Continuous Subcutaneous Insulin Infusion (CSII) in Diabetes Management: Who, Why & How

HAYLEY MILLER, MD
DIABETES, PREVENTION AND CONTROL PROGRAM
TELE-HEALTH CONFERENCE
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Evolution of Diabetes Technology and Treatments: Timeline

1776 Urine Tasting

1900s Insulin Injections

1922 Urine Test Strips

1977 Glucose Meters

1978 Insulin Pumps

1999 Artificial Pancreas: “Closing the Loop”

- Glucose Sensors
- Insulin Analogs
- New Oral agents
- REAL-Time monitoring
- Incretin-based Therapies
- Inhaled Insulin
Insulin Pumps: Overview
U.S. Pump Usage

Year:
- '90: 6,600
- '91: 8,700
- '92: 11,400
- '93: 15,000
- '94: 20,000
- '95: 26,500
- '96: 35,000
- '97: 43,000
- '98: 60,000
- '99: 81,000
- 2000: 120,000
- 2001: 162,000

Counts:
- U.S. Pump Usage

Units:
- Volume
Estimated Pump Use Around the World

- UK
- Czech Republic
- Switzerland
- France
- Sweden
- Netherlands
- Germany
- Israel
- USA
Ideal Basal/Bolus Insulin

Time

Plasma insulin

Breakfast  Lunch  Dinner
Pump Therapy

Basal rate
- Continuous flow of insulin
- Takes the place of glargine or detemir

Boluses
- Insulin needed pre-meal
  - Pre-meal BG
  - Carbohydrates in meal
  - Activity level
- Correction bolus for high BG

Time of day

Basal rate

Meal bolus

Units

12 am 12 pm 12 am
Pump Components

Insulin pump

Indwelling subcutaneous catheter

Subcutaneous tissue
Pump Components
How does the insulin get into your body?

- Insulin in the blood

Flexible tubing delivers insulin from the pump reservoir to the infusion set.

A tiny tube called a cannula is inserted under your skin to deliver insulin.
Additional Features

Bolus Calculators:
- Carbohydrates
- Blood glucose
- Insulin on board
Insulin Pump Benefits
HbA$_{1c}$ Reduction

Change from Baseline HbA1c: Comparing CSII with MDI

<table>
<thead>
<tr>
<th>Study, Year (Reference)</th>
<th>Mean Difference (95% CI)</th>
<th>CSII, n</th>
<th>MDI, n</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children/adolescents with T1DM</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doyle et al, 2004 (32)</td>
<td>-0.80 (-1.89 to 0.29)</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Schiaffini et al, 2007 (35)</td>
<td>-0.60 (-1.43 to 0.23)</td>
<td>19</td>
<td>17</td>
</tr>
<tr>
<td>Cohen et al, 2003 (31)</td>
<td>-0.52 (-1.67 to 0.63)</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>Nuboer et al, 2008 (33)</td>
<td>-0.16 (-0.68 to 0.36)</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Opipari-Arrigan et al, 2007 (34)</td>
<td>-0.13 (-1.74 to 1.48)</td>
<td>6</td>
<td>8</td>
</tr>
<tr>
<td>Skogsberg et al, 2008 (36)</td>
<td>0.00 (-1.25 to 1.25)</td>
<td>34</td>
<td>33</td>
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<tr>
<td>Weintrob et al, 2003 (37)</td>
<td>0.26 (-0.32 to 0.84)</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td><strong>Subtotal (I^2 = 0.0% ; P = 0.561)</strong></td>
<td>-0.17 (-0.47 to 0.14)</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

| **Adults with T1DM**                   |                          |         |        |
| DeVries et al, 2002 (40)              | -0.84 (-1.31 to -0.37)   | 39      | 40     |
| Thomas et al, 2007 (44)               | -0.10 (-2.12 to 1.92)    | 7       | 7      |
| Bolli et al, 2009 (39)                | -0.10 (-0.52 to 0.32)    | 24      | 26     |
| Tsui et al, 2001 (45)                 | 0.25 (-0.42 to 0.92)     | 13      | 14     |
| **Subtotal (I^2 = 64.5% ; P = 0.038)**| -0.30 (-0.58 to -0.02)   | –       | –      |
| **Subtotal, excluding DeVries et al** | -0.01 (-0.35 to 0.34)    | –       | –      |

