Diabetes Technology in the Pediatric Population

What Healthcare Professionals Needs to Know to Treat Type 1 Diabetes

Paula Clinton, RD, CDE

Stanford University, Pediatric Endocrinology

Clinical Research Artificial Pancreas/Closed Loop Technology
Diabetes Technology

Insulin Pumps & Continuous Glucose Monitors (CGMs)
  • Advantages
  • Disadvantages

Pattern Recognition with CGM Data
  • Review of downloaded data

Future Technology
Insulin Pumps
• 1964

• Measured venous blood every 15 seconds with 7 min lag time

• Delivered insulin at 0.1 U/min if >150 mg/dl (8.3 mmol/L)

• Delivered glucagon at 0.05 mg/min if < 50 mg/dl (2.8 mmol/L)
Investigators from the T1D Exchange (US), the UK National Paediatric Diabetes Audit (England/Wales) and the DPV initiative (Austria/Germany) pooled their data from T1D patients under the age of 18 years.

Researchers compared the proportion of patients who had used an insulin pump at any time during a two-year period from 2011 to 2012 to those using injections; HbA1c levels also were examined.

The percentage of children over the age of 6 years living with T1D who use insulin pumps is higher in the US than in England, Wales, Germany, and Austria.

In all countries, the use of insulin pumps was higher among patients with longer T1D duration. Overall, those using pumps had a lower HbA1c level (average 8.1) than those using injections (average 8.6).
Polling Question:

Advantages of insulin pump therapy include:

A. Increased lifestyle flexibility
B. Improved hypoglycemic awareness
C. More physiologic insulin delivery
D. All of the above
Pump It Up!
Advantages of Insulin Pump Therapy

- Lifestyle flexibility/individualization (meals, snacks, exercise, sports, parties)
- More comfortable with exercise, school, work, menses
- Easier sick day management
- Sleeping in
- Managing growth spurts
- Dawn phenomenon
- Improved hypoglycemic awareness
- Alerts/alarms
- Eating to appetite
- Visibility
- Independence
- Improved glycemic control (less roller coaster effect)
- More physiologic insulin delivery
- Extended meal delivery/dual wave
- No injections in public
- Keeps track of insulin on board (IOB)
To Pump or Not to Pump ...  
Disadvantages of Insulin Pump Therapy

- It is not perfect
- Increased family involvement
- Visibility/loss of privacy
- Time site/set change
- Always being attached
- If disconnection or no infusion - KETONE production in less than four hours / Risk of diabetic ketoacidosis (DKA)
- Double the cost of injections
- School issues (e.g. who will bolus and trouble shoot at school)
- Risk of infection at the injection sites
- Increased monitoring/checking blood glucose (BG)
- Allergies to tape and skin prep products
- Excessive sweating causing lack of adhesion
- Pump runs dry
- Pushing the site limits
- Ignoring hyperglycemia
- Not checking ketones
Steps to Better Glycemic Control

• Stop the lows first
• Review basal/bolus percentage
• Look for and correct unwanted patterns/trends
• Pre-meal bolus when possible
  • < 100 mg/dl (5.5 mmol/L) - give bolus with start of meal
  • 101-149 mg/dl (5.6 – 8.2 mmol/L) - give bolus 10 to 15 minutes before meal
  • 150 -199 mg/dl (8.3 – 11 mmol/L) - give bolus 15 to 20 minutes before meal
  • 200 - 249 mg/dl (11.1 – 13.8 mmol/L) - give bolus 20 to 25 minutes before meal
  • 250 - 300 mg/dl (13.9 – 16.7 mmol/L) - give bolus 25 to 30 minutes before meal
Reasons to Stop Pump Therapy

- Emergency room visits, hospitalizations
- Parent or child wants to stop
- Unsafe based on other clinical data (e.g. one bolus per week)
- Not checking BG enough
- Not checking for ketones
- Not changing sites
- Other - A1c remains above 10%
- Skin complications: lipohypertrophy, tape allergy, infections
Continuous Glucose Monitors
Polling Question:

Data from the Davis EA, et al. “Hypoglycemia: Incidence and clinical predictors in a large population-based sample of children and adolescents with IDDM” found that _____% of seizures occurred at night.

A. 25%
B. 50%
C. 75%
D. 100%
Hypoglycemia in Children and Adolescents

- 657 children followed for 3 years
- 8.5% had severe (seizure/coma) hypoglycemia
- 27% had moderate (required assistance) hypoglycemia
- 75% of seizures occurred at night
- Recent CGM data shows seizure may require prolonged severe hypoglycemia prior to event

Advantages of CGM

• Provides information about the direction, magnitude, duration, frequency and causes of fluctuations in BG
• Provides trending/pattern information in real-time on the device
• Displays rapid fluctuations and trends in BG
• Alerts for hypo/hyperglycemia…helps with prevention of lows/highs
• Basal rate testing, adjustment of ratios
• Data sharing
• Adjustment of insulin for exercise (use of temporary basal, removal of pump, pre-exercise carb load)
• Helps with “reactive pumping” (pumping gas then putting on the breaks)
Disadvantages of CGM

• Does not measure whole blood, but rather the glucose concentration within the interstitial fluid compartment.

• Sensor is not accurate enough to be used to make therapeutic decisions

• “Rage bolus” - impatience or lack of understanding of lag time and may lead to over treating and creating roller coaster

• Must still do fingersticks/adjunctive therapy

• Complicated/time consuming to teach

• Data overload! Alarm/alert overload!

