Pumping Protocol
A Guide to Insulin Pump Therapy Initiation
Includes an introduction to continuous glucose monitoring (CGM) and therapy management software
# Table of Contents

- Purpose .......................................................... 3
- Insulin Pump Therapy ......................................... 4
- Guidelines for Initial Pump Settings .......................... 5
- Calculate Starting Doses ...................................... 6
- The Bolus Wizard® Calculator .................................. 10
- Adjusting Pump Settings ....................................... 12
- Basal Rate Adjustments ....................................... 14
- Bolus Adjustments .............................................. 15
- Infusion Site Care .............................................. 16
- DKA Prevention ................................................... 18
- Unexplained High Glucose ..................................... 19
- Prevention of Hypoglycemia ................................... 20
- Treatment of Hypoglycemia .................................... 21
- Special Populations ............................................. 22
- Therapy Management Software ............................... 27
- Continuous Glucose Monitoring (CGM) ...................... 32
- Forms ............................................................. 34
- References and Suggested Reading .......................... 36
Bruce W. Bode, MD, FACE

An internationally known speaker and author on insulin pump therapy and continuous glucose monitoring, Dr. Bode, a graduate of Emory University School of Medicine, is in private practice with Atlanta Diabetes Associates. He is active in both the Georgia affiliate of the American Diabetes Association and the Juvenile Diabetes Research Foundation. Dr. Bode is also the editor of the American Diabetes Association’s *Medical Management of Type 1 Diabetes*.

Contributors

Jennifer Kyllo, MD

Jennifer Kyllo, MD is the Medical Director of the McNeely Pediatric Diabetes Center and Endocrine Clinic at Children’s Hospitals and Clinics of Minnesota. She attended medical school at the University of Minnesota and completed her residency and fellowship at the University of Iowa. Her principal areas of interest include caring for children with diabetes and improving access to new diabetes technology for children.

Francine R. Kaufman, MD

Francine Ratner Kaufman, MD is Chief Medical Officer and VP of Global Clinical, Medical and Health affairs at Medtronic Diabetes and a Distinguished Professor Emerita of Pediatrics and Communications at the Keck School of Medicine and the Annenberg School of Communications of the University of Southern California. Dr. Kaufman was president of the American Diabetes Association (2002-03), and serves on the Advisory Council of the Diabetes Branch of the NIH.

While every reasonable precaution has been taken in the preparation of this guide, the author, sponsor and publisher assume no responsibility for errors or omissions, nor for the uses made of the materials contained herein and the decisions based on such use. This document does not contain all of the information necessary for the proper care and treatment of patients with diabetes. As such, no individual may rely on the information presented herein in forming a comprehensive treatment program or in treating any patient with diabetes. No warranties are made, expressed or implied, with regard to the contents of this work or to its applicability to specific patients or circumstances. Neither the author, sponsor, nor the publisher shall be liable for direct, indirect, special, incidental or consequential damages arising out of the use or inability to use the contents of this guide.
Purpose

This booklet is designed for clinicians who are just beginning to prescribe pump therapy, as well as those who already have experience and want to review the latest strategies for optimizing glycemic control with insulin pump therapy. It provides information on proper candidate selection and the indications and protocols for initiating insulin pump therapy. Guidelines for fine-tuning insulin doses and strategies for preventing insulin pump problems are also presented.

Fundamental Concepts

Over the past three decades, insulin pump therapy has proven to be the most effective insulin regimen available for achieving tight glycemic control while minimizing the risk for hypoglycemia. It is readily used for the intensive management of adults, adolescents and children with type 1 diabetes and those with insulin-requiring type 2 diabetes.

Effectiveness of insulin pump therapy is attributed to three fundamental principles:

1. **Pumps use only rapid-acting insulin for basal and bolus insulin requirements.**
   Eliminating longer acting insulin helps improve glycemic control during fasting states because:
   - The action/peak time of rapid-acting insulin is more predictable and reproducible than long-acting insulin.
   - The tiny basal doses that are continuously delivered over each hour are more consistently absorbed by the body.

2. **Pumps deliver insulin in two ways, basal and bolus.**
   - **Basal Insulin** is a continuous infusion of insulin that is delivered automatically 24 hours a day. The purpose of basal insulin is to cover hepatic glucose production and to maintain glucose stability during fasting states (between meals and during sleep).
   - **Bolus Insulin** is delivered “on-demand,” by the patient, for food intake and/or to correct glucose levels that are above the patient’s target range, delivered separately or together.
     - **Food Bolus:** Insulin given to cover food or drink that contains carbohydrates.
     - **Correction Bolus:** Insulin given to correct blood glucose (BG) levels that are abnormal.

3. **Medtronic pumps use a Bolus Wizard® calculator.**
   The Bolus Wizard calculator helps make diabetes management and bolus dosing easier and more accurate because it:
   - Calculates the bolus amount for the patient, according to their personalized settings.
   - Tracks the amount of active insulin remaining from previous boluses.
   - Subtracts active insulin from correction doses before suggesting the total bolus amount, which helps to prevent lows that result from the stacking of insulin.
   - Records BG readings, carbohydrates consumed, units of insulin delivered and the time each was entered. Data can be downloaded into reports for easier, more accurate evaluation.
Insulin Pump Therapy

Indications

Type 1 and insulin-requiring type 2 patients who are unable to achieve acceptable glycemic control, including those with:

- Elevated A1C.
- Glycemic variability.
- Recurrent hypoglycemia, nocturnal hypoglycemia, activity-induced hypoglycemia and hypoglycemia unawareness.
- Pregnancy/Pre-pregnancy.
- Recurrent diabetic ketoacidosis (DKA)/recurrent hospitalizations.
- Dawn phenomenon.
- Gastroparesis.
- Patient preference, meal-timing flexibility and normalization of lifestyle.
- Low insulin requirements (not easily measured via syringe).
- Inability to self-administer insulin (pre-school/grade school).
- Inability to predict food or meal intake (infant/toddler).

Patient Requirements

- Responsible and psychologically stable
- Willingness to monitor blood glucose (BG) a minimum of four times a day
- Willingness to quantify food intake
- Willingness to comply with medical follow-up

Benefits

- Improved glycemic control and decreased glycemic variability
- Improved control of dawn phenomenon
- Decreased severity and frequency of hypoglycemia
- Increased flexibility, normalization of lifestyle and sense of well-being

Precautionary Areas

- Hyperglycemia and/or DKA if insulin infusion is interrupted
- Lipohypertrophy (when infusion sites are not rotated properly)
- Infusion site reactions (rash and skin irritation) or infections
Guidelines for Initial Pump Settings

Insulin pump therapy uses rapid-acting insulin for both basal and bolus insulin requirements.

- Hypoglycemic unawareness or other concerns, use the lower dose.
- The percentage split for total daily basal and total daily bolus varies, especially in pediatric populations.

### Reduced Dose

Based on Daily Injection Dose

\[
\text{Injection Dose} \times 0.75 = \text{Reduced Dose}
\]

### Weight Dose

Based on Weight

\[
\begin{align*}
\text{kg} \times 0.50 & = \text{Wt. Dose} \\
\text{lb} \times 0.23 & = Wt. Dose
\end{align*}
\]

### Pump Total Daily Dose (TDD)

Average of Reduced Dose and Weight Dose

\[
\frac{(\text{Reduced Dose} + \text{Weight Dose})}{2} = \text{Pump TDD}
\]

### Total Daily Basal Dose

Pump TDD x 40% to 50% = Daily Basal Dose

### Basal Rate (BR)

\[
\text{Daily Basal Dose} \div 24 = \text{Hourly BR}
\]

### Insulin Sensitivity Factor (ISF)

\[
1700 \div \text{Pump TDD} = \text{ISF}
\]

### Total Daily Bolus Dose

Pump TDD - Daily Basal Dose = Daily Bolus Dose

### Insulin-to-Carb Ratio (ICR)

\[
\text{Daily Carbs} \div \text{Daily Bolus Dose} = \text{ICR}
\]

* Hypoglycemic unawareness or other concerns, use the lower dose.
† The percentage split for total daily basal and total daily bolus varies, especially in pediatric populations.

Guidelines for Transitioning to Pump Therapy

**Goal:** Eliminate as much intermediate/long-acting insulin as possible before starting pump.

- Stop intermediate-acting insulin 12 hours before and long-acting insulin 24 hours before initiating pump therapy.
- Have patient give injections using small amounts of rapid-acting insulin as needed (every 3 to 4 hours) to keep BGs acceptable until pump therapy is initiated.
- In situations where intermediate or long-acting insulin is not discontinued, program a temporary basal rate to deliver a reduced basal amount (50% to 90% less than calculated starting rate) for the first 12 to 24 hours of therapy.
**Calculate Starting Doses**

**Pump Total Daily Dose (Pump TDD)**

Reduce the current total daily injection dose by 25 percent, calculate the weight dose and then average the two together.