| **Adults with T2DM**                   |                          |         |        |
| Derosa et al, 2009 (47)                | -0.50 (-1.57 to 0.57)    | 32      | 32     |
| Wainstein et al, 2005 (50)             | -0.50 (-1.57 to 0.57)    | 20      | 20     |
| Raskin et al, 2003 (49)                | -0.16 (-0.51 to 0.19)    | 66      | 61     |
| Herman et al, 2005 (48)                | -0.10 (-0.52 to 0.32)    | 53      | 54     |
| **Subtotal (I^2 = 0.0% ; P = 0.840)**  | -0.18 (-0.43 to 0.08)    | –       | –      |
Reduces Hypoglycemia

- Bode: n = 55, Mean age 42
- Rudolph: n = 107, Mean age 36
- Chanteleau: n = 116, Mean age 29
- Boland: n = 25, Mean age 14
- Chase: n = 56, Mean age 17

Incidence Rate Ratio Severe Hypoglycemia: CSII vs MDI

<table>
<thead>
<tr>
<th>Study, Year (Reference)</th>
<th>IRR for Severe Hypoglycemia, events/person-year</th>
<th>IRR (95% CI)</th>
<th>Total Events, n</th>
<th>Person-Years</th>
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<tr>
<td></td>
<td></td>
<td>CSII</td>
<td>MDI</td>
<td>CSII</td>
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<td>Cohen et al, 2003 (31)</td>
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<td>0.22 (0.02–1.94)</td>
<td>1</td>
<td>4</td>
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<td>Opipari-Arrigan et al, 2007 (34)</td>
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<td>0</td>
<td>2</td>
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<td>0.33 (0.03–3.21)</td>
<td>1</td>
<td>3</td>
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<td>Skogsberg et al, 2008 (36)</td>
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<td>1.50 (0.58–3.88)</td>
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<td>7</td>
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<tr>
<td>Overall (I² = 6.5%; P = 0.370)</td>
<td></td>
<td>0.99 (0.57–1.71)</td>
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<td>–</td>
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Quality of Life

- Liberalization of diet — timing & amount
- Increased control with exercise
- Able to work shifts & through lunch
- Less hassle with travel — time zones
- Weight control
- Less anxiety in trying to keep on schedule
Continuation Rate

Continued 97%

Discontinued 3%

N = 165
Average Duration = 3.6 years
Average Discontinuation <1%/yr

## Pros and Cons of Pump Therapy

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<th>Insulin Pump Therapy</th>
<th>Pros</th>
<th>Cons</th>
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<tr>
<td></td>
<td>Slightly better glycemic control</td>
<td>Cost</td>
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<tr>
<td></td>
<td>Fewer injections</td>
<td>Superficial infection</td>
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<tr>
<td></td>
<td>Less variable insulin absorption day to day</td>
<td>Pump failure $\rightarrow$ DKA</td>
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<td></td>
<td>Lifestyle flexibility, improved QOL</td>
<td>Inconvenience of wearing device 24/7</td>
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<td></td>
<td>Capability to store history of bolus/basal: clinicians can assess adherence</td>
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<td>Decreased frequency of hypoglycemia (in peds)</td>
<td></td>
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<tr>
<td>Multiple Daily Injections</td>
<td>Lower cost</td>
<td>Multiple injections</td>
</tr>
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<td>Freedom from wearing pump</td>
<td>Inferior glycemic control</td>
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<td></td>
<td></td>
<td>Less flexible</td>
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Insulin Pumps: Indications
Pump Therapy Indications

- HbA$_1c$ >6.5%
- Frequent hypoglycemia
- Dawn phenomenon
- Exercise
- Pediatrics
- Pregnancy
- Gastroparesis

- Hectic lifestyle
- Shift work
- Type 2???

