Making the Most of Continuous Glucose Monitoring

1. What Information Is Available
2. How to Use Immediate Data
3. How to Use Intermediate Data
4. What Can Be Learned from Retrospective Analysis
5. Optimizing CGM System Performance

Report Options: Medtronic Carelink Personal

Sensor Daily Overlay

Sensor Overlay By Meal

Report Options: Medtronic Carelink Personal

Daily Summary Layered Report:
- Sensor tracing & BG entries
- Basal & bolus delivery
- Carbohydrate, exercise & logbook entries

Statistical Summary
- Avg, SD, Hi/Low
- # Hi/Low Excursions, AUC
- % Time above, below, within target range

Report Options: DexCom DM3

Hourly Stats w/data table for each hour

Glucose Trend Includes event entries
**What Do We Get in Real Time?**

- **Trends**
- **Alerts**
- **Numbers**

**Decision-Making Based on Trend Information**

- **Self-Care Choices**
  - To snack?
  - To check again soon?
  - To exercise?
  - To adjust insulin?

- **Key Situations**
  - Driving
  - Sports
  - Tests
  - Bedtime
Bolus Adjustment Based on Trend Information

- BG Stable: Usual Bolus Dose
- BG Rising Gradually: ↑ bolus slightly*
- BG Rising Sharply: ↑ ↑ bolus modestly**
- BG Dropping Gradually: ↓ bolus slightly*
- BG Dropping Sharply: ↓ ↓ bolus modestly**

* Enough to offset 25 mg/dl (1.5 mmol/l)
** Enough to offset 50 mg/dl (3 mmol/l)

Immediate Info: Hypoglycemia Alerts

- Predictive Hypo Alert or Hypo Alert & recovering: Subtle Treatment
  - 50% of usual carbs
  - Med-High G.I. food
- Hypo Alert & Dropping: Aggressive Treatment
  - Full or increased carbs
  - High G.I. food

Types of Alerts

- Hi/Low Alert: Cross specified high or low thresholds
- Predictive Alert: Anticipated crossing of high or low thresholds
- Rate of Change: Rapid rise or fall

The Value of Alerts: Minimizing the DURATION and MAGNITUDE of BG Excursions

CGM Turns Mountains into Molehills

Uniform Response is Key!

1. Fingerstick
2. Act on the Fingerstick
Setting Alerts

• Hi/Low alert thresholds are not BG target ranges
• Balance need for alerts against “nuisance factor”
• Predictive alerts lose value the further the advance warning (keep below 10 min)
• Rate of FALL alerts helpful for long-term hypo prevention (>3 mg/dl/min)

Initial Hi/Low Alert Settings

LOW: 80 mg/dl (4.5 mmol)
(90/5+ if hypo unaware)
HIGH: 300 mg/dL (18 mmol)
(lower progressively toward 180/10)

NOT RECOMMENDED: Low 70 (4)
NOT RECOMMENDED: High 140 (8)

Special Alert Settings

• Young children (higher, wider range)
• Hypoglycemia unawareness, high-risk professions (higher hypo setting)
• Pregnancy (lower, narrower range)
• HbA1c of 11.0% (higher initially)

The Numbers: Ballpark Estimates

+/- 20% (if >80) +/- 20 mg/dl (if <80)

Can The Numbers Be Trusted?

• Not during first 1-2 cycles of using the system
• Not during the first 12-24 hrs after sensor insertion
• If BG Stable
• If Recent calibrations in-line
• If No recent alarms

Specific Insights to Derive

(a purely retrospective journey)
CGM Data Analysis Tools

Hardware/Software

• Medtronic:
  – Internet Access to Carelink
  – Carelink USB Adapter

• Dexcom:
  – PC, DM3 Software
  – Connector Cable

• Color Printer

Before You Analyze, Qualify.

• Were sufficient calibrations performed?
• Did the calibrations match the CGM data reasonably well?
• Was the data mostly continuous?
• Was the time/date set correctly?

Objectives-Based Analysis

1. Are bolus amounts appropriate?
   – Meal doses
   – Correction doses
2. How long do boluses work?
3. What is the magnitude of postprandial spikes?
4. Is basal insulin holding BG steady?
5. Are asymptomatic lows occurring?
   – Are there rebounds from lows?
   – Are lows being over/under treated?
6. How does exercise affect BG?
   – Immediate
   – Delayed effects
7. Is amylin/GLP-1 doing the job?
8. How do various lifestyle events affect BG?
   – Hi-Fat meals
   – Unusual foods
   – Stress
   – Illness
   – Work/School
   – Sex
   – Alcohol
Reports to Focus on

- Summary Statistics
- Modal Day / Overlay Graphs
- Individual Day Details

Case Examples

(\textit{the “retrospective journey”})

These Are a Few of My Favorite Stats...

- Mean (avg) glucose
- % Of Time Above, Below, Within Target Range
- Standard Deviation
- # Of High & Low Excursions Per Week

Case Study 1:

The “\textit{Dark Side of the Moon}”

- Type 2; using glargine and metformin
- Fasting readings OK; HbA1c elevated

BG rising & staying high after meals.
Consider meglitinide, exenatide, mealtime bolus insulin

Case Study 2a:

Fine-Tuning Meal/C Orrection Boluses

- 34-y.o. pump user

Dinner dose appears OK
Night-snack dose clearly insufficient
Breakfast and lunch doses \textit{may} be too low

Case Study 2b:

Fine-Tuning Meal/C Orrection Boluses

- 5-year-old on MDI; levetir BID.