**TOTAL DAILY DOSE**  
The total amount of insulin (basal and bolus) delivered by the pump each day.

**BASAL INSULIN**  
A continuous infusion of insulin given to cover hepatic glucose production.  
- Intended to mimic pancreatic basal secretion and maintain glucose stability in fasting states (between meals and during sleep).  
- Replaces long-acting insulin.  
- Programmed to match patient’s individual diurnal variation.

**BOLUS INSULIN**  
Given on demand by patient, as needed, for carbohydrate intake and correcting abnormal glucose levels.

**REDUCED DOSE**  
Based on daily injection dose  
\[ \text{Injection Dose} \times 0.75 = \text{Reduced Dose} \]

**WEIGHT DOSE**  
Based on weight  
\[ \text{kg} \times 0.5 \text{ u} = \text{Weight Dose} \]

or  
\[ \text{lb} \times 0.23 \text{ u} = \text{Weight Dose} \]

**INITIAL PUMP TDD**  
Take average of Reduced and Weight Dose  
\[ (\text{Reduced Dose} + \text{Weight Dose}) \div 2 = \text{Pump TDD} \]

**EXAMPLE PATIENT**  
Type 1 Male  Weight: 70 kg (154 lb)

<table>
<thead>
<tr>
<th>Current Daily Insulin Regimen</th>
<th>Rapid-acting: 11 units pre-meal x 3</th>
<th>33 u/day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Long-acting: 20 units (Bedtime)</td>
<td>+ 20 u/day</td>
</tr>
<tr>
<td>Total Daily Injection Dose</td>
<td></td>
<td>= 53 u/day</td>
</tr>
</tbody>
</table>

**Reduced Dose**  
53 u/day \( \times 0.75 = 40 \text{ u/day} \)

**Weight Dose**  
\[ 70 \text{ kg} \times 0.5 \text{ u} = 35 \text{ u/day} \]

or  
\[ 154 \text{ lb} \times 0.23 \text{ u} = 35 \text{ u/day} \]

**Initial Pump TDD**  
\[ (40 \text{ u/day} + 35 \text{ u/day}) \div 2 = 37.5 \text{ u/day} \]

**Clinical Considerations for Pump TDD**

- Use less than a 25% reduction if daily injection dose is more than 70% rapid-acting insulin.
- Pediatric patients who have good control on injections may require as little as a 5% reduction.
- For children & teens, TDD is variable. May require as much as 1.0 u/kg to calculate weight dose.
- Hypoglycemia or hypoglycemia unawareness, use the lower of the two values.
- Persistent hyperglycemia, elevated A1C or pregnancy, use the higher value.
- Erratic glucose control, starting therapy at diagnosis or from oral medications, use weight method.
**Total Daily Basal and Total Daily Bolus**

First, determine the percent of TDD to be delivered as basal insulin and then multiply TDD by that percent. This will give you the Total Daily Basal amount. To calculate Total Daily Bolus subtract the Total Daily Basal amount from the TDD.

### BASAL

\[
Pump \ TDD \times \% \ Basal = Total \ Daily \ Basal
\]

### BOLUS

\[
Pump \ TDD - Total \ Daily \ Basal = Total \ Daily \ Bolus
\]

#### EXAMPLE PATIENT

50% of TDD as Total Daily Basal

<table>
<thead>
<tr>
<th>Total Daily Basal</th>
<th>Total Daily Bolus</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 u/day x 0.5 = 18.75 u/day (Pump TDD)</td>
<td>37.5 u/day - 18.75 u/day = 18.75 u/day (Daily Basal Amount)</td>
</tr>
<tr>
<td>(Total Daily Basal)</td>
<td>(Total Daily Bolus)</td>
</tr>
</tbody>
</table>

#### Clinical Guidelines for Total Daily Basal and Bolus Percentages

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Total Daily Basal</th>
<th>Total Daily Bolus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>40% to 50%</td>
<td>50% to 60%</td>
</tr>
<tr>
<td>Puberty to Adult</td>
<td>30% to 40%</td>
<td>60% to 70%</td>
</tr>
<tr>
<td>Pre-Puberty to Puberty</td>
<td>20% to 40%</td>
<td>60% to 80%</td>
</tr>
</tbody>
</table>

**Basal Rate**

Pump therapy is typically initiated with a single basal rate that is delivered evenly over each hour, 24 hours a day. To calculate the initial basal rate, divide 24 hours into the Total Daily Basal amount.

### INITIAL BASAL RATE

\[
Total \ Daily \ Basal \div 24 \ hours = Hourly \ Basal \ Rate
\]

#### EXAMPLE PATIENT

Total Daily Basal: 18.75 u/day

<table>
<thead>
<tr>
<th>Initial Basal Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>18.75 u/day \div 24 hours = 0.78 u/hour (Hourly Basal Rate)</td>
</tr>
</tbody>
</table>

Start initial basal rate at 0.775 or 0.800 units per hour

**TOTAL DAILY BASAL**

Total amount of basal insulin delivered over 24 hours.

**TOTAL DAILY BOLUS**

Total amount of bolus insulin (food and correction) delivered over 24 hours.

**BASAL RATE**

The amount of basal insulin programmed to deliver evenly over each hour.

**BASAL RATES**

<1 UNIT/HOUR

Program in 0.025 unit increments.

>1 UNIT/HOUR

Program in 0.050 unit increments.
### Insulin-to-Carbohydrate Ratio (ICR)

If a patient on multiple daily injections has established an ICR that provides reasonable post-prandial control, start pump therapy using that ICR. Or, use one of the methods below to calculate the initial ICR. If a patient is not yet carb counting or does not have an accurate food log, use the 450 Rule.

#### Method 1

Estimated Daily Carb Intake

\[
\text{Carb Grams} \div \text{Total Daily Bolus} = \text{ICR}
\]

#### Method 2

450 Rule

\[
450 \div \text{Pump TDD} = \text{ICR}
\]

#### Example Patient

<table>
<thead>
<tr>
<th>Method 1</th>
<th>Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Daily Carbs: 225 grams</td>
<td>Total Daily Bolus: 18.75 u/day</td>
</tr>
<tr>
<td>225 grams ÷ 18.75 u/day = 12 grams/unit</td>
<td>450 ÷ 37.5 u/day = 12 grams/unit</td>
</tr>
<tr>
<td>1 unit covers ~ 12 grams of carbohydrate</td>
<td>1 unit covers ~ 12 grams of carbohydrate</td>
</tr>
<tr>
<td>ICR = 12 grams</td>
<td>ICR = 12 grams</td>
</tr>
</tbody>
</table>

### Fixed Gram or Exchanges per Meal Method

For patients who are not yet carbohydrate counting or who have low cognitive ability, use the Fixed Gram or Exchange per Meal method explained below:

1. Calculate patient’s ICR using the 450 Rule.
2. Instruct patient on number of carbs or exchanges to enter for: a snack, a small meal, a medium size meal, a large meal.
3. Have patient use the Bolus Wizard® calculator to enter current BG and the number of grams or exchanges you told them to use for the size meal they are planning to eat.

This allows non-carb counting patients to use the Bolus Wizard and receive similar benefits to a carb counting patient, making diabetes management and record keeping easier.

### Key Concepts for ICR

- Patients often require more than one ICR to obtain optimal post-prandial control.
- Different ICRs can be programmed into the Bolus Wizard for different times during the day. Example: breakfast, lunch, dinner, snack times.
Insulin Sensitivity Factor (ISF)

If a patient on multiple daily injections has an established ISF that currently provides reasonable correction doses, you can start pump therapy using that ISF. Or, use one of the methods below to calculate the initial ISF. For patients who have frequent hypoglycemia or hypoglycemia unawareness, use the 2000 Rule.

**INSULIN SENSITIVITY FACTOR**
The number of mg/dL one unit of insulin lowers glucose.

Used to calculate correction bolus amounts.

**BG TARGET**
BG value used in the correction formula when calculating a correction dose.

**CORRECTION DOSE**
Amount of insulin calculated to correct a BG that is above target. Or, the amount of insulin subtracted from a food bolus when the BG is below target.

