Navigating Insulin Pumps and Continuous Glucose Monitors for Improved Diabetes Management

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Nothing to disclose
Objectives

• Examine advanced technologies to assist the clinician in hyperglycemia and hypoglycemia treatment
• Evaluate the evidence and indications for continuous glucose monitors and insulin pumps use
• Integrate practical application of advance technologies for improved diabetes management
IHS Division of Diabetes Treatment and Prevention
Resources for Glucose Management with Insulin

• **Webinars**
  • Insulin Management. Richard Arakaki, 4/20/22
  • Simple to Advanced Approaches to Carbohydrate Counting. Kibbe Brown and Wendy Castle, 3/8/23

• **Algorithm**
  • Insulin Therapy in Type 2 Diabetes
  • Insulin Concentration

IHS Division of Diabetes Treatment and Prevention. [https://www.ihs.gov/diabetes/](https://www.ihs.gov/diabetes/)
Case study- Scenario 1

• 51 yo patient with T1DM on basal insulin 20 units at bedtime and rapid-acting insulin 8-7-8 units, TID ac (ICR is 1:15 and ISF is 1:40 mg/dL over 140 mg/dL).

• Prelunch BGM value was 120 mg/dL and he took is 7 units had soup and sandwich meal with water. He had a snack at 4 PM, following his afternoon walk as he felt a little “woozy” (didn’t check BG).
Case study- Scenario 1

• 51 yo patient with T1DM on basal insulin 20 units at bedtime and rapid-acting insulin 8-7-8 units, TID ac (ICR is 1:15 and ISF is 1:40 mg/dL over 140 mg/dL).

• Prelunch BGM value was 120 mg/dL and he took is 7 units had soup and sandwich meal with water. He had a snack at 4 PM, following his afternoon walk as he felt a little “woozy” (didn’t check BG).

What do you make of his BGM reading of 141 before dinner (not at goal of <130 mg/dL)?
What should his dinner insulin dose be? Should he take more or less than the 8 units?
Case study- Scenario 1 (con’t)

• He took 8 units at 6 PM just before his dinner, and he had a snack at 7:30 PM. He was feeling quite well.

• His bedtime BGM read 110 mg/dL and he is scheduled to take his long-acting insulin soon.

What do you make of his bedtime BGM reading (BS decreased from 141 to 110 after dinner)? Adequate or too much dinner dose? He is scheduled for 20 units of basal insulin? Should he take more or less insulin; 10 or 20 % increase or decrease?
Case study- Scenario 1 (con’t)

• He took 8 units at 6 PM just before his dinner, and he had a snack at 7:30 PM. He was feeling quite well.

• His bedtime BGM read 110 mg/dL and he is scheduled to take his long-acting insulin soon.

What do you make of his bedtime BGM reading (BS decreased from 141 to 110 after dinner)? Adequate or too much dinner dose?
He is scheduled for 20 units of basal insulin? Should he take more or less insulin; 10 or 20 % increase or decrease?

• He took his usual dose of 20 units and had a bedtime snack. At 3 AM, he woke up feeling “funny” and a little sweaty. His BGM showed a glucose value of 58 mg/dL.
Case Study- Scenario 1A

- 51 yo patient with T1DM on basal insulin 20 units at bedtime and rapid-acting insulin 8-7-8 units, TID ac (ICR is 1:15 and ISF is 1:40 mg/dL over 140 mg/dL).

- Prelunch CGM value was 120 mg/dL and he took 7 units had soup and sandwich meal with water. He had a snack at 4 PM, following his afternoon walk as he felt a little “woozy” (his CGM showed glucose values of 70-80 mg/dl).
Case Study- Scenario 1A

• 51 yo patient with T1DM on basal insulin 20 units at bedtime and rapid-acting insulin 8-7-8 units, TID ac (ICR is 1:15 and ISF is 1:40 mg/dL over 140 mg/dL).
• Prelunch CGM value was 120 mg/dL and he took is 7 units had soup and sandwich meal with water. He had a snack at 4 PM, following his afternoon walk as he felt a little “woozy” (his CGM showed glucose values of 70-80 mg/dl).