Dropping low 2-3 hours after dinner.
Consider decreasing dinner bolus.
Case Study 2c: Fine-Tuning Meal/Correction Boluses

Teenager on a pump; stays up late.

BG Rising 9pm-1am.
Consider structured night snacks with increased bolus amount.

Case Study 2d: Fine-Tuning Meal/Correction Boluses

Pumper, dropping low after correcting for highs during the night.

Consider increasing nighttime correction factor / insulin sensitivity.

Case Study 3a: Postprandial Analysis

- Young adult on MDI.
- HbA1c are higher than expected based on SMBG.
- Tired and lethargic after meals.

Significant postprandial spikes (300s). Consider pramlintide before meals.

Case Study 3b: Postprandial Analysis

Pump user, usually bolusing right before eating.
Potatoes w/dinner most nights.

Spiking primarily after dinner. Consider lower g.i. food or pre-bolusing.

Case Study 3c: Postprandial Analysis

- Pump user, 6 months pregnant.
- Pre-bolusing (15-20 min) at most meals.

Spiking primarily after breakfast. Consider “splitting” breakfast or walking post-bkfst.

Case Study 4a: Basal Insulin Regulation

Pump user, 6 months pregnant.
- Generally not eating (or bolusing) after 8pm.

BG rising 1am-6am. Consider raising basal insulin 12am-5am.
**Case Study 4b: Basal Insulin Regulation**

- Type 1 diabetes; using insulin glargine & MDI
- History of morning lows
- Snacking at night and not "covering" w/bolus

**Case Study 4c: Basal Insulin Regulation**

- Pump user, frequent lows before breakfast and dinner.

**Case Study 5: Determination of Insulin Action Curve**

- 3-Hour Duration
- 4-Hour Duration
- 5-Hour Duration

**Case Study 6: Detection of Silent Hypoglycemia**

- Type 1 college student; on pump
- Frequent fasting highs (9-10 AM). Wanted to raise overnight basal rates.

**Case Study 7: Effectiveness of Pramlintide/Exenatide**

- 15 mcg pramlintide
- 60 mcg pramlintide

**Case Study 8: Response Curve to Different Food Types**

- Postprandial peak: cereal > oatmeal > yogurt
Case Study 9: Immediate Responses to Unusual Events

- Type 1 diabetes; pump user
- 40 years old; athletic
- Handsome, excellent speaker
  - Late for meeting
  - Gets flat tire; eats 15g carbs to prepare for tire change
  - Spare is flat too!

STRESS CAN RAISE BLOOD GLUCOSE... A LOT!!!
**Optimal Calibration**

- Calibrate at times when blood glucose (BG) is **stable** (fasting, pre-meals)*
- Avoid calibrations during times of rapid glucose change*
  - Post meal
  - UP or DOWN arrows are displayed
  - In the period following a correction with food or insulin
  - During exercise

* Not required w/Dexcom system

**Calibration**

- Calibrate before bedtime to avoid alarms during the night
- Use good SMBG technique
  - Proper coding
  - Clean hands
  - Sufficient blood sample
  - Fresh strips
- **USE FINGERSTICKS**
- Enter the calibration immediately after the fingerstick (Dexcom, Medtronic systems)

**The Sensors**

- **Storage**
  - Refrigeration preferred (but not required)
  - OK to use 1-2 months past expiration

- **Site Selection**
  - “Fleshy” areas
  - At least 2" Away from insulin infusion
  - Avoid tight clothing areas, scars, bruises, lipoatrophy
  - Rotate sites

**The Sensors**

- **Timing**
  - Allow adequate "wetting" time (Medtronic)
  - Put sensor in the night before connecting the transmitter (Medtronic)
- **Bleeding/Irritation**
  - Slight bleeding OK
  - Profuse bleeding: remove
  - Remove introducer needle at proper angle

**The Sensors**

- **Adhesive**
  - Completely cover the Transmitter & Sensor (Navigator & Medtronic systems)
  - Check sensor daily for loose tape
  - Apply extra tape over sensor & transmitter if tape patch begins to “curl” around edges

- **Site Irritation**
  - Watch for redness, swelling, tenderness
  - Remove sensor with prolonged irritation (>1 hour)

**Signal Reception**

- **Heed transmitter ranges**
  - Medtronic: 6 ft.
  - Dexcom: 5 ft.
  - Navigator: 10 ft.
- **Signals do not travel well through water**
  - Wear receiver on same side of body as sensor
- **Keep receiver very close while charging** (Dexcom)
- **Charge transmitter fully every 6 days** (Medtronic)
Ingredients For Success

• Have the right expectations
• Wear the CGM at least 90% of the time
• Look at the monitor 10-20 times per day
• Do not over-react to the data; take IOB into account
• Adjust your therapy based on trends/patterns
• Calibrate appropriately
• Minimize “nuisance” alarms

Questions?