INSULIN PUMPS

ISHP Spring CE Conference
April 12, 2015
St. Luke’s Medical Center
Randi Lynn Griffiths, PharmD
Clinical outpatient pharmacist
Boise VA Medical Center
Boise, Idaho

WHAT IS AN INSULIN PUMP

- Alternative method for delivering insulin using continuous subcutaneous insulin infusion (CSII)
- “open loop” system
  - Pumps do not automatically adjust based on BG reading.

[Image: http://www.mkillustrations.com/images/i36_insulin_pump.jpg]

http://www.mkillustrations.com/images/i36_insulin_pump.jpg
Arnold Kadish invents the first insulin pump

1970's:
- First computer controlled insulin pump: "Biostator"
- Slama et al. Research with IV insulin pump
- Keen et al. test CSII for T1DM using Mill Hill Infuser
- Pharmaceutical companies begin to invest in product development
- Pumps are large, inaccurate, unreliable, and often cause infusion site reactions

1980's:
- Pharmaceutical companies begin to invest in product development
- Pumps are large, inaccurate, unreliable, and often cause infusion site reactions

1990's to present:
- Pumps become smaller, more reliable and functional
- "smart pumps" allow for individualized insulin delivery


- Medtronic: Revel, 530G
- Accu-Check: Combo
- Animas: Ping & Vibe
- Insulet: Omnipod
- Tandem: T-Slim
- Asanti: Snap
- Valeritas: V-Go

- Each boast various features: Tubeless, remote, water proof, integrated with continuous glucose monitoring, prefilled/disposable cartridges, touch screen, small size, etc.
EQUIPMENT AND SUPPLIES

- Pump
- Reservoir
- Infusion set
- Linking BG meter

HOW DO THEY WORK

- Insulin pumps use a rapid or fast acting insulin to deliver both basal and bolus insulin
  - Basal insulin
  - Bolus insulin
    - Prandial bolus
    - Correction bolus
- Insulin is delivered subcutaneously through an infusion set with a plastic canula
**BASAL INSULIN**

- Delivered at a constant rate of X units/hour
- May be programmed with multiple basal rates throughout a 24 hour period
- May be programmed with multiple basal patterns throughout the week
  - Weekend pattern
  - Weekday pattern
  - Exercise pattern, etc.
- May set a “temporary basal”
  - Ex: 50% of basal rate for 2 hours
  - This is particularly useful for physical activity

---

**EXAMPLE BASAL PATTERN**

![Bar chart showing basal insulin patterns over a 24-hour period.](image)

**Standard**
- 24 Hr Total: 18.8 U
- Last Edit: 8/15/12 9:53 AM

**Profiles**

<table>
<thead>
<tr>
<th>Time</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>12:00a</td>
<td>1.00</td>
</tr>
<tr>
<td>01:00a</td>
<td>0.85</td>
</tr>
<tr>
<td>02:00a</td>
<td>0.90</td>
</tr>
<tr>
<td>03:00a</td>
<td>0.85</td>
</tr>
<tr>
<td>04:00a</td>
<td>0.95</td>
</tr>
<tr>
<td>05:00a</td>
<td>0.90</td>
</tr>
<tr>
<td>06:00a</td>
<td>0.90</td>
</tr>
<tr>
<td>07:00a</td>
<td>0.85</td>
</tr>
<tr>
<td>08:00a</td>
<td>0.70</td>
</tr>
</tbody>
</table>
**BOLUS INSULIN**

- **Prandial Bolus**
  - Bolus is calculated based on patients pre-prandial glucose reading, the number of carbohydrates consumed during the meal and any “insulin on board”
  - Can be delivered over time if ingesting a high fat meal
- **Correction Bolus**
  - Bolus is calculated based on patients blood glucose reading and “insulin on board”
- **May be programmed with multiple ratios throughout a 24 hour period**

