Using CGM to Improve Outcomes

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Making the Most of Continuous Glucose Monitoring

1. CGM Basics
2. Real-Time Use
3. Analyzing Downloaded Data
CGM Options

“Personal” CGM

• DexCom G6
• Medtronic Guardian (670G / Connect)
• Freestyle Libre
• Senseonics Eversense

“Professional” CGM

• Medtronic iPro
• Dexcom G4 Professional
• Freestyle Libre Pro
How They Work

- Glucose sensor is inserted in subcutaneous tissue and connected to a transmitter.
- Glucose sensor sends values to the transmitter.
- Transmitter then sends data wirelessly to a phone, watch, pump or handheld monitor where data can be viewed and acted upon in real-time.
Interstitial Fluid and “Lag Time”

- Capillary glucose must diffuse into the interstitial fluid (ISF)
- ISF glucose levels may lag capillary levels by 5–15 minutes
- When glucose levels are stable, ISF glucose levels and capillary blood glucose levels are similar
- Overall, the sensor glucose trends are more important than the absolute measurements

Understanding Lag Time

Glucose Rising:

SG likely lower than actual BG
Understanding Lag Time

Glucose Falling:

SG likely higher than actual BG
Understanding Lag Time

Glucose Stable:
SG likely in equilibrium with BG
Understanding Lag Time

During Exercise:
Lag Time is extended.

Aerobic exercise:
CGM tends to over-estimate glucose

Anaerobic/HIIT exercise:
CGM tends to under-estimate glucose
Clinical Advantages of CGM

- Reduction in HbA1c
- Less glycemic variability
- Increased time in-range
- Reduced hypoglycemia
  - Frequency
  - Severity
  - Duration
- Permits true pattern analysis

References:
Diabetes Care 2010;33:17-22
Diabetes Care 2013;36(12):4160-4162
JAMA 2017;317(4):371-378
JAMA 2017;317(4):379-387
Quality of Life Advantages

❖ ▼▼▼▼ SMBG Requirements
❖ Real-time data sharing
❖ Overnight peace of mind
❖ Enhanced safety
  ❖ Driving
  ❖ Sports/Exercise
  ❖ Hazard Situations
❖ Learn cause:effect relationships
❖ Drive hybrid closed-loop technology
What Do We Get in Real Time?

✓ Numbers
✓ Alerts
✓ Trends
The Numbers: How Accurate Are They Really?

MARD Compared to YSI(lab)

Freestyle Libre\textsuperscript{1}: 11.4%

Older popular meters\textsuperscript{5}: 10-11%

Medtronic Guardian\textsuperscript{2}: 10.6%

Dexcom G6\textsuperscript{3}: 9.9%

Senseonics\textsuperscript{™} Eversense\textsuperscript{4}: 8.8%

State-of-the-art BG Meters\textsuperscript{5}: 4-6%

1 Wadwa et al. Diab Tech & Ther, 20:6, 2018 (0 cal/day)
2 FDA SSED P160017/S017, 2/13/2018 (2 cal/day)
3 Bailey et al. Diab Tech & Ther, 17:11, 2015 (0 cal/day)
4 PRECISE II: Diab Tech & Ther, 20:3, 2018 (2 cal/day)
Can The Numbers Be Trusted?

Two years ago, 81% of CGM Users openly admitted to using CGM glucose values for determining insulin doses.*
Can The Numbers Be Trusted?

YES. but…

- Not if a CGM novice
- Not during sensor day 1*
- Not when recovering from hypoglycemia
- Not in state of rapid rise or fall
- Not if recent calibration off >20%
- Not if acetaminophen taken in past 4 hrs*
- Not if symptoms don’t match SG value

* Not applicable to Dexcom G6
Alerts
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
• **Hi/Low Alert:**
  - ✓ must balance benefit vs nuisance
  - ✓ low: ≥ 80 mg/dl
  - ✓ high: start very high (300?), titrate down to allowable postprandial peak

• **Predictive Alert:**
  - ✓ potential for false positives
  - ✓ set for short time interval (≤ 10 min)

• **Rate of Change:**
  - ✓ >3 mg/dl/min fall rate (for preventing lows)
  - ✓ >3 mg/dl/min rise rate (for missed boluses)
The Value of Alerts: Minimizing the DURATION and MAGNITUDE of BG Excursions
CGM Turns **Mountains** into **Molehills**
CGM Alerts Are Like BLOOD SUGAR BUMPERS!
Timely, consistent response is Key!