### Calculate Starting Doses

**METHOD 1**

1700 Rule

\[ 1700 \div \text{Pump TDD} = \text{ISF} \]

**METHOD 2**

2000 Rule

\[ 2000 \div \text{Pump TDD} = \text{ISF} \]

### EXAMPLE PATIENT

Pump TDD: 37.5 u/day

<table>
<thead>
<tr>
<th>Method 1</th>
<th>Method 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ 1700 \div 37.5 = 45.3 \text{ mg/dL} ]</td>
<td>[ 2000 \div 37.5 = 53.3 \text{ mg/dL} ]</td>
</tr>
<tr>
<td>One unit decreases BG ~ 45 mg/dL</td>
<td>One unit decreases BG ~ 53 mg/dL</td>
</tr>
<tr>
<td>ISF = 45 mg/dL</td>
<td>ISF = 53 mg/dL</td>
</tr>
</tbody>
</table>

### ISF CORRECTION FORMULA

\[ (\text{Current BG} - \text{BG Target}) \div \text{ISF} = \text{Correction Dose} \]

### EXAMPLE PATIENT

BG Target = 100 mg/dL  ISF = 45 mg/dL

**IF BG IS ABOVE TARGET (160 mg/dL):**
A positive correction dose is calculated.
\[ (160 - 100) \div 45 = 1.3 \text{ units} \]

**IF BG IS AT TARGET:**
No correction amount is calculated.

**IF BG IS BELOW TARGET (60 mg/dL):**
A negative correction dose is calculated and subtracted from the food bolus.
\[ (60 - 100) \div 45 = -0.9 \text{ units} \]
The Bolus Wizard® Calculator

Once the Bolus Wizard is programmed with the patient’s settings, the patient simply enters their current BG and the grams of carbohydrate they plan to eat. The Bolus Wizard uses this information to calculate the total bolus (called the “Estimate Total”) for the patient.

**Benefits of using Bolus Wizard calculator**

- More accurate bolus dosing
- Tracks active insulin
- Helps prevent stacking of insulin doses
- Reduces risk of lows related to stacking
- Keeps comprehensive record of:
  - BG readings
  - Carbohydrate grams
  - Insulin doses
  - Times of each entry

**Bolus Wizard Settings**

- Insulin-to-Carbohydrate Ratio (ICR)
- Insulin Sensitivity Factor (ISF)
- BG Target Range
- Active Insulin Time

**Correction Bolus and Bolus Wizard Target Ranges**

When a BG reading is above the programmed Target Range, the Bolus Wizard uses the higher value in the range to calculate the correction dose. When a BG is below the Target Range, the Bolus Wizard uses the lower value to calculate the negative or reverse correction dose.

<table>
<thead>
<tr>
<th>EXAMPLES OF BOLUS WIZARD CORRECTION CALCULATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target Range Setting = 90 – 110 mg/dL ISF = 45 mg/dL</td>
</tr>
<tr>
<td><strong>ABOVE RANGE:</strong> (175 mg/dL) (175 - 110) ÷ 45 = 1.4 units (correction bolus)</td>
</tr>
<tr>
<td><strong>BELOW RANGE:</strong> (72 mg/dL) (72 - 90) ÷ 45 = -0.40 units (subtracted from food bolus)</td>
</tr>
</tbody>
</table>

Negative correction amounts are subtracted from food boluses before the Estimate Total is given.

Multiple target ranges are used to accommodate daytime, nighttime, pre- and post-meal glucose goals. When determining Bolus Wizard target ranges, keep in mind, these are not the same as ADA or AACE BG guidelines; instead they are the values the pump “targets” when correcting high or low BGs.

**Clinical Considerations for Setting Initial Bolus Wizard Target Ranges**

<table>
<thead>
<tr>
<th>Daytime</th>
<th>Nighttime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults and Adolescents (13+ yrs)</td>
<td>90 – 100 mg/dL</td>
</tr>
<tr>
<td>School Age (6 – 12 yrs)</td>
<td>90 – 110 mg/dL</td>
</tr>
<tr>
<td>Toddler to Pre-school (0 – 6 yrs)</td>
<td>100 – 120 mg/dL</td>
</tr>
<tr>
<td>Hypoglycemia Unawareness</td>
<td>100 – 120 mg/dL</td>
</tr>
<tr>
<td>Pregnancy</td>
<td>80 – 90 mg/dL</td>
</tr>
</tbody>
</table>

*Modifications to Bolus Wizard Target Ranges should be based on each patient’s clinical history.
**Active Insulin Time**

The length of time rapid-acting insulin lowers glucose varies in each individual. Therefore, Active Insulin Time can be adjusted to track for 2, 3, 4, 5, 6, 7 or 8 hours. The 7 and 8 hour Active Insulin times are only needed if regular insulin is used in place of rapid-acting insulin.

The Bolus Wizard tracks and calculates the amount of active insulin based on the patient’s individually programmed Active Insulin Time. When a patient’s BG is above target, the Bolus Wizard subtracts the active insulin from the correction insulin before calculating the Estimate Total.

<table>
<thead>
<tr>
<th>Clinical Considerations for Setting the Active Insulin Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults: 4 to 5 hours • Children: 3 to 4 hours • Pregnancy: 3 to 4 hours</td>
</tr>
</tbody>
</table>

**How the Bolus Wizard Calculates the Estimate Total**

When a patient enters their BG and carbohydrate grams, the Bolus Wizard does the math, using the patient’s pre-programmed settings (ICR, ISF, Target Range and Active Insulin Time) to calculate the Estimate Total for the patient.

**TOTAL BOLUS**

\[
\text{Food bolus} + (\text{Correction bolus} - \text{Active Insulin}) = \text{Estimate Total}
\]

**EXAMPLE PATIENT**

<table>
<thead>
<tr>
<th>ICR: 12 grams</th>
<th>ISF: 42 mg/dL</th>
<th>BG Target: 100 – 110 mg/dL</th>
<th>Active Insulin Time: 5 hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food to be Eaten: 24 grams</td>
<td>Current BG: 220 mg/dL</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Bolus Wizard® Settings</th>
<th>Estimate Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wizard: On</td>
<td>Estimate total: 3.0 units</td>
</tr>
<tr>
<td>Carb Units: Grams</td>
<td>Food Intake: 24 grams</td>
</tr>
<tr>
<td>Carb Ratios: 12</td>
<td>BG: 220 mg/dL</td>
</tr>
<tr>
<td>Sensitivity: 42</td>
<td>Food: 2.0 units</td>
</tr>
<tr>
<td>BG Target: 100–110</td>
<td>Correction: 2.6 units</td>
</tr>
<tr>
<td>Active Ins Time: 5 hours</td>
<td>Active Insulin: 1.6 units</td>
</tr>
</tbody>
</table>

1. Calculates food bolus: \[
24 \text{ grams} \div 12 \text{ grams/unit} = 2.0 \text{ units}
\]

2. Calculates correction bolus: \[
\frac{220 \text{ mg/dL} - 110 \text{ mg/dL}}{42 \text{ mg/dL/unit}} = 2.6 \text{ units}
\]

3. Subtracts active insulin: \[
2.6 \text{ units} - 1.6 \text{ units} = 1.0 \text{ unit}
\]

4. Adds food + adjusted correction for estimate total: \[
2.0 \text{ units} + 1.0 \text{ unit} = 3.0 \text{ units}
\]
Adjusting Pump Settings

Evaluating glucose control and adjusting pump settings is a logical, systematic process. It is based on the concept that rapid-acting insulin has a predictable glucose lowering effect, basal insulin covers hepatic glucose production, and bolus insulin covers food intake and the correction of high BGs.

Evaluating and adjusting insulin pump settings is accomplished by reviewing pertinent BG data, insulin delivery and carb intake. This data is typically obtained either by having patients manually write the information on a BG log sheet, or by uploading the pump into CareLink Personal or Professional Software and reviewing the CareLink reports.

Like all insulin regimens, adjusting insulin is an ongoing process. During the first few weeks of pump therapy, and any time pump settings need to be re-evaluated, have the patient follow these guidelines.

Patient Guidelines

- During adjustment phases check BG as follows:
  - Upon waking
  - Bedtime
  - Pre-meal
  - Mid-sleep (or every 3 to 4 hours during sleep)
  - Post-meal (2 hours)
- Avoid snacking between meals (unless treating a low).
- Eat low-fat meals in which carb grams can be accurately counted.
- Use the Bolus Wizard® calculator to give all boluses.
- Upload pump to CareLink Personal every 3 to 7 days.
- If not using CareLink, record BGs, carbs, boluses on log sheet for review every 3 to 7 days.
- Call your office if any lows occur (lows must be eliminated to successfully fine-tune).