**BOLUS INSULIN PUMP SETTINGS**

- **Insulin to carbohydrate ratio**
  - Provides insulin to cover carbohydrates (CHO) consumed
  - 1 unit of insulin for every X grams of CHO
- **Correction factor**
  - Provides insulin to bring blood glucose up/down to pre-set target
  - 1 unit of insulin will drop patients BG by X mg/dL
**Bolus Insulin Pump Settings**

- **Blood glucose target**
  - Bolus insulin injections are calculated to achieve this number/range

- **Active Insulin on board**
  - Account of bolus insulin that has been given within a pre-set period of time
    - Typically 4 hours, may be increased to 6 hours in patients with significant decrease in renal function
  - Prevents “stacking” of insulin when multiple bolus injections are given within a short time frame

---

**Example Bolus Pump Settings**

<table>
<thead>
<tr>
<th>Carbohydrate Insulin Ratio</th>
<th>Blood Glucose Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time</td>
<td>grams/Unit</td>
</tr>
<tr>
<td>12:00a–12:00p</td>
<td>13</td>
</tr>
<tr>
<td>12:00p–04:00p</td>
<td>18</td>
</tr>
<tr>
<td>04:00p–12:00a</td>
<td>10</td>
</tr>
<tr>
<td>24 Hour Average</td>
<td>12.8</td>
</tr>
</tbody>
</table>

- **Active Insulin Time** 4 hours

- **Insulin Sensitivity**
  - **Time**         | **mg/dL/U** |
  - 12:00a–12:00a     | 40          |
  - 24 Hour Average   | 40          |
SAMPLE BOLUS WIZARD® CALCULATOR

ESTIMATE DETAILS
- Est Total: 4.0U
- Food Intake: 45gr
- (Meter) BG: 160
- Food: 3.0U
- Correction: 2.0U
- Active Ins: 1.0U

ACT to Proceed
ESC to Back Up

http://aadityamedix.net/minimed712.html

INJECTABLE INSULIN

Activity Profiles of Different Types of Insulin

INDICATIONS FOR INSULIN PUMP

- Elevated HbA1c with MDI
- Recurrent hypoglycemia
  - MDI failure of maintaining HbA1c <7% without hypoglycemia
  - ≥1 episode/year of unexplained hypoglycemia
- Marked same-day or between day variability in glucose
- Variability of insulin requirements
  - Dawn phenomenon
  - Shift workers, business travelers, ect.

https://www.accu-chek.co.uk/gb/pumptherapy/subcutaneous-insulin-infusion.html

Diabetes & Metabolism 2008; 34401-423
**ABSOLUTE CONTRAINDICATIONS**

- Severe psychiatric disorder
- Rapidly progressive retinopathy
- Non-educated medical environment
- Extreme heat or cold patient environment
- Underwater diving
- Exposure to high electromagnetic fields

Diabetes & Metabolism 2008; 34401-423

**RELATIVE CONTRAINDICATIONS**

- Poor compliance
- Patient reluctance
- Poor local hygiene
- Visual or physical impairment

Diabetes & Metabolism 2008; 34401-423
**Requirements for Pump Use**

- Sensitive to insulin
  - Total daily dose must be less than about 60 units
- Technology savvy or willing to learn
- Competent and willing to count carbohydrates
- Willing to check BG at least 4 times daily

---

**Practical Considerations**

- Infusion sets and reservoirs should be changed every 3 days
- Infusion sites should be rotated frequently
- Pt should ALWAYS carry an extra infusion set
- Pt should carry extra insulin and syringes when traveling
- Pt should not take insulin pump into medical test procedure rooms such as CT scans as these may cause pump to malfunction
**PROS**
- Can decrease frequency of hypoglycemia
- Provides flexibility in insulin dosing
- Helpful for patients who experience hypoglycemia during exercise or strenuous physical activity or for those who have hypoglycemia unawareness

**CONS**
- Steep learning curve
- Insulin delivery can be interrupted d/t dislodging, canula blockage, battery loss, etc
- Hyperglycemia and ketoacidosis can occur quickly d/t the use of rapid acting insulin
- Pump is bulky and can be a constant reminder to the patient that they have DM
- Expensive
- Requires frequent BG testing and CHO counting
CASE STUDY

AP is a 53 YOF with a hx of DM type I (x 35 years), HTN, hyperlipidemia and CKD who expresses interest in starting an insulin pump. Pt has hypoglycemia unawareness and has had more than 10 hypoglycemic episodes in the last week. Most hypoglycemic episodes occur while sleeping and while exercising.