What do you make of his CGM reading of 141 and the diagonal falling arrow before dinner? What should the patient do?
- Lower his meal dose (<8 units)?
- Give usual dose, delay his meal 30 minutes?
- Recommend increase his meal CHO?
- No change in treatment
Addressing Rate of Change (ROC):
What does the arrows mean?

- Predicting glucose levels based on preceding values
  - Targets glucose levels over 30 minutes
  - Based on previous 10-minute values

<table>
<thead>
<tr>
<th>Glucose change rates:</th>
<th>Patient intervention:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rapidly rising &gt; 3 mg/min</td>
<td>- Patient with 141 mg/dl and diagonal falling arrow.</td>
</tr>
<tr>
<td>Rising &gt; 2-3 mg/min</td>
<td>- Expect to have glucose between 111 to 81 mg/dL in 30 minutes</td>
</tr>
<tr>
<td>Slowly rising &gt; 1-2 mg/min</td>
<td>- ISF: 1:40 over 140 mg/dL</td>
</tr>
<tr>
<td>Steady, not increasing or decreasing &gt; 1 mg/min</td>
<td>What should he do with is mealtime insulin dose?</td>
</tr>
<tr>
<td>Slowly falling &gt; 1-2 mg/min</td>
<td></td>
</tr>
<tr>
<td>Falling &gt; 2-3 mg/min</td>
<td></td>
</tr>
<tr>
<td>Rapidly Falling &gt; 3 mg/min</td>
<td></td>
</tr>
</tbody>
</table>

Addressing Rate of Change (ROC):
What should patients do with the arrows

<table>
<thead>
<tr>
<th>Trend Arrow</th>
<th>DirecNet (43)</th>
<th>Scheiner (44)</th>
<th>Pettus and Edelman (45)</th>
<th>Klonoff and Kerr (46)</th>
<th>Endocrine Society (Dexcom G5 only) (47)</th>
</tr>
</thead>
<tbody>
<tr>
<td>↑↑</td>
<td>20% increase</td>
<td>+60 mg/dL</td>
<td>+100 mg/dL</td>
<td>+2 units</td>
<td>+1.5–4.5 based on correction factor</td>
</tr>
<tr>
<td>↑</td>
<td>20% increase</td>
<td>+30 mg/dL</td>
<td>+75 mg/dL</td>
<td>+1.5 units</td>
<td>+1–3.5 based on correction factor</td>
</tr>
<tr>
<td>→</td>
<td>10% increase</td>
<td>0</td>
<td>+50 mg/dL</td>
<td>+1 units</td>
<td>+0.5–2.5 based on correction factor</td>
</tr>
<tr>
<td>←</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
<td>No changes</td>
</tr>
<tr>
<td>→</td>
<td>10% decrease</td>
<td>0</td>
<td>-50 mg/dL</td>
<td>-1 units</td>
<td>-0.5–2.5 based on correction factor</td>
</tr>
<tr>
<td>↓</td>
<td>20% decrease</td>
<td>-30 mg/dL</td>
<td>-75 mg/dL</td>
<td>-1.5 units</td>
<td>-1–3.5 based on correction factor</td>
</tr>
<tr>
<td>↓↓</td>
<td>20% decrease</td>
<td>-60 mg/dL</td>
<td>-100 mg/dL</td>
<td>-2 units</td>
<td>-1.5–4.5 based on correction factor</td>
</tr>
</tbody>
</table>

Note: Intermittent corrections for persistent trends 2 hours after previous bolus

### Patient intervention:

- Patient with 141 mg/dl and diagonal falling arrow.
- Expect to have glucose between 111 to 81 mg/dL in 30 minutes
- ISF: 1:40

What should he do with his mealtime insulin?

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**Hirsch IB, Battelino T, Peters AL, Chamberlain JJ, Aleppo G, Bergenstal RM. Role of Continuous Glucose Monitoring in Diabetes Treatment.** Arlington, Va., American Diabetes Association, 2018
Case Study - Scenario 1A con’t

• 51 yo patient with T1DM on basal insulin 20 units at bedtime and rapid-acting insulin 8-7-8 units, TID ac (ICR is 1:15 and ISF is 1:40 mg/dL over 140 mg/dL).

• Prelunch CGM value was 120 mg/dL and he took is 7 units had soup and sandwich meal with water. He had a snack at 4 PM, following his afternoon walk as he felt a little “woozy” (his CGM showed glucose values of 70-80 mg/dl).