• Only 24 hours worth of data available for review on device. Must download devices to see trends/patterns over time (last 1-2 weeks)

• Skin and site insertion issues/not enough “real estate”

• Loss of privacy
Considerations for the Pediatric Population

• Wear ability and durability
  • location on the body, not enough real estate
  • keeping the transmitter/sensor stuck to the body
  • active bodies in constant motion

• Family conflict:
  • related to data “management”
  • focusing on the negative vs. the positive
  • nagging

• Response rate, or lack thereof:
  • to the alarms/alerts
  • trends/patterns

• For older adolescents/teens loss of privacy with “share” devices
Reasons Patients and Families Choose CGM

- Alerts for lows and highs
- Avoiding frequent hypos & hypo unawareness
- Seeing effect of specific foods and exercise
- A child too young to report a low glucose
- Security during sleep or when living alone
- Frequent driving or travel
- Real time info and data downloads
- Sharing glucose data
Why Isn’t Everyone on a CGM?

• The seeming invulnerability of adolescence
• Single and dating
• Concepts of beauty or body image
• Marks one as having a chronic disease
• Hot, wet climate, contact sports
• Expense/no insurance coverage
• Technophobes or not wanting a device attached
• Desire to avoid “bad” news/data overload
How Do Patients Use CGM?

Of 222 survey respondents with Type 1 diabetes:

- 51% rated trend line/trend arrow as the most important
- 30% rate high and low alerts as most important
- 15% thought real-time and downloaded information were important
- Only 3.6% reported that finding patterns from downloads was important
  - 40% never download
  - 17% do so rarely

CGM Data:
Real-Time (RT) Screen vs. Download

- **RT Trend Lines Show:**
  - 1-24 hour readings
  - One night’s basal profile
  - Profile of day’s meals/snacks
  - Limited patterns

- **Downloaded Data Shows:**
  - Many days of readings
  - Frequent lows/highs
  - Post-meal spikes
  - Trend patterns
Take Home for HCPs

- Patient selection is key
- Can be used for medical management and patient ownership of disease management
- Match the devices to the patient needs
- Education is the key to patient success
- CGM devices can improve patient outcomes and quality of life but the patient must be invested/engaged
- You MUST download the devices to get the complete picture
- Do not think of reimbursement as a barrier
Data
Let’s Talk About Data

• **It’s just DATA/INFORMATION!** If your patient is sharing it with you consider it a privilege, and thank them.

• Consider it investigative reporting by looking for clues, like a scavenger hunt.

• You AND the patient/family will likely learn more if they do not feel defensive.

• You are partners in diabetes care. The goal is to teach patients and families **how to use the system effectively**. This includes making their own therapy modifications.

• Ask them…what do you see?

• “May I tell you what you see?” Ask permission. Then have a non-judgmental discussion about what you think is working and what seems to be challenging.

• Discuss collaboratively how to address challenges.
Trend Report
Daily Report

Comparison: Day by day overview

Combo Bolus

Combo Bolus
Polling Question:

If BG is rising sharply (i.e. double trend arrow up), the bolus insulin dose can be increased by 20%.

A. True
B. False
Adjustments to Insulin Based on BG and Trend

Stable BG = usual dose

BG rising gradually = \[\uparrow\ \text{increase bolus dose by 10\%}\]

BG rising sharply = \[\uparrow\uparrow\ \text{increase bolus dose by 20\%}\]

BG dropping gradually = \[\downarrow\ \text{decrease bolus dose by 10\%}\]

BG dropping sharply = \[\downarrow\downarrow\ \text{decrease bolus dose by 20\%}\]
Future Technology
The Future
of Insulin Pumps and CGMs

• Improved infusion sets
  • Longer duration of wear
  • Duel sensor/pump insertion on one infusion set

• Improved Sensors
  • MARD less than 10%
  • Duration of wear 2 weeks
  • Factory calibration vs. manual calibration by patient
Closed-Loop/AP Systems:
What Are the Challenges?

- Time Delays
  - Sensor lag times
  - Onset of subcutaneous insulin action

- Accuracy of Sensor

- Biologic Variability
  - Insulin action
  - Meal absorption

- Exercise

- Meals/food!
What do participants think?

- Great to wake up with glucose in target and no lows overnight
- Sensors are much more accurate
- Feel liberated from food constraints
- Not perfect during the day
- When can I get one of these?
Closed Loop Systems
Algorithm Development

- Algorithms will continue to improve
- Algorithms adapting to individuals
- Modifying set points/targets
- Modifying overnight basal (basal modulation)
- Modifying meal responses
- Algorithms adapting over time
- Short term for acute changes
- Long term for weekly and monthly patterns
Closed Loop Systems

- Hybrid Closed-Loop During the Day and Full Closed-loop Overnight
  - Pre-meal bolus
  - Carbohydrate count

- Fully Automated Closed Loop System
  - No carbohydrate counting
  - No pre-meal bolus
  - Lessen the daily burden of diabetes self management

- Bi-hormonal Closed Loop System
  - Use of insulin and glucagon
Wearable Devices

• Use of Accelerometers and Heart Rate Monitors
  • Detect and adjust automatically for activity
  • Allows detection of sleep to modify algorithm

• Integration into Consumer Devices (e.g. smartphones)
The Future is Now...
You cannot escape the responsibility of tomorrow by evading it today – Abraham Lincoln