Evaluation Guidelines

Evaluate glycemic control by time segments:

- Bedtime to mid-sleep (or every 3 to 4 hours during sleep)
- Mid-sleep to wake-up
- Pre-meal to post-meal (2 hour)
- Post-meal to next pre-meal
- Post-meal to bedtime
Adjustment Guidelines

Basal rates, carbohydrate ratios and insulin sensitivity factors are the primary settings that need to be adjusted. While all three are reviewed simultaneously, it is usually best to first focus on getting basal rates (especially overnight) set correctly. The secondary settings, Active Insulin Time and Target Ranges, rarely need to be adjusted, and should not be changed until after primary settings have been verified as correct.

To make adjustments:

- Identify glycemic rise/fall patterns and any other issues in each time segment.
- Adjust settings based on the glycemic rise/fall pattern and identified issues.
- Make one (no more than two) changes at a time.
  - Hyperglycemia Adjustments: Make adjustments after observing pattern for 3 to 7 days.
  - Hypoglycemia Adjustments: Consider adjusting if any lows occur. Avoiding lows during adjustment phases is key, because lows and the treatment of lows disrupts BG patterns.
- Re-evaluate BGs 3 to 7 days post adjustment to confirm no other changes are needed.

Key Concept

Basal insulin delivers in tiny amounts each hour and its affect on glucose takes place over a period of time. Therefore, changes made to basal rates should be programmed to begin 2 to 3 hours prior to the observed BG rise or fall. Goal: Prevent the glycemic excursion from occurring.

Typical diabetes management behaviors and therapy checks that should be assessed prior to adjusting insulin settings are listed below.

<table>
<thead>
<tr>
<th>BEHAVIORAL CHECKS</th>
<th>THERAPY CHECKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are there 3 or more boluses/day?</td>
<td>Verify pump settings</td>
</tr>
<tr>
<td>Are there 4 or more BGs/day?</td>
<td>Verify basal percent is &lt; 50% of TDD</td>
</tr>
<tr>
<td>Is the Bolus Wizard® calculator being used?</td>
<td>Evaluate overnight control (basal)</td>
</tr>
<tr>
<td>Is infusion set changed every 2 to 3 days?</td>
<td>Evaluate pre-meal control (basal)</td>
</tr>
<tr>
<td>Is pump suspended less than 1 hour/day?</td>
<td>Evaluate post-meal control (carb ratio)</td>
</tr>
<tr>
<td>Troubleshoot decision making</td>
<td>Are they having significant excursions?</td>
</tr>
<tr>
<td>Do they use a temp basal for exercise?</td>
<td></td>
</tr>
</tbody>
</table>
Basal Rate Adjustments

When basal rates are set correctly, patients should be able to sleep late, eat late, or even skip a meal without experiencing glycemic excursions.

**Overnight Basal Rates**

Evaluation Guidelines
Assess overnight control by observing rise/fall patterns across time segments (bedtime to mid-sleep; mid-sleep to wakeup). Adjust basal insulin to match diurnal variations.

**Adjustment Guidelines**

**Goal:** BG remains within target (does not rise or fall >30 mg/dL) through the night.

- If BG rises or falls >30 mg/dL: Adjust rate by 10–20%, 2 to 3 hours before observed rise or fall.
- If BG drops below 70 mg/dL: Instruct patient to treat the low and decrease rate 10–20%.

Obtaining optimal overnight glycemic control minimizes the risk of nocturnal hypoglycemia, allows patients to sleep through the night and wake within target, making evaluation of daytime basal easier since patients are not treating lows or correcting highs.

**Daytime Basal Rates: Fasting Method**

Evaluation Guidelines
Evaluate BGs across skipped-meal time segment (pre-breakfast to pre-lunch, pre-lunch to pre-dinner, or pre-dinner to bedtime). Adjust/add basal rate(s) based on rise/fall pattern across skipped-meal time.

**Adjustment Guidelines**

**Goal:** BG remains stable (does not rise or fall >30 mg/dL) during skipped-meal time.

- If BG rises or falls >30 mg/dL: Adjust rate 10–20%, 2 to 3 hours before observed rise or fall.
- If BG drops below 70 mg/dL: Instruct patient to treat the low and decrease rate 10–20%.

**Daytime Basal Rates: Non-Fasting Method**

Evaluation Guidelines
Evaluate basal rates by comparing the two-hour post-meal BG to the next pre-meal BG. If a high is corrected, do not include that post- to pre-meal segment in your evaluation.

The following principles apply when evaluating basal rates in a non-fasting state:

- Two-hour post-meal BGs should be 30 to 60 mg/dL higher than pre-meal BGs;
- Two-hour post-meal BGs should steadily decline and be within pre-meal ranges by next meal.

**Adjustment Guidelines**

**Goal:** Post-meal BGs steadily decline and are back within pre-meal target range by next meal.

- If BG falls >60 mg/dL, or drops below target: Lower rate 10–20%.
- If BG rises, stays the same or decreases <30 mg/dL: increase rate 10–20%.
Bolus Adjustments

Insulin-to-Carbohydrate Ratios (ICR)

Evaluation Guidelines
Evaluate ICRs by comparing each pre-meal BG to its corresponding 2-hour post-meal BG.

Adjustment Guidelines
Goal: Two-hour post-meal BG is between 30 mg/dL to 60 mg/dL higher than pre-meal BG.
- If 2-hour post-meal BG has increased more than 60 mg/dL from the pre-meal BG: Decrease ICR 10–20% or 1 to 2 grams/unit.
- If 2-hour post-meal BG has increased less than 30 mg/dL from the pre-meal BG: Increase ICR 10–20% or 1 to 2 grams/unit.

Questions to Ask Prior to Adjusting ICR
- Were boluses missed or administered late? Boluses should be given before eating.
- Did the patient count carbohydrates correctly?
- Did patient adhere to Bolus Wizard® calculator recommendations?

Insulin Sensitivity Factor (ISF)

Evaluation Guidelines
Evaluate ISF by comparing pre-correction BG to the 2- and 4-hour post-correction BGs.

Adjustment Guidelines
Goal: Post-correction, 2-hour BG is about halfway to target and at target by 4 hours.
- If 2-hour post-correction BG is not halfway to target and 4-hour post-correction is not at target: Adjust ISF 10–20% as needed.

Bolus Wizard Target Ranges and Active Insulin Time
BG target ranges and active insulin settings are based on patient history, glycemic awareness and clinical judgment. These settings rarely need to be changed and should only be adjusted after primary settings (basal rates, ICRs and ISF) are correctly set.

Adjusting ICR and ISF Ratios

<table>
<thead>
<tr>
<th>When working with ICR and ISF ratios:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• To decrease bolus amounts, increase the ratio.</td>
</tr>
<tr>
<td>• To increase bolus amounts, decrease the ratio.</td>
</tr>
</tbody>
</table>

Example: For 60 grams of carbohydrate if ICR is: 1:15 = 4 units; 1:12 = 5 units; 1:10 = 6 units.
Infusion Site Care

Infusion Sets
Medtronic offers many types of infusion sets with varying lengths of cannulas and angles of insertion. Generally, when a patient has minimal subcutaneous fat, a shorter cannula or a set that goes in at an angle is used.

Auto-insertion devices designed to ensure proper insertion technique and reduce pain upon insertion are available for most infusion sets. The clinical manager in your area can help you and your patients decide which set is most appropriate.

- Sites should be changed and rotated every 2 to 3 days.
- Proper site rotation helps to:
  - Prevent lipohypertrophy and scar tissue.
  - Ensure tissue heals before inserting in that area again.
  - Maintain healthy, viable tissue, which enhances consistent insulin absorption.

Patient Guidelines for Insertion and Rotation
Instruct patients to:

- Insert infusion sets into easy-to-access subcutaneous tissue.
- Insert sets into sites that are at least 2 to 3 inches away from previous site.
- Use “clock”, “M” or “W” method to help ensure proper rotation.
- Avoid inserting into scar tissue or areas with lipohypertrophy.
- Avoid areas subject to excessive movement or constricted by clothing.

Commonly Used Infusion Sites

PREGNANCY
Consider inserting infusion sets in areas of subcutaneous tissue that are not tense from increasing abdominal girth, especially during the third trimester.
Infection Prevention

Infection is rare when proper insertion guidelines are followed. To minimize the risk of infection encourage the use of good clean technique:

- Wash hands
- Clean site thoroughly with a skin prep wipe
- Keep all infusion sets sterile
- Change set and rotate site every 2 to 3 days

If an infection occurs:

- It is usually staphylococcal in nature and typically requires oral antibiotic treatment.
- If infections are recurrent, recommend routine:
  - Use of Hibiclens®, followed by alcohol to cleanse the site before inserting the set.
  - Application of an antibiotic ointment immediately after removing the infusion set.
- If an abscess occurs, perform an incision, drain the area and culture the fluid.
  - Rule out methicillin-resistant staphylococcus.
  - Consider using Bactroban® in the nares weekly to minimize recurrent infections.