The patient lowered his meal dose to 6 units (25% reduction).

He took is usual dose of basal insulin, 20 units at bedtime as his glucose reading was 135 mg/dl at bedtime with a horizontal arrow. He took no snacks. He woke the next morning with BS level of 102 mg/dL.

Should he change his basal insulin dose?
Recommendation for BGM and CGM

• **Blood Glucose Monitoring (BGM)**
  - Most patients using intensive insulin regimens (MDI or pump) should assess glucose levels using BGM prior to meals and snacks, at bedtime, occasionally postprandially, prior to exercise when they suspect low blood glucose, and prior to critical tasks such as driving.

• **Continuous Glucose Monitoring (CGM)**
  - When used properly, real-time continuous glucose monitoring in conjunction with intensive insulin regimens is a useful tool to lower A1c in adults with type 1 diabetes not meeting glycemic targets.
  - Real-time continuous glucose monitoring may be a useful tool in those with hypoglycemia unawareness and/or frequent hypoglycemic episodes.
  - Real-time continuous glucose monitoring may be used effectively to improve A1C levels and neonatal outcomes in pregnant women with type 1 diabetes.

Note: Prescribe as part of a broad educational program, training, and support for BGM and CGM.

Effectiveness of Glucose Monitoring

• Blood Glucose Monitoring
  • A1C reduction is associated with more frequent use
  • Limited value in people not using insulin
  • No impact on hypoglycemic rates

• Realtime Continuous Glucose Monitoring (rtCGM)
  • Glycemic benefits in all adults and teens with type 1 and adults with type 2 diabetes (basal and MDI treatments)
  • Benefits in children unclear
  • Decrease hypoglycemic rates in patients with type 1 diabetes treatment but not in patients with type 2 diabetes
CGM Components

Sensor: Checks glucose levels every 5 minutes. Can be worn on the abdomen, arm, or buttock depends on on age. Water resistant tape to secure sensor on the skin.

Transmitter: Connects to sensor and sends glucose information to reader or smartphone (via Bluetooth)

Reader: Provided by the company
  Must have on hand; personal use for management;
  transfer data to PC via USB port

Smartphone (via cloud):
  Personal use for management; Apps available to transfer data into central repository (company-based)- allow others to view realtime data; allow provider to view AGP
### Table 7.3—Continuous glucose monitoring devices

<table>
<thead>
<tr>
<th>Type of CGM</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>rtCGM</td>
<td>CGM systems that measure and store glucose levels continuously and without prompting</td>
</tr>
<tr>
<td>isCGM with and without alarms</td>
<td>CGM systems that measure glucose levels continuously but require scanning for storage of glucose values</td>
</tr>
<tr>
<td>Professional CGM</td>
<td>CGM devices that are placed on the patient in the provider’s office (or with remote instruction) and worn for a discrete period of time (generally 7–14 days). Data may be blinded or visible to the person wearing the device. The data are used to assess glycemic patterns and trends. These devices are not fully owned by the patient—they are clinic-based devices, as opposed to the patient-owned rtCGM/isCGM devices.</td>
</tr>
</tbody>
</table>

CGM, continuous glucose monitoring; isCGM, intermittently scanned CGM; rtCGM, real-time CGM.
A Patient with CGM: Reviewing the Data

AMBULATORY GLUCOSE PROFILE (AGP)

AGP is a summary of glucose values from the report period, with median (50%) and other percentiles shown as if occurring in a single day.

Each daily profile represents a midnight to midnight period with the date displayed in the upper left corner.
A Patient with CGM: Reviewing the Data

WED Feb 1

- Glucose mg/dL
- Carbs grams
- Rapid-Acting Insulin
- Long-Acting Insulin

THU Feb 2

- Glucose mg/dL
- Carbs grams
- Rapid-Acting Insulin
Another Patient with CGM: Reviewing the Data

