CLINICAL BENEFITS OF CGM

Whittier Institute of Diabetes
San Diego, May 3, 2016

John Walsh, PA, CDTC
Advanced Metabolic Care and Research
San Diego, CA
jwalsh@diabetesnet.com

Outline

- Current CGMs
- Who Wears a CGM?
- Clinical Benefits from CGMs
- 5 Paths to Better Readings
- Better Readings from Real Time CGM
- CGM Downloads Help Find Patterns
- CGM Tips

The Competition

CGM Advantages

- Average A1c reduction = 0.3%[1]
- Reads glucose every 5 min
- Alarms when low and high
- Security for wearer and family
- Glucose value, trend line and arrows guide bolus doses, carb intake, and exercise
- Lower A1c, less severe hypoglycemia, less BG variability
- Better data (clinicians, pumpers, parents)

[1] Y Hsin-Chieh et al: Ann Intern Med. 2012;157(5):336-347.

21st Century CGM's

Better BG meters have a mean average relative difference (MARD or error) of 5-6%

Dexcom G4AP (505), MARD 9.0%, 1-2 weeks

Medtronic 530G, MARD 13.9%, 6-10 days

Abbott Libre/Flash, MARD 11.4%, no cal, no alarms, 2 weeks use

1. Bailey TS, Chang A, Mark Christiansen M: *J Diabetes Sci Technol November 3, 2014*
2. Bailey TS, Ahmann A, Mark Christiansen M, et al.: Diabetes Tech Therap. 2014, 16(5): 277-83

Infusion Line Pumps

Tandem t:slim G4

Animas Vibe

Accu-Chek Insight

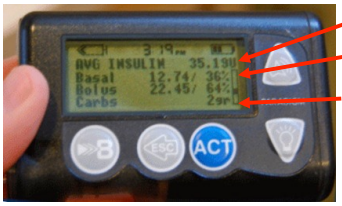
Medtronic Veo

Patch Pumps

Insulet Omnipod

Calibra Finesse

Intervention Data Found on the Pump – Avg. TDD, Basal/Bolus Balance, and Carbs



TDD = 35.19 u

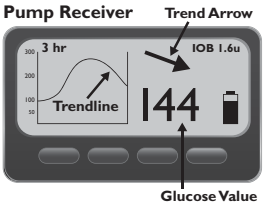
Basal% is low at 36%

2 grams of carb/day means bolus calculator is not used – helps determine practice/ compliance

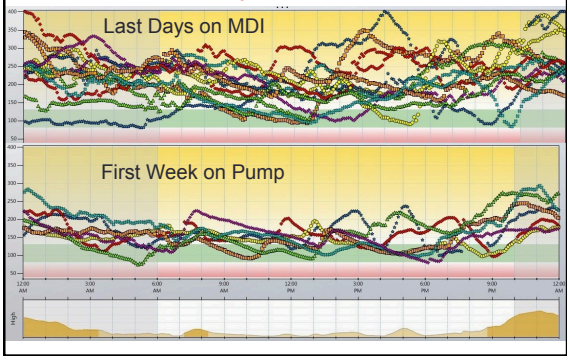
Pens and injections do not show this!

Advantages of a Pump/CGM

- Glucose, insulin, and carb count data is collected in one location
- Pump shows BOB along with glucose and trend line
- Helps both left brain "intuitive dosers" and right brain "analysts"



Benefit of Pump and CGM



Who Wears a CGM?

2.1 Reasons People Choose CGMs:

- 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
- Tight control before and during pregnancy
- Security during sleep or when living alone
- Frequent driving, travel, high-risk professions
- Real time info and data downloads
- Sharing glucose data with others

2.2 Reasons Significant Others Like a CGM:

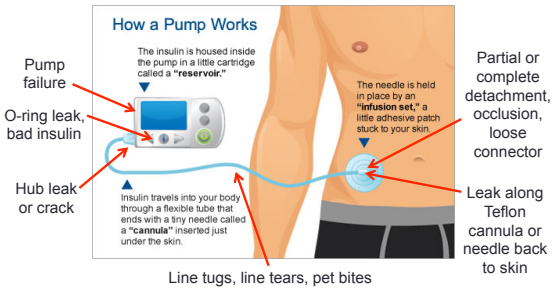
- Peace of mind
- Alerts that signal lows and highs
- Better glucose management
- Avoiding frequent hypos & hypo unawareness
- Security while sleeping or living alone
- Safer driving and travel
- Knowing when a young child is or will go low
- The security of knowing another's glucose at a distance

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, or contact sports or employment
  - Swimming, surfing, wrestling, air conditioner repair, plumbing, roofing
- Expense
- Technophobes, not wanting a device attached
- Desire to avoid "bad" news

Clinical Benefits from CGMs

CGMs Find Weak Spots in Insulin Delivery



Graphic courtesy of Liberty Medical

CGMs Help Spot Common Pump Problems

- Delayed boluses – high post meal BG ✓
- Inaccurate CHO bolus / CHO counting ✓
- Bolusing just before or after eating ✓
- Excessive insulin stacking ✓
- Too many basal rates (over and understeering) ✓
- Insufficient monitoring data – no pump/meter/sensor downloads ✓
- Reactive pumping (pumping gas and brakes) ✓
- Infusion site failure ✓

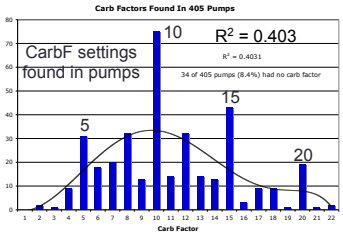
✓ = where a CGM helps

Do Pumps and CGMs Improve Control?

- US Agency for Healthcare Research and Quality in a 2012 report, reassessed in Feb, 2015, from over 200 research articles.
- AHRQ compared pumps to MDI and found:
  - Moderate evidence for lowering the A1c by 0.05% to 0.20% (4 studies)
  - Low evidence for benefit in hypoglycemia, weight, or QOL
  - Insufficient evidence for hyperglycemia benefit
- And when comparing CGM to BGM, they found:
  - Low evidence for any benefit

https://www.effectivehealthcare.ahrq.gov/ehc/products/242/2182/insulin-blood-sugar-surveillance-160215.pdf

APP Study – Pump Settings Often Wrong[1,2]



Only 40% of CarbFs have expected value

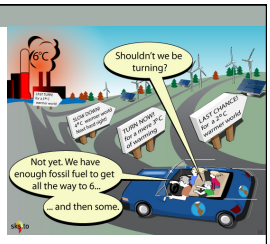
People prefer "magic" numbers – 5, 10, 15, and 20 g/unit.

Formulas provide accurate settings –> far better than WAG!

Don't use "magic" numbers!