Skin Irritation

If skin irritation occurs, different treatment approaches are recommended depending on the source of irritant:

- **Tape**: Change type of tape (i.e., Polyskin®, IV 3000® or silk tape).
- **Tubing**: Place tape under and over tubing (sandwich technique).
- **Soap or Alcohol**: Change to antibacterial soap or use Skin Prep™ wipes.

If a patient experiences problems with their infusion set tape, he or she can download a copy of *Tape Tips and Site Management* at www.medtronicdiabetes.com/downloads. The patient may also call the 24-Hour HelpLine at 1.800.646.4633.

**Key Point**: Instruct patients to wait to insert infusion sets until their skin is completely dry. This helps reduce the risk of skin reactions that can occur when adhesive dressing is placed on a wet site that has been cleansed with a skin prep, cleaner or wipe.
DKA Prevention

Because insulin pump therapy uses only rapid-acting insulin, the onset of diabetes ketoacidosis (DKA) can occur quickly if insulin delivery is interrupted for a period of time. Therefore, all type 1 patients must be educated on DKA prevention strategies. The most important of which are: 1) adhering to a routine BG monitoring schedule (four to six times per day) and 2) never ignoring an unexplained high blood glucose.

Protocol for Treating Hyperglycemia

When BG is ≥250 mg/dL:

If Ketones are Positive
Or nausea and/or vomiting is present

- Give a correction dose via injection
- Change infusion set, reservoir and insulin
- Monitor BG every 1 to 2 hours and give insulin via injection until BGs are within target
- If BG is not decreasing, and you have moderate to high ketones, nausea, vomiting or difficulty breathing, call healthcare provider or go to emergency room

If Ketones are Negative

- Give a correction dose via insulin pump
- Recheck BG in one hour
- If BG has not decreased
  - Give a manual injection
  - Change infusion set, reservoir and insulin
- Continue to monitor BG until glucose levels are within desired range

*The most common causes of unexplained hyperglycemia that does not respond to a correction bolus include: a kinked or displaced cannula, an infusion set or reservoir issue or a “bad” (denatured) vial of insulin.*

Have patients follow the “Troubleshooting Guidelines” (found on next page) any time they have unexplained high BGs that do not respond to a correction bolus.

Best Practice: Provide type 1 patients with a prescription for ketone strips prior to pump initiation. Teach and reinforce the importance of testing for ketones any time BGs are above 250 mg/dL.

Patients should fully understand the following concepts:

- Unexplained high BGs should NEVER be ignored.
- Two unexplained high BGs in a row or a high BG that is not responding to a correction bolus may indicate an infusion set or insulin pump problem.
- Nausea and vomiting can be caused by DKA.
- Illness increases the risk for developing DKA.
- When ill, patients should check BG every one to two hours, check for urine ketones every time they urinate, and drink fluids. Staying hydrated helps prevent DKA.
- Never exercise when ketones are positive.

*When DKA does occur, keep in mind that even after DKA has been properly treated and glucose returns to normal ranges, ketones may continue to be present for up to 24 hours.*
## Troubleshooting Guidelines

<table>
<thead>
<tr>
<th>What to Check</th>
<th>Questions to Ask</th>
<th>If Yes…</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infusion site</td>
<td>• Is it red, irritated or painful?</td>
<td>Change infusion set, reservoir and insulin</td>
</tr>
<tr>
<td></td>
<td>• Is it wet, or does it smell like insulin?</td>
<td></td>
</tr>
<tr>
<td>Infusion set tubing</td>
<td>• Are there bubbles (larger than champagne bubbles) in the tubing?</td>
<td>Change infusion set, reservoir and insulin</td>
</tr>
<tr>
<td></td>
<td>• Is there blood in the tubing?</td>
<td></td>
</tr>
<tr>
<td>Connection between reservoir and infusion set</td>
<td>• Are there leaks/breaks?</td>
<td>Change infusion set, reservoir and insulin if unable to correct the problem by tightening</td>
</tr>
<tr>
<td></td>
<td>• Is connection loose/easily moved?</td>
<td></td>
</tr>
<tr>
<td>Reservoir</td>
<td>• Is it loaded incorrectly?</td>
<td>Change infusion set, reservoir and insulin if unable to correct the issue</td>
</tr>
<tr>
<td></td>
<td>• Is the reservoir empty?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Are there excessive bubbles?</td>
<td></td>
</tr>
<tr>
<td>Insulin</td>
<td>• Has insulin vial expired?</td>
<td>Change infusion set and reservoir using a new vial of insulin. (When in doubt, change it out!)</td>
</tr>
<tr>
<td></td>
<td>• Has insulin been exposed to high temperatures or direct sunlight?</td>
<td></td>
</tr>
<tr>
<td>Check insulin pump settings</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Bolus Delivery</td>
<td>• Was last meal bolus missed?</td>
<td>Give correction dose</td>
</tr>
<tr>
<td>- Basal Rates</td>
<td>• Are basal rates set incorrectly?</td>
<td>Reset basal rates</td>
</tr>
<tr>
<td>- Time</td>
<td>• Is time (AM/PM) set correctly?</td>
<td>Set time correctly</td>
</tr>
<tr>
<td>Insulin pump</td>
<td>• Is insulin pump not working or inoperable?</td>
<td>Call the Medtronic Diabetes 24-Hour HelpLine at 1.800.646.4633</td>
</tr>
<tr>
<td></td>
<td>• Not sure if insulin pump has a problem?</td>
<td>(The phone number is located on the back of the insulin pump)</td>
</tr>
</tbody>
</table>
Prevention of Hypoglycemia

Insulin pump therapy is associated with a marked reduction in the incidence of severe hypoglycemia. This is due to the predictable glucose lowering effects of rapid-acting insulin and the precise and flexible delivery system of an insulin pump. Patients should be taught the following concepts to help further reduce the risk of hypoglycemia.

Check BG a Minimum of 4 to 6 Times a Day
Routine monitoring of pre-meal, bedtime, nocturnal and exercise-related blood glucose levels is essential for safe and effective pump use. Therefore consider:

- Periodic monitoring of post-meal and 3:00 AM BGs regardless of symptoms.
- Conservative correction doses at bedtime and post-exercise.
- Periodic CGM use to obtain continuous tracings and confirm trends, patterns and missed hypoglycemia.

Use the Bolus Wizard® Calculator for all Bolus Doses
Using this feature can help prevent hypoglycemia that results from the stacking of insulin and the over-correction of highs when there is active insulin remaining from previous boluses. The Bolus Wizard:

- Tracks the amount of active insulin remaining from previous boluses.
- Subtracts active insulin from correction doses before calculating a total bolus amount.

BG Target Range Settings can be adjusted to prevent hypoglycemia.

- Bedtime target ranges can be set higher than daytime target ranges.
- Patients with a history of hypoglycemia may need a higher target range all day.

Exercise Precautions

- Monitor BG
  - Pre-exercise (BG must be >100 mg/dL)
  - Every 30 minutes during exercise
  - Post-exercise (periodically, until BG lowering effect of exercise has subsided)

- Use Temporary Basal Rate
  - Start by decreasing the basal rate 50% one hour before exercise begins, throughout the exercise time, and for at least one hour post-exercise.
  - Adjust temporary basal rate percentage and duration as needed (varies depending on the intensity and duration of exercise).
  - Use conservative correction doses during the post-exercise period.
  - For intense endurance exercise, patients may need to consume 15 grams of carbohydrate for each 15 to 30 minutes of activity. Titrate according to individual glycemic response.

Accurate Carbohydrate Counting
Hypoglycemia can result from overestimating carbohydrate intake. Post-meal hypoglycemia is an indication that additional training on carb counting is needed or that the ICR needs to be adjusted.
Treatment of Hypoglycemia

A common problem in diabetes is over-treating hypoglycemia, which causes hyperglycemia. To help patients prevent highs that result from over-treating, have patients follow a specific strategy, such as the 15-15 Rule, for treating low blood sugars. Encourage the use of glucose tablets for treating lows.

15 – 15 Rule

When glucose levels fall below 70 mg/dL:
1) Consume 15 grams of a fast-acting carbohydrate.
2) Recheck BG in 15 minutes.
3) If BG <70 mg/dL, repeat steps one and two until BG returns to normal range (If BG is <50 mg/dL, patient can start treatment with 30 grams).