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Details</th>
<th>Glucose</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:07 PM</td>
<td>Fast-Acting</td>
<td>8.0 u</td>
<td>250 mg/dL</td>
</tr>
<tr>
<td>9:07 PM</td>
<td>Carbs</td>
<td>60 g</td>
<td>250 mg/dL</td>
</tr>
<tr>
<td>3:22 PM</td>
<td>Fast-Acting</td>
<td>3.0 u</td>
<td>245 mg/dL</td>
</tr>
<tr>
<td>2:21 PM</td>
<td>Carbs</td>
<td>60 g</td>
<td>163 mg/dL</td>
</tr>
<tr>
<td>9:05 AM</td>
<td>Carbs</td>
<td>60 g</td>
<td>176 mg/dL</td>
</tr>
<tr>
<td>9:05 AM</td>
<td>Fast-Acting</td>
<td>2.0 u</td>
<td>176 mg/dL</td>
</tr>
<tr>
<td>8:29 AM</td>
<td>Long-Acting</td>
<td>10.0 u</td>
<td>171 mg/dL</td>
</tr>
</tbody>
</table>

- Meal and bolus
- Correction dose
- Meal and no bolus
- Meal and bolus
AGP Report: Continuous Glucose Monitoring

**Test Patient**
DOB: Jan 1, 1970

14 Days: August 8-August 21, 2021

Time CGM Active: 100%

**Glucose Metrics**

- **Average Glucose**: 175 mg/dL (Goal: <154 mg/dL)
- **Glucose Management Indicator (GMI)**: 7.5% (Goal: <7%)
- **Glucose Variability**: 45.5% (Defined as percent coefficient of variation, Goal: ≤36%)

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Ambulatory Glucose Profile Example
<table>
<thead>
<tr>
<th>Measured TIR (70–180 mg/dL)</th>
<th>A1C</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>40%</td>
<td>8.1%</td>
<td>7.1–9.1%</td>
</tr>
<tr>
<td>50%</td>
<td>7.7%</td>
<td>6.7–8.7%</td>
</tr>
<tr>
<td>60%</td>
<td>7.3%</td>
<td>6.3–8.3%</td>
</tr>
<tr>
<td>70%</td>
<td>6.9%</td>
<td>5.9–7.9%</td>
</tr>
<tr>
<td>80%</td>
<td>6.5%</td>
<td>5.5–7.5%</td>
</tr>
</tbody>
</table>
7.25 Insulin pump therapy alone with or without sensor-augmented pump low glucose suspend feature and/or automated insulin delivery systems should be offered for diabetes management to youth and adults on multiple daily injections with type 1 diabetes \textbf{A} or other types of insulin-deficient diabetes \textbf{E} who are capable of using the device safely (either by themselves or with a caregiver) and are not able to use or do not choose an automated insulin delivery system. The choice of device should be made based on the individual’s circumstances, preferences, and needs. \textbf{A}

7.26 Insulin pump therapy can be offered for diabetes management to youth and adults on multiple daily injections with type 2 diabetes who are capable of using the device safely (either by themselves or with a caregiver). The choice of device should be made based on the individual’s circumstances, preferences, and needs. \textbf{A}

Insulin Pump Systems

- **Patch pumps**
  - V-GO: disposable preset pumps for patients with type 2 diabetes; provides basal rate with occasional correction bolus. 20, 30, 40 units basal/24hrs. 36 units max bolus in 2 unit increments
- **Sensor-augmented pump therapy** with or without low-glucose suspend (basal-bolus rates are managed by the patient)
- **Hybrid closed-loop system** (automated insulin delivery systems) requires CGM (basal rates controlled by pump with sophisticated algorithm and bolus doses requires CHO input by patient)
- **Closed-loop insulin delivery** (Artificial Pancreas) is the future; a combination of CSII and CGM system providing insulin delivery without input from the user.

Insulin Pump Systems
Efficacy and Limitations

• Benefits (primarily in type 1 diabetes)
  • Trend to decrease A1C level
  • Decrease rate of hypoglycemia
  • Improve Quality of Life
  • Requires CGM to improve and sustain glycemic effect

• Limitations
  • Wearability and skin reactions
  • Dependent on manufacturer’s products and software updates
  • DKA occurrence due to loss of insulin infusion

Insulin Pump Systems: Components

- Insulin goes in the reservoir inside the pump.
- Flexible tubing delivers insulin from the pump to your body.
- Continuous insulin drops from the cannula into your skin.
- A flexible plastic tube called a cannula sits under your skin.
Insulin Pump Systems: Additional Considerations