1. Act on the highs
   - hydrate
   - exercise
   - bolus (less IOB)

2. Act on the lows
   - rapid carbs
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
Adjust Boluses Based on Arrows

- Add enough to offset 75 mg/dl rise
- Add enough to offset 50 mg/dl rise
- Add or subtract enough to offset 25 mg/dl change
- Subtract enough to offset 50 mg/dl drop
- Subtract enough to offset 75 mg/dl drop
Simplify It With Sticky Notes!

Example: Correction Factor = 30

- ↑↑ +2.5u
- ↑ +1.6u
- ↑ + 0.8u
- ↓ - 0.8u
- ↓ -1.6u
- ↓↓ -2.5u
Betty Lou’s blood sugar is rising going into lunch. She should:

A. Take her usual insulin dose (based on BG and carbs)
B. Take her usual dose, but delay her meal
C. Take more than her usual dose
Other Applications for Trend/Curve: Hyperglycemia Treatment:

(When the trend graph breaks)

- Break within 2 hours of bolus: do **not** correct!
- No break within 2 hours of bolus: Correct!
What Can We Get From Analyzing CGM Data?

(a retrospective journey)
Completely Overwhelmed!
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?
Objectives-Based Analysis

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. Are there day-of-the-week patterns?
Objectives-Based Analysis

8. How do various lifestyle events affect BG?
   - Hi-Fat meals
   - Unusual foods
   - Stress
   - Illness
   - Work/School
   - Sex
   - Alcohol
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 1a: Fine-Tuning Meal/Correction Boluses

- 34-y.o. insulin pump user, applying insulin:carb ratios

- Breakfast dose is sufficient

- Lunch dose is insufficient

- Dinner dose is insufficient
Case Study 1b: Fine-Tuning Meal/Correction Boluses

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

Dropping low 2-3 hours after dinner. Consider decreasing dinner bolus.
Case Study 1c: Fine-Tuning Meal/Correction Boluses

Teenager on a pump; stays up late snacking & playing video games.

Raise I:C ratio after dinner? Work on carb counting? Structured snacks?
Case Study 1d: Fine-Tuning Meal/Correction Boluses

- Adult T1, detemir BID and MDI, 11% of time below target.

Consider increasing correction factor
Case Study 2a: Postprandial Analysis

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

Greatest “spikes” after lunch. Strategies???
Case Study 2b: 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 2c: 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-breakfast.
Case Study 3a: Basal Insulin Regulation

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

BG rising 1am-6am.
Consider raising basal insulin 11pm-4am.
Case Study 3b: Basal Insulin Regulation

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

Basal dose is likely too high. Consider reducing.
Case Study 3c: Basal Insulin Regulation

- Pump user, fasted (and no bolus) from 10am to 5pm.

BG stable 1pm-5pm.
Basal setting verified 12-4.
Case Study 4a: Determination of Insulin Action Curve

3-Hour Duration

4-Hour Duration

5-Hour Duration
Case Study 4b: Determination of Insulin Action Curve

- Correction bolus at 1am
- BG levels off at 4:30 am

3.5 Hour Duration of Bolus Action.
Case Study 5:
Patterns Surrounding Hypoglycemia

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

Dropping & rebounding during the night. Consider decreasing basal in early part of night.
Case Study 6: Effectiveness of Ancillary Meds

- 6 mg liraglutide

![Graph showing blood glucose levels](image1)

- 12 mg liraglutide

![Graph showing blood glucose levels](image2)
Case Study 7: Day-Of-The-Week Analysis

- Significantly more lows on Thursdays.

Look for days of the week with unusual proportion of highs or lows. Ask the right questions!
Case Study 8a: Lifestyle Responses

- 55 y.o. T1, pump user
- No food or bolus 6am-3pm

Dentist appointment (root canal) at noon

STRESS CAN RAISE BLOOD GLUCOSE!!!
Case Study 8b: Lifestyle Responses

- Pump user
- Basal rates confirmed overnight
- “yellow” night: **light cardio** workout prior evening
- “Red” night: **Lifting & cardio** workout prior evening

Experiencing delayed-onset hypoglycemia from heavy workouts. Consider temp basal reduction.
Case Study 8c: Lifestyle Responses

- Pump user
- Normal fasting readings during the week, but high on weekends

Delayed rise from high-fat meals. Consider using temp basal increase.
YOU DON’T HAVE TO DO ALL THIS AT ONE TIME!!!
Ingredients For Success

- Go in with the right expectations
- Use at least 90% of the time
- Look at the display 10-20 times per day
- Do not over-react to the data; take IOB into account
- Adjust your therapy based on trends/patterns
- Calibrate properly
- Minimize “nuisance” alarms
Questions?