Below 70 mg/dL at Mealtime

When BG is below 70 mg/dL at mealtime:
- Instruct patients to eat and make sure glucose levels are within target before bolusing.
- Have them give the bolus amount that was calculated using their pre-meal low.

Glucagon
- As with all insulin-requiring patients, provide a prescription for a Glucagon Emergency Kit before starting insulin pump therapy.
- Refill once a year and immediately upon usage.

Reporting Hypoglycemic Events

Because some hypoglycemic incidents go unreported, ask about hypoglycemia at every visit
- Since your last visit, have you had any hypoglycemia that required assistance from a family member? ... a coworker? ... others?
- Is your glucagon kit available? Where do you keep it? Who knows how to use it?

Use of Continuous Glucose Monitoring (CGM)

Consider the use of CGM in patients who have a history of hypoglycemia and/or those who are unable to alert others when hypoglycemic symptoms occur.
Special Populations

Type 2 Patients
Insulin-requiring, type 2 patients respond favorably to insulin pump therapy. Below are some clinical considerations to assess when placing type 2 patients on pump therapy.

Initiation
Initiation is the same as in type 1 diabetes.

- The starting TDD can be based on weight (0.5 x kg = TDD Units). This method has been shown to be effective.
  - Start with 50% as basal and 50% as bolus.
  - Type 2 patients typically require only one or two basal rates.

Since many type 2s do not carb-count at initiation, consider using the “Fixed Gram or Exchange per Meal” method (as explained in the ICR section of this book). Set up the Bolus Wizard® using the ICR calculated with the 450 Rule. Evaluate 2-hour, post-prandial control and adjust ICR as needed.

Oral Medications
1) Stop sulfonylureas and meglitinides.
2) Continue metformin, incretin mimetics, and insulin sensitizers, if you choose.
   - Once at goal, consider discontinuing any of the above medications, one at a time, to see if they are actually needed.
   - If glucose levels decompensate when discontinued, resume the medication.

Insulin Resistance
1) Some type 2s have marked insulin resistance, aggravated by both lipo and glucose toxicity.
   - Once glucose levels normalize, insulin requirements may decrease.
   - When this occurs, adjust pump settings (basal rate, ICR, ISF) to prevent hypoglycemia.

2) In other cases, insulin resistance persists and large insulin requirements continue to be needed.
   - Try to reduce insulin resistance with exercise and by decreasing consumption of calories (specifically high carbohydrate-containing foods).
   - Consider using insulin sensitizers and/or GLP-1 agonists.

EASY BOLUS FEATURE
An alternate way to program bolus amounts when the patient does not use the Bolus Wizard feature, does not count carbs or check BG before meals.

Modified Pump Start
For patients who are unable to count carbohydrates and check BGs before meals, consider the fixed unit per meal bolus method using the Easy Bolus feature.
Pregnancy Patients

Maintaining tight glycemic control during pregnancy is key to preventing complications for both mother and neonate. Consider using Continuous Glucose Monitoring (CGM) throughout the perinatal period to help achieve optimal glucose control.

- BGs should be monitored frequently in pregnancy (pre- and post meal, bedtime and mid-sleep).
- Adjustments to pump settings need to be made frequently for continued optimal control.
- Expect insulin requirements to steadily rise as the pregnancy advances. Increased insulin requirements are primarily due to the progressive rise in placental hormones which results in increased insulin resistance and decreased sensitivity to insulin action.

Pre-Conception and 1st Trimester
Maintaining glucose control during organogenesis greatly reduces the risk of fetal anomalies and spontaneous abortion.

- The risk of hypoglycemia, especially overnight, increases during the first few weeks of pregnancy and insulin requirements are often less than pre-conception requirements.
- Monitor fasting glucose and check urine for ketones every morning.
  - Positive ketones with high BG indicate need for additional basal insulin.
  - Positive ketones with normal or low BG is indicative of "starvation ketones." Consider increasing bedtime snack or adding a midnight snack.
- In situations of hyperemesis, consider using a square wave bolus over 30 minutes so bolus can be stopped if vomiting occurs.

2nd Trimester
The placenta is fully developed and growth as well as hormones will begin to steadily rise causing insulin requirement to steadily increase as the pregnancy progresses.

- Usually requires increase in basal, meal, and correction insulin.
- Pump settings may need to be adjusted every 2 to 3 weeks.

3rd Trimester
Maintaining tight glucose control throughout the last trimester helps to enhance fetal lung development, prevent fetal macrosomia and reduce the risk of neonatal hypoglycemia (post-delivery).

- Insulin requirements typically increase every week (during the last few weeks of gestation).

Labor and Delivery
Patients can remain on pump throughout labor and delivery.

- BGs should be monitored every hour and small boluses given (if needed) to keep glucose in desired range.

Post-Partum
Immediately after delivery and up to 24 hours post-delivery, insulin requirements decrease significantly. Therefore, basal rates, ICR, ISF and Target Ranges should be reduced to pre-conception settings or to at least half the current settings.

Breastfeeding
BG levels can drop dramatically during breastfeeding.

- Instruct mother to:
  - Monitor BGs closely during and for at least an hour after nursing.
  - Always drink and eat while breastfeeding.
  - Consider use of temporary basal rate (reduction up to 50%) for an hour post-nursing.
  - Consider use of CGM.
## Special Populations

### Pediatric Patients

Diabetes brings unique challenges in the pediatric, adolescent and young adult age ranges. Depending on cognitive maturity and development skills, the need for increasing independence and the eventual transition to adult care, there is variability in parental/care giver involvement necessary for insulin pump management.

<table>
<thead>
<tr>
<th>Age</th>
<th>Knowledge/Skills/Attitudes</th>
<th>Diabetes and Pump Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth to 3 years of age</td>
<td>• Inherent trust in parents/care givers</td>
<td>• Pumps able to deliver small doses of insulin with accuracy</td>
</tr>
<tr>
<td>of age, infants and</td>
<td>• Rapid changes in cognitive and motor skills, nutrition requirements, sleep/wake</td>
<td>• Issues with pump placement, infusion sites, tubing, skin and child acceptance</td>
</tr>
<tr>
<td>toddlers</td>
<td>patterns, and acquisition of developmental milestones</td>
<td>• Child cannot understand requirements of diabetes management</td>
</tr>
<tr>
<td></td>
<td>• Unaware and unable to communicate any issues with health and diabetes/glucose levels</td>
<td>• Erratic food intake, activity, mood, behavior</td>
</tr>
<tr>
<td></td>
<td>• Temper tantrums may be frequent and associated with diabetes tasks</td>
<td>• Parents/care givers must do all diabetes management tasks</td>
</tr>
<tr>
<td></td>
<td>• Pumps able to deliver small doses of insulin with accuracy</td>
<td>• Risk and fear of hypoglycemia</td>
</tr>
<tr>
<td>3–6 years of age,</td>
<td>• Begins to show some minimal understanding of diabetes procedures and management issues,</td>
<td>• Child increasingly aware of presence of devices, early understanding as to need to</td>
</tr>
<tr>
<td>preschool</td>
<td>such as nutrition</td>
<td>protect devices</td>
</tr>
<tr>
<td></td>
<td>• Might begin to recognize hypoglycemia and tell others</td>
<td>• More interaction with peers who are interested in devices as well</td>
</tr>
<tr>
<td></td>
<td>• Can have negative attitudes</td>
<td>• Interacts with decisions as to which finger to check glucose, where pump is worn and</td>
</tr>
<tr>
<td></td>
<td>• Overall still lacks motor skills and cognitive ability to contribute to diabetes</td>
<td>infusion set placed</td>
</tr>
<tr>
<td></td>
<td>management</td>
<td>• Starts to ask about food items and if they can be eaten, and if bolus must be given</td>
</tr>
<tr>
<td></td>
<td>• Begins to realize having diabetes is different</td>
<td></td>
</tr>
<tr>
<td>7–11 years of age,</td>
<td>• Increasing awareness of tasks and goals of diabetes management and ability to do them</td>
<td>• Emerging ability to carb count, take boluses</td>
</tr>
<tr>
<td>school-aged</td>
<td>• Still reliant on parents/care givers for diabetes decisions</td>
<td>• Increasing ability to manage infusion set, hooks/unhooks</td>
</tr>
<tr>
<td></td>
<td>• Might struggle with being different and begin to be self-conscious about diabetes</td>
<td>• More time away from parents/ primary care givers</td>
</tr>
<tr>
<td></td>
<td>• Might be angry or depressed about diabetes</td>
<td>• Able to protect devices</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Able to do blood glucose testing, and knows numbers/goals</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Some awareness as to role of exercise in glucose control</td>
</tr>
</tbody>
</table>
By age 12, suggest that your patients/parents hold a weekly diabetes meeting. Rather than parents quizzing the child on what they are doing all day long, they should upload pump and meter data to review reports together. Determine number of BGs, boluses/day, use of Bolus Wizard, infusion site change, carb entries. Use the reports to assess behavior, reward improvement, and identify adherence problems.