- **U-100 Insulins for the reservoir**
  - Aspart (Novolog) and Faster Aspart (Fiasp)
  - Lispro (Humalog) and Lispro_{abc} (Lyumjev)

- **Pump and Reservoir**
  - MiniMed- 5x10x2 cm with 300 unit capacity, requires tubing
  - T:slim- 8x5x1.5 cm with 300 unit capacity, requires tubing
  - Omnipod- 4x5x1.4 with 200 unit capacity, no tubing and disposable

- **CGM coupling**
  - MiniMed 770G/780G has internal CGM (Guardian 4 sensor)
  - T:slim X2 and Omnipod uses DEXCOM CGM

<table>
<thead>
<tr>
<th>Feature</th>
<th>MINIMED™ 780G</th>
<th>OMNIPOD 5</th>
<th>T:SLIM X2 control IQ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auto correction bolus</td>
<td>Every 5 mins</td>
<td>Every 5 mins—</td>
<td>Every 60 mins</td>
</tr>
<tr>
<td>Extra bolus</td>
<td>100% correction bolus</td>
<td>60% correction bolus</td>
<td></td>
</tr>
<tr>
<td>Meal detection technology</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Basal delivery</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Infusion/cannula set duration</td>
<td>7 days Infusion set</td>
<td>3 days Infusion set</td>
<td>3 days Infusion set</td>
</tr>
<tr>
<td>Glucose targets</td>
<td>100 mg/dL</td>
<td>110 mg/dL</td>
<td>112 mg/dL</td>
</tr>
<tr>
<td>CGM and transmitter lifespan</td>
<td>Guardian 4 1 year lifespan</td>
<td>DEXCOM 6 3 months</td>
<td>DEXCOM 6 3 months</td>
</tr>
<tr>
<td>CGM and transmitter lifespan</td>
<td>1 year lifespan</td>
<td>3 months</td>
<td>3 months</td>
</tr>
</tbody>
</table>
Case study: CGM with MDI

**Time in Ranges**

Goals for Type 1 and Type 2 Diabetes

- **17% Very High**
  - Goal: 5%
- **34% High**
  - Goal: 25%
- **48% In Range**
  - Goal: 70%
- **1% Low**
  - Goal: 4%

**Target Range**: 70-180 mg/dL  
- Very High: Above 250 mg/dL  
- Very Low: Below 54 mg/dL

**Glucose Metrics**

- **Average Glucose**
  - Goal: 154 mg/dL
  - **185 mg/dL**
- **GMI**
  - Goal: <7%
  - **7.7%**
- **Coefficient of Variation**
  - Goal: <46%
  - **37.7%**
- **Time CGM Active**
  - **94.7%**

**Ambulatory Glucose Profile (AGP)**

AGP is a summary of glucose values from the report period, with median (50%) and other percentiles shown as if they occurred in a single day.

**Daily Glucose Profile**

Each daily profile represents a midnight-to-midnight period.

<table>
<thead>
<tr>
<th>Day</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
</tr>
</thead>
<tbody>
<tr>
<td>mg/dL</td>
<td>24</td>
<td>25</td>
<td>26</td>
<td>27</td>
<td>28</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>12pm</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>mg/dL</td>
<td>180</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
<td>70</td>
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</tbody>
</table>
Case study: Hybrid Closed-Loop System
# Case study: Hybrid Closed-Loop System

## Boluses

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bolus Delivered</td>
<td>0.75</td>
<td>1.8</td>
<td>2.2</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Suggested</td>
<td>0.75</td>
<td>1.8</td>
<td>2.2</td>
<td>1.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>MEAL</td>
<td>0.25</td>
<td>2</td>
<td>1.87</td>
<td>1.62</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Correction</td>
<td>0.55</td>
<td>0</td>
<td>0.35</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Insulin On Board</td>
<td>0.7</td>
<td>0.75</td>
<td>0.15</td>
<td>0.5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Initial</td>
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<td>Extended</td>
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<tr>
<td>Duration</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
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</tr>
</tbody>
</table>