PUMP INDICATIONS

• “Ideal CSII candidate is a patient with T1DM or absolutely insulin-deficient T2DM who. . .”
  ○ Performs 4+ injections daily
  ○ Is motivated to achieve tighter glycemic control
  ○ Is willing & intellectually/physically able to comply with initiation and maintenance of pump therapy
  ○ Is emotionally mature with stable life situation
  ○ Maintains frequent contact with health care provider

• Eligible patients should be capable of
  ○ Frequent SMBG and/or use of CGM
  ○ Carb counting and insulin correction
  ○ Troubleshooting problems
Target Populations

- Young children, especially infants and neonates
- Adolescents with eating disorders
- Children and adolescents with pronounced dawn phenomenon
- Children with needle phobia
- Pregnant women (before conception)
- Ketosis-prone individuals
- Competitive athletes
When to Consider

- Recurrent severe hypoglycemia
- Wide fluctuations in blood glucose levels regardless of A1C
- Suboptimal diabetes control
- Microvascular complications and/or risk for macrovascular complications
- Good metabolic control but insulin regimen compromises lifestyle
- Gastroparesis
Remember: The Smart Pump Arrives Dumb

- Glycemic control depends on
  - An accurate total daily dose
  - Appropriate basal rate (~50$ of total daily dose)
  - Accurate carb ratio
  - Accurate insulin sensitivity factor
  - Appropriate insulin on board
  - Appropriate correction target
Insulin Pumps: Available Options
Patch Pump vs Infusion Set

- **Patch Pump (Omni-Pod)**
  - Worn on body
  - No external tubing
  - Can loosen, leak, be knocked off
  - Lower start-up cost, greater monthly cost

- **Infusion set (tubed)**
  - More site options
  - Variety of needle and tubing lengths
  - Easy pump removal for showers, sports
  - Can loosen, leak, get ripped off
Omni-Pod

- Patch pump (no tubing)
- Watertight up to 25 feet for 60 minutes
- Color screen
- “Meter remote”
- Built-in FreeStyle blood glucose meter
- Food library
- Future integration with CGM (?)
MiniMed Paradigm Revel

- Tubed pump
- 2 different size options available (523/723)
- Only available pump with integrated CGM
- Meter communicates to pump (not remote)
- No food database
- No color screen
- Low basal rate increment up to 1 unit
- Splash resistant (not waterproof)
Animas OneTouch Ping

- Tubed pump
- Waterproof
- Color Screen
- Meter remote
- Integrated food database
- Future integration with Dexcom CGM (Animas Vibe)
- Durable
Tandem t:slim

- Tubed pump
- Water resistant (3 feet 30 minutes)
- Color touch screen
- Smallest dimensions
- No integrated meter
- Rechargeable battery
- No returns
- Occlusion shuts off pump
- Cannot tolerate extreme temperatures
Accu-Check Combo

- Tubed pump
- Water resistant
- Color screen on meter
- Meter remote
- ? Food database
- Must program basal rate for each hour
- No bolus calculator on pump
- Complicated programming
User Considerations

- How much insulin does the patient use in 3 days?
- How active is the patient?
- Is tethering patient to pump practical?
- Is the patient exposed to:
  - Water?
  - Extremes of temperature?
- Will the patient need a more durable device?
- What does the patient want and why?
Misc. Points

My BG is low again

Insulin Absorption & Temp

- Epidermis

Vasoconstriction

Vasodilation

Air or water

Heat loss across epidermis
Air Travel & Insulin Pumps

- Study looked at 10 insulin pumps during flight & in hypobaric chamber with pressure simulating flight.
- Decrease in ambient pressure ➔ predictable unintended insulin delivery by:
  - Air coming out of solution & forming bubbles
  - Expansion of existing bubbles in cartridge before takeoff ➔ increase by 36% in size

Pumps in Young Women

- Perceived body images & social acceptance
- Increased self-consciousness
- Greater body dissatisfaction
- Decreased body esteem
Pump Concealment
Misc Points

- Increased risk for DKA
- Pump volume should approximate
  - total daily dose x 3
- Infusion sets MUST BE CHANGED Q3 days
- Insulin on board 4-5 hours
- Close follow-up by specialist (CDE, Diabetologist)
- All rapid acting insulin analogues equivalent
- Infusion should never be stopped – loss of insulin during a shower ~ .25 units
- Bolus wizard should be used for ALL corrections
- Have a back-up plan for pump failure (glargine dose and prescription)
Most Important Factor when Prescribing Pump Therapy??

THE PATIENT!!!
References