AP’S CURRENT INSULIN REGIMEN

<table>
<thead>
<tr>
<th>Current insulin regimen:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detemir:</td>
</tr>
<tr>
<td>AM</td>
</tr>
<tr>
<td>Sundays:</td>
</tr>
<tr>
<td>Running days:</td>
</tr>
<tr>
<td>All others:</td>
</tr>
</tbody>
</table>

Aspart: carb-ratio + corrective with meals
Carb ratio: 1 unit:10g carb ratio with breakfast (add 1 unit on non-running days if BD<150; add 2 units on Sundays), lunch, and dinner
AP’S BLOOD GLUCOSE/FOOD LOG

<table>
<thead>
<tr>
<th>Date</th>
<th>AM</th>
<th>NOON</th>
<th>PM</th>
<th>HS</th>
<th>MN</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/21</td>
<td>102(2/17g)</td>
<td>RUN</td>
<td>Dec6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/20</td>
<td>88(3/30g)</td>
<td>60(3/33g)</td>
<td>61(3/39g)</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec7 GRANOLA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/19</td>
<td>107(2/17g)</td>
<td>RUN</td>
<td>65(3/36g)</td>
<td>00(3/20g)</td>
<td>70 GRANOLA</td>
</tr>
<tr>
<td></td>
<td>Dec6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/18</td>
<td>260(1/17g)</td>
<td>225(4/33g)</td>
<td>8PM: 75(2/17g)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec9</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/17</td>
<td>525(6/30g)</td>
<td>299(4/33g)</td>
<td>64(2/23g)</td>
<td>94</td>
<td>710947</td>
</tr>
<tr>
<td></td>
<td>Dec7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/16</td>
<td>111(2/13g)</td>
<td>244(3/19g)</td>
<td>96(7/64g)</td>
<td>199(g)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>New novolog vial</td>
<td>Popcorn, Dec4 cookies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3/15</td>
<td>115(3/30g)</td>
<td>113(4/37g)</td>
<td>150(4/37g)</td>
<td>175</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IS AP A GOOD CANDIDATE FOR INSULIN PUMP THERAPY?

- **Why?**
  - Frequent hypoglycemia
  - Nocturnal hypoglycemia
  - Hypoglycemia unawareness
  - Variability in insulin requirements during exercise days and weekends
- **Bonus**
  - Carbohydrate counting
  - Testing 4+ times/day
CAN AP EXPECT IMPROVEMENT IN HER HGA1C?

- Studies do not support improvement in glycemic control in patient switched from multiple daily injections to continuous subcutaneous insulin infusion (pump) over the long term.

CONTINUOUS GLUCOSE MONITORS (CGM)

- CGM’s continuously monitor interstitial glucose levels
- Professional CGM
  - Blinded to patient
  - Information used to make adjustments to therapy
- Personal CGM
  - Linked to insulin pump (ie: Dexcom, Medtronic)
  - Worn independently (ie: Dexcom)
- Useful for detecting excursions in BG, particularly hypoglycemia
NEW DEVELOPMENTS

Threshold Suspend
- Available with Medtronic Minimed 530G pump
- Used with Enlite CGM sensors
- Automatically suspends insulin delivery for 2 hours if patient fails to respond to Threshold Suspend alarm (alarms at a pre-set low BG level)

FUTURE OF PUMP THERAPY
THE “ARTIFICIAL PANCREAS”

Closed Loop System = CGM + insulin pump + Diabetes Assistant (PDA, smart phone)
- Stage 2 clinical trials
- CGM feeds BG to DiA (contains an algorithm)
- DiA adjusts basal rate in pump

Goal:
- More time in euglycemia
- Minimize/eliminate hypoglycemia
QUESTIONS?