**Bolus Table only shows the first 10 bolus events for the day.**

## Statistics

<table>
<thead>
<tr>
<th></th>
<th>Avg. BG</th>
<th>Median BG</th>
<th>BG Readings</th>
<th>Avg. CGM</th>
<th>Median CGM</th>
<th>% CGM Very High</th>
<th>% CGM High</th>
<th>% CGM Target Range</th>
<th>% CGM Low</th>
<th>% CGM Very Low</th>
<th>Total Daily Bolus</th>
<th>Total Daily Basal</th>
<th>Total Daily Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>194</td>
<td>0</td>
<td>201</td>
<td>3</td>
<td>0%</td>
<td>13%</td>
<td>174%</td>
<td>0%</td>
<td>0%</td>
<td>6.3 u</td>
<td>21.6 u</td>
<td>27.8 u</td>
</tr>
</tbody>
</table>

## System Details

<table>
<thead>
<tr>
<th>Automated Mode</th>
<th>100%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automated: Activity</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Automated: Limited</td>
<td>0%</td>
<td>1%</td>
</tr>
<tr>
<td>Manual</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Case study: Hybrid Closed-Loop System

**Glucose - Time In Range**
- 6%: Very High > 250 mg/dL
- 45%: High 181-250 mg/dL
- 49%: Target Range 70-180 mg/dL
- 0%: Low 54-69 mg/dL
- 0%: Very Low < 54 mg/dL

**Summary**
- GMI: 7.7% (60.5 mmol/mol)
- Average: 183 mg/dL
- % Time CGM Active: 95.5% (13.4 days)

**Ambulatory Glucose Profile (AGP)**
- Target Range (70-180 mg/dL)
- Median: 10.90%

**Insulin**
- 6.7%: 24.9 units
- 23%: 12.2 units
- Daily Dose: 37.1 units
- Overrides (%): 25% (15 boluses)
- Bolus/Day: 4.3

**System Details**
- Insulet Omnipod® 5 (229/3h)
- Automated Mode: 100% (229/3h)
- Automated: Limited 2% (3d 23h)
- Automated: Activity 0%
- Manual Mode 0% (3h)

**Diet**
- Carbs/Day: 82.9 g
- Entries/Day: 2.8

**Fitness**
- No fitness tracker connected

**Comments**
Another case study: Hybrid Closed-Loop System

Time in Ranges: Goals for Type 1 and Type 2 Diabetes

- **5% Very High**
  - Goal < 3%
- **21% High**
  - Goal < 10%
- **78% In Range**
  - Goal < 70%
- **1% Low**
  - Goal < 50%
- **< 1% Very Low**
  - Goal < 50%

Glucose Metrics

- **Average Glucose**
  - Goal: < 154 mg/dL
  - Value: 151 mg/dL
- **GMI**
  - Goal: < 7%
  - Value: 6.9%
- **Coefficient of Variation**
  - Goal: < 36%
  - Value: 37.9%
- **Time CGM Active**
  - Value: 70.4%

Ambulatory Glucose Profile (AGP)

AGP is a summary of glucose values from the report period, with median (50%) and other percentiles shown as if they occurred in a single day.

![Ambulatory Glucose Profile](chart)

Daily Glucose Profile

Each daily profile represents a midnight-to-midnight period.

- **Friday**
  - 70 mg/dL to 180 mg/dL
- **Saturday**
  - 70 mg/dL to 180 mg/dL
- **Sunday**
  - 70 mg/dL to 180 mg/dL
- **Monday**
  - 70 mg/dL to 180 mg/dL
- **Tuesday**
  - 70 mg/dL to 180 mg/dL
- **Wednesday**
  - 70 mg/dL to 180 mg/dL
- **Thursday**
  - 70 mg/dL to 180 mg/dL
Insulin Pump Systems: Future Considerations

• Automated pump (hybrid closed-loop) with glucagon or pramlintide
• Use with concentrated insulin to accommodate T2DM patients requiring high doses
  • U-500 Regular insulin
  • U-200 Humalog
• Working toward the artificial pancreas

IHS Division of Diabetes Treatment and Prevention
Resources for Glucose Management with Insulin

• Webinars
  • Insulin Management. Richard Arakaki, 4/20/22
  • Simple to Advanced Approaches to Carbohydrate Counting. Kibbe Brown and Wendy Castle, 3/8/23

• Algorithm
  • Insulin Therapy in Type 2 Diabetes
  • Insulin Concentration

IHS Division of Diabetes Treatment and Prevention. https://www.ihs.gov/diabetes/
Any Questions or Comments?