### Resources

The National Diabetes Education Program website (http://ndep.nih.gov/) has comprehensive information regarding rights of children with diabetes in school. There are guides for school nurses, teachers, coaches, administrators, parents and students. All diabetes management and safety information is covered, including pump therapy.
Special Populations

Hospitalized Patients

In general, patients who self-manage on insulin pump therapy prior to hospitalization prefer to stay on the pump when hospitalized. Having patients self-manage their own therapy is practical and easier for staff, as long as the patient remains mentally alert, psychologically sound and physically able.

If a hospital does not have a protocol for managing patients on insulin pump therapy, provide orders upon patient admission.

Orders should include:

- Rx for a vial of rapid-acting insulin (supplied by hospital pharmacy).
- Current settings (Basal Rates, ICR, ISF, Target Range and Active Insulin Time).
- BG monitoring requirements:
  - Frequency and if monitoring is to be performed by patient or staff.
  - Documentation of BG readings.
  - Glucose levels (upper and lower) at which treatment is required.
    - Hypoglycemia protocol
    - Hyperglycemia protocol
  - Events/glucose levels for which you or your office should be notified.
- Alternate insulin regimen for procedures:
  - Lasting longer than 2 hours and require pump removal/discontinuation.
  - Requiring fasting (basal insulin continues to be needed).
  - Requiring sedation (intravenous insulin should be started just before discontinuing the pump).
- Instructions to remove infusion set, sensor, pump and transmitter and leave outside of imaging room for procedures involving MRI, CT scans, X-Ray (reconnect pump upon completion).
- Procedure to follow if patient status changes and is unable to self-manage.
- Frequency for infusion site and reservoir change to be completed by patient.
- Troubleshooting resources such as:
  - Medtronic HelpLine number 1.800.646.4633 (located on back of pump).
  - Family member who is well versed in pump therapy.
  - Your office staff contact.

Hospitals do not typically stock insulin pump supplies. Instruct patients to bring enough infusion sets and reservoirs to change their infusion site every 2 to 3 days during hospitalization.
Therapy Management Software

Advances in technology have now made it possible to electronically capture glucose data necessary for effective evaluation. CareLink® Therapy Management Software organizes captured data (BG values, bolus amounts, basal rates, carb intake) into meaningful reports for a historical, comprehensive review of the “cause-and-effect” relationship between these parameters.

Ask patients to upload their meter and insulin pump regularly. Review reports at each visit.

The reports that follow are available through CareLink Pro Software.

Example of Daily Detail Report

Displays each day’s pump and BG meter information and lists the details (time, amount, type) of each bolus that was given.
**Example of Adherence Report**

Provides new insights into a patient’s self-management behavior and helps confirm optimal device use.

<table>
<thead>
<tr>
<th>Glucose Measurements</th>
<th>Bolus Events</th>
<th>Fill Events</th>
<th>Suspend Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BG Readings</strong></td>
<td>Manual Boluses</td>
<td>Bolus Events</td>
<td>With Food</td>
</tr>
<tr>
<td>Wednesday 6/2/2010</td>
<td>3</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Thursday 6/3/2010</td>
<td></td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Friday 6/4/2010</td>
<td></td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Saturday 6/5/2010</td>
<td>6</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Sunday 6/6/2010</td>
<td>5</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Monday 6/7/2010</td>
<td>3</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Tuesday 6/8/2010</td>
<td>5</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Wednesday 6/9/2010</td>
<td>8</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Thursday 6/10/2010</td>
<td>6</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Friday 6/11/2010</td>
<td>5</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Saturday 6/12/2010</td>
<td>7</td>
<td>13</td>
<td>6</td>
</tr>
<tr>
<td>Sunday 6/13/2010</td>
<td>4</td>
<td>11</td>
<td>6</td>
</tr>
<tr>
<td>Monday 6/14/2010</td>
<td>5</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>Tuesday 6/15/2010</td>
<td>3</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td><strong>Summary</strong></td>
<td>4.8/day</td>
<td>0.0/day</td>
<td>8.8/day</td>
</tr>
</tbody>
</table>

**1 Glucose Measurements**
This section displays frequency of BG meter tests and duration of glucose sensor tracing information.

**2 Bolus Events**
This section captures the patient’s use of the Bolus Wizard® calculator including the frequency of manual boluses and overrides.

- **Bolus Wizard Overrides**: May be appropriate, but should always be investigated as they may indicate the need for additional patient education, or the need to assess insulin pump settings.

**3 Fill (Priming) Events**
This section is used to determine if the patient is rewinding and priming the insulin pump appropriately.

- Rewinding less than once every three days indicates extended use of infusion sets or insulin sets.

**4 Suspend Duration**
Use this section to evaluate if suspend time is reasonable. Investigate frequent suspends and suspend times greater than one hour.
Example of Sensor and Meter Overview Report

Displays blood glucose meter readings and statistics to allow for identification of glycemic excursions and patterns.

**Breakfast Example**

- **Meals Analyzed:** 9
- **Avg Carbs:** 28g
- **Avg Insulin:** 2.4U
- **Avg Carbs/Insulin:** 11.6g/U

<table>
<thead>
<tr>
<th>Time</th>
<th>Avg BG (mg/dL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>116</td>
</tr>
<tr>
<td>6</td>
<td>140</td>
</tr>
<tr>
<td>8</td>
<td>120</td>
</tr>
</tbody>
</table>

**Statistics**

<table>
<thead>
<tr>
<th>Statistics</th>
<th>6/2 - 6/15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avg BG (mg/dL)</td>
<td>147 ± 56</td>
</tr>
<tr>
<td>BG Readings</td>
<td>65 ± 4.8/day</td>
</tr>
<tr>
<td>Readings Above Target</td>
<td>33 ± 51%</td>
</tr>
<tr>
<td>Readings Below Target</td>
<td>3 ± 5%</td>
</tr>
<tr>
<td>Sensor Avg (mg/dL)</td>
<td>11.0</td>
</tr>
<tr>
<td>Avg AUC &gt; 140 (mg/dL)</td>
<td>134 ± 23</td>
</tr>
<tr>
<td>Avg AUC &lt; 70 (mg/dL)</td>
<td>147 ± 56</td>
</tr>
<tr>
<td>Avg Daily Carbs (g)</td>
<td>11.0 ± 23</td>
</tr>
<tr>
<td>Carbs/Bolus Insulin (g/U)</td>
<td>11.0</td>
</tr>
<tr>
<td>Avg Total Daily Insulin (U)</td>
<td>23.0 ± 1.7</td>
</tr>
<tr>
<td>Avg Daily Basal (U)</td>
<td>11.0 ± 48%</td>
</tr>
<tr>
<td>Avg Daily Bolus (U)</td>
<td>12.0 ± 52%</td>
</tr>
</tbody>
</table>

**Target BG Range**

(70–140 mg/dL)

**Target determined by provider during report setup**

---

**Meter Overlay**

Displays BG meter readings to assist in identifying excursions and/or patterns.

**Statistics Table**

Displays BG meter, sensor glucose, carbohydrate, and insulin statistics over the reporting period.

**Bedtime to Wake-up Meter Overlay**

Displays BG meter readings from bedtime to wake-up to help identify overnight patterns.

**Meal Meter Overlay**

Realigns BG meter readings around meals (at the time carbohydrates are entered into the Bolus Wizard) to assess pre- and post-meal control.

*Targets determined by provider during report setup*
Example of Logbook Report

Provides logbook information in an hour-by-hour format to help identify repeated patterns and possible causes for glycemic excursions.

Logbook Cell Section

Each cell contains up to three numbers:
- Top Number: BG meter reading
- Middle Number: Carbohydrates
- Bottom Number: Bolus Insulin Delivered

Meals can be quickly identified by looking for the carbohydrate amounts (highlighted in black).

Daily Totals

Summarizes the following values from each day of the reporting period:
- Average: Displays the total number of BG meter readings taken and the BG meter average.
- Carbs: Displays the total amount of carbohydrates entered into the Bolus Wizard calculator.
- Insulin: Displays the total amount of insulin delivered and the percentage delivered as a bolus.

*Targets determined by provider during report setup
## Example of Device Settings Report

Displays insulin pump and sensor settings.

