservoirs and pods are one-time use only
  - Any insulin left inside them when they are changed gets thrown out
Infusion Set

- Pump delivers insulin through an infusion set
- Pump is attached to its user through a cannula (a tiny straw) that is inserted through the skin and taped into place
  - Omnipod – placed directly onto the skin
- A needle is used to insert the cannula and then removed
- There are multiple infusion sets available for each tubing pump
  - Some are inserted manually while others have an automatic inserter available.
Infusion Set

- The infusion set is inserted into subcutaneous tissue
- Stays in Place for 2-3 days
- Must be changed at least every 3 days
- Rotate between same sites used for insulin injections:
  - Abdomen
  - Buttocks
  - Outer Thighs
  - Back of Arms
Infusion Sets

Pod

Comfort Short

Inset

Inset 30
Caution!

- An insulin pump provides rapid-acting insulin ONLY.
- If the pump stops infusing, ketones and ketoacidosis can happen quickly.
  - The pump may not alarm!
    - For this reason, only patients who check blood glucose at least four times daily are safe to use pumps
    - Avoid changing pump site right before bedtime
- If blood sugar is >300, then user needs to check urine ketones and blood sugar every 1-2 hours
- You **MUST** change infusion set and give insulin boluses via injection if you have moderate or large ketones!
- Sick Day Action Plan for pump users
# Diabetes Sick Day Action Plan - Pump

**Name:** _____________

**DOB:** _____________

**Date of visit:** __________

**Weight:** ____________

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**Diabetes Sick Day Action Plan**

Ketones are caused by lack of insulin.

1. CHECK KETONES IF
   - Blood sugar is above 300 mg/dl
   - Blood sugar is below 300 mg/dl but you are sick – vomiting, fever, stomach pain

2. FIND YOUR KETONE ZONE BELOW.

## Green Zone:

- Urine ketones – negative or trace
- Blood ketones – less than 0.6

**Drink lots of sugar free fluids, Drink _____________ per hour - (at least 1 oz for each year of age every hour, example: a 5 year old should drink at least 5 oz every hour).**

Continue checking blood sugar every 2 hours and ketones every time you pee while you are sick or your blood sugar is above 300 mg/dl.

## Yellow Zone: Watch Out!

- Urine ketones – small
- Blood ketones – 0.6-1.4

**Keep usual basal rate(s) running and continue to give boluses according to your usual scale. Boluses may be given through pump as usual.**

Consider changing your pump site, especially if blood sugar does not come down within 2 hours of an insulin bolus.

**If you have vomiting for more than 2 hours or blood sugars less than 100 and are not eating/drinking well call your doctor.**

## Red Zone: Danger!

- Urine ketones – moderate or large
- Blood ketones – 1.5-3.0

**My Sick Day Diabetes Regimen**

Change your pump site. Give all boluses by syringe until you are in the Green Zone.

<table>
<thead>
<tr>
<th>MEDICINE</th>
<th>MY DOSES:</th>
<th>WHEN:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Insulin</td>
<td>Total Daily Basal</td>
<td>Give as Lantus if pump is not working.</td>
</tr>
<tr>
<td>Rapid Acting Insulin</td>
<td>(0.1 units/kg)</td>
<td>Every 2 hours if blood sugar is above 200mg/dl. If eating, add to carb dose.</td>
</tr>
</tbody>
</table>

Check blood sugar and ketones every 1-2 hours.

**Drink lots of sugar free fluids (see above).** If blood sugar is less than 250 mg/dl then include 15 grams of sugar containing fluids (Gatorade, juice, soda, etc.) every 1-2 hours.

**If ketones do not decrease after 2 Red zone insulin doses, you have vomiting for more than 2 hours, your blood sugar is less than 100 or other concerning symptoms – CALL YOUR DOCTOR right away.**

**STOP:** High risk of diabetic ketoacidosis!

- Blood ketones – more than 3.0
- Fast or abnormal breathing
- Weak or difficult to awaken
- Chest pain or severe headache
- Appears confused

**CALL YOUR DOCTOR RIGHT AWAY!**

**Phone Number of Doctor/Nurse**

Day: 314-454-6051
Night: 314-454-6000 Ask for Diabetes Doctor on call

If unable to wake your child or if child appears very weak, call 911 immediately
Extra Pump Supplies

- Fast acting insulin (pen or vial)
- Insulin syringes
- Infusion sets / reservoirs
- Pump batteries / charger
- Owner’s manual
- Unopened Lantus/Levemir
Continuous Glucose Monitors (CGM)

- Catheter inserted under the skin
  - Sites similar to those for insulin pumps
- Some insulin pumps are paired with a glucose monitor (Medtronic, T-slim, Animas)
- CGM may be used without a pump
  - Can be purchased/used independent of one another
Continuous Glucose Monitors

- Require calibration by fingerstick checks at least twice daily
- **Does not** replace fingersticks at meals and bedtime
- Can recognize trends in blood sugars
  - Blood glucose level should be confirmed by fingerstick if CGM indicates a low blood sugar
  - May help identify highs and lows at times fingersticks not normally done (and while sleeping)
Common Pump Myths

- Easy, no more injections EVER
- Less time-consuming
- Less blood sugar monitoring
- Perfect blood sugars
- No complications
- Can eat whatever/whenever you want
- Involves a surgical procedure
Challenges of Insulin Pumps

- Increases risk of diabetic ketoacidosis
- Requires more frequent blood sugar monitoring
- Potential infusion site infection
- Inconvenience of wearing
- Troubleshooting problems during class, sports or activities
- **Cost**
Psychological Roadblocks

- Being connected to insulin pump continuously
- Self image/modesty issues
- Where to wear the pump for special events (i.e. sports, prom)
Psychological Benefits

- Increased flexibility in lifestyle
- Can more easily eat with friends at parties and events
- Sleepovers
- Late night snacking
- Sleeping in
- Can adjust rates for exercise or activities
Potential for Better Control

- Provides more precise dosage delivery
- Better absorption of insulin
- Potential to improve blood sugar control
- Less variability in blood sugars
- Decreases hypoglycemia
- Advanced insulin pump features
So What’s Next?

- Meet with company representatives
- Figure out which device works for you
  - Your insurance
- Insulin pumps
  - Pump readiness test
  - Saline trial (test drive)
  - Insurance approval
  - Pump start
- Continuous glucose monitor
  - Discuss with your provider and insurance company
Endocrinology and Diabetes | Diabetes Education

Adjusting Insulin Doses
To best manage type 2 diabetes, it is important that your pre-meal blood sugar is in a range that isn't too high or too low. You should make changes to your insulin doses to help keep blood sugar in the target range. Here you can learn how to make adjustments in your insulin doses to better control your diabetes, Read more...

Be Healthy Today; Be Healthy For Life
Information for Youth and their Families Living with Type 2 Diabetes
This easy-to-use guide was adapted from the TODAY study education manual by the American Diabetes Association to provide helpful information for teens managing diabetes. Read more...
Click to visit the American Diabetes Association website

Glucagon
Glucagon is a hormone that raises blood glucose by releasing sugar from the liver. It is used as an emergency rescue medication to treat severe low blood sugars. Read more...

Insulin Pumps
Insulin pumps are a tool often used to give more flexibility in managing your diabetes. While insulin pumps can be helpful, you must follow basic steps to make sure they are used safely and correctly. For a quick overview of safety, click here. For more detailed information about how pumps work and what are different pumps, click here.

www.pediatrics.wustl.edu/DiabetesEd
Thanks!

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