### Basal Settings
Displays the patient’s basal rates at the time the patient’s device was uploaded.

### Bolus Settings
Displays the patient’s bolus settings at the time the patient’s device was uploaded.

### Sensor Settings
Displays the patient’s sensor settings at the time the patient’s device was uploaded.

### Utilities
Displays the patient’s alert type and low reservoir warning settings at the time the patient’s device was uploaded.

### Notes
Section can be used to record notes for patient records, to provide comments and recommendations for patient therapy, and/or to record documentation for health insurance providers.
Continuous glucose monitoring measures glucose levels in the interstitial fluid and provides a record of glucose readings 24 hours a day. These glucose tracings detail the patient’s daily glycemic control and provide insight into trends and patterns that are often missed with finger-stick monitoring alone. CGM technology can help clinicians and patients make more informed decisions regarding diabetes management.

There are two types of CGM systems: Professional and Personal.

**Professional CGM**

Professional CGM systems are owned and managed by healthcare providers and can be used on multiple patients. Each system consists of a glucose sensor (temporarily inserted into subcutaneous tissue and replaced after each use) and a small recording device that attaches to the sensor. These systems are designed for periodic use and provide detailed continuous glucose data for retrospective evaluation.

During the evaluation period, the patient’s glycemic levels (blinded to the patient) are recorded continuously. At the end of the evaluation period, the glucose data is uploaded by the healthcare provider to CareLink® iPro®, where it is compiled into reports.

These reports provide comprehensive information about glycemic control. Including:

- 24-Hour continuous glucose tracings for the entire evaluation period
- Markers that indicate meal times and medications taken
- Overlays of post-prandial (breakfast, lunch and dinner) and overnight glucose tracings
- Hyper- and hypoglycemic area under the curve (AUC) data
- Pie charts summarizing glycemic control and distribution of hyper- and hypoglycemia

These reports provide a historical review of glycemic trends and patterns, allowing clinicians to retrospectively and objectively evaluate a patient’s glucose control and make more informed therapy management decisions.
Personal CGM

Personal CGM systems are owned and operated by the patient. These systems consist of the glucose sensors, a transmitter (sends glucose data to a monitor) and a small external monitor. The monitor displays the patient’s most recent glucose reading (updated every 5 minutes) and a continuous tracing of the past 24 hours of glucose readings. There are two types of Personal CGM: one is a stand-alone device, and the other is integrated into the insulin pump.

Indications for Personal CGM*

Patients on MDI or insulin pump therapy who check BG four or more times a day and who have:

- A1C above goal (non-pregnancy >7%, preconception >6.5%, pregnancy >6%).
- History of frequent hypoglycemia or hypoglycemia unawareness.
- Marked glucose variability with multiple glucose readings outside the desired range.

Patient Requirements for Starting CGM

The same as insulin pump therapy, plus:

- Willingness to calibrate the glucose sensor a minimum of three to four times a day.
- Willingness to validate sensor glucose (SG) values with BG test prior to making treatment decisions.

Considerations Before Starting CGM

- Understanding of importance of glucose trends versus “point-in-time” BG values.
- Understanding of sensor glucose (SG) versus blood glucose (BG) and the potential differences in the two values.
- Insurance coverage or ability to pay out-of-pocket.

The full benefit of CGM is best realized when current data and historical data are utilized in concert.

*The insulin pump is indicated for persons of all ages requiring insulin. The REAL-Time Continuous Glucose Monitoring components of the MinMed Paradigm® REAL-Time Insulin Pump and Continuous Glucose Monitoring System are indicated for ages 7 years or older. A version of the product specially designed for children is indicated for patients ages 7 to 17.
## Blood Glucose Log Sheet

**Patient:** ____________________________________________  **DOB:** _____________________________

**Phone:** (Home) __________________________ (Work) ____________________________ / ____________________________

<table>
<thead>
<tr>
<th>Basal Rate:</th>
<th>1.</th>
<th>12 A.M.</th>
<th>___________</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2.</td>
<td></td>
<td>___________</td>
</tr>
<tr>
<td></td>
<td>3.</td>
<td></td>
<td>___________</td>
</tr>
<tr>
<td></td>
<td>4.</td>
<td></td>
<td>___________</td>
</tr>
<tr>
<td></td>
<td>5.</td>
<td></td>
<td>___________</td>
</tr>
</tbody>
</table>

**Meal Bolus:** 1 Unit of insulin covers this many grams of carbohydrate. Carb Ratio: (B)_______(L)_______(D)_______

**Insulin Sensitivity Factor:** 1 Unit of insulin lowers BG _______mg/dL

(Current BG – Target) ÷ Sensitivity Factor = Correction Dose

**BG Target Range:**
- Daytime = _______mg/dL – _______mg/dL
- Nighttime = _______mg/dL – _______mg/dL

### Food Dose

<table>
<thead>
<tr>
<th>Time</th>
<th>12 A.M.</th>
<th>3 A.M.</th>
<th>Pre-Breakfast</th>
<th>Post-Breakfast</th>
<th>Pre-Lunch</th>
<th>Post-Lunch</th>
<th>Pre-Dinner</th>
<th>Post-Dinner</th>
<th>Bedtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>/</td>
<td>/</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blood Glucose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Carb Grams</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food Dose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correction Dose</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Bolus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Notes:

---

**Pumping Protocol** by Bruce Bode, MD. ©2008 Medtronic MiniMed, Inc. All rights reserved. 9402236-011 042408

---

Fax to: ____________________________________________
### Calculations for Insulin Pump Initiation Settings

<table>
<thead>
<tr>
<th>Formula</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduced Dose</td>
<td>Injection Dose x 0.75 = Reduced Dose</td>
</tr>
<tr>
<td>Weight Dose</td>
<td>Weight (lbs) x 0.23 = Weight Dose</td>
</tr>
<tr>
<td>Pump TDD</td>
<td>(Reduced Dose + Weight Dose) / 2 = Pump TDD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basal Rate</th>
<th>Formula</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Daily Basal Units</td>
<td>Pump TDD x % Basal (40–50%) = Total Daily Basal</td>
<td></td>
</tr>
<tr>
<td>Initial Basal Rate</td>
<td>Total Daily Basal / 24 hours = Hourly Basal Rate</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ICR</th>
<th>Formula</th>
<th>Calculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulin-to-Carb Ratio</td>
<td>Daily Carb Grams / Total Daily Basal = Carb Ratio OR 450 / Pump TDD = Carb Ratio</td>
<td></td>
</tr>
<tr>
<td>Insulin Sensitivity Factor</td>
<td>1700 / Pump TDD = Insulin Sensitivity Factor</td>
<td></td>
</tr>
</tbody>
</table>

### Pump Settings

<table>
<thead>
<tr>
<th>Time Rates</th>
<th>Carb Ratio</th>
<th>Sensitivity Factor</th>
<th>Bolus Wizard® Calculator Target Ranges</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 12 a.m. @</td>
<td>(B) ______</td>
<td>ISF = ______ mg/dL/1 unit</td>
<td></td>
</tr>
<tr>
<td>2) ______ @</td>
<td>(L) ______</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) ______ @</td>
<td>(D) ______</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) ______ @</td>
<td>(M) ______</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5) ______ @</td>
<td>(N) ______</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max Basal Rate: ______ units</td>
<td>Max Bolus: ______ units</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Active Insulin Time

- **Adults:** 4-5 hours
- **Children:** 3-4 hours
- **Pregnancy:** 3-4 hours

### Instructions for Adjustments

- If nocturnal, fasting/pre-meal or bedtime BG > target, *increase* basal 10–20%
- If nocturnal, fasting/pre-meal or bedtime BG < target, *decrease* basal 10–20%
- If post-meal BG > 60 mg/dL above pre-meal BG, *decrease* carb ratio by 10–20%
- If post-meal BG < 30 mg/dL above pre-meal BG, *increase* carb ratio by 10–20% (Elevated BG: Verify trends 2–3 days before adjusting)
- **Low BG:** Consider immediate adjustment

### Adjustments should be made when BGs are outside of these ranges

- **Fasting/pre-meal:** ______ to ______ mg/dL
- **Post-meal:** ______ to ______ mg/dL
- **Bedtime:** ______ to ______ mg/dL
- **Nocturnal:** ______ to ______ mg/dL

---

**Prescriber Name:** [Signature:] [Date:]

*These instructions shall be valid for 6 months unless otherwise specified here: ______ months.*

Call MD for severe low BG or ketones. Call Medtronic for technical issues at 800-646-4633. *Pumping Protocol by Bruce Bode, MD.*
References


Suggested Reading


Cersosimo E. Response to Schade: To pump or not to pump? *Diabetes Care*. 2003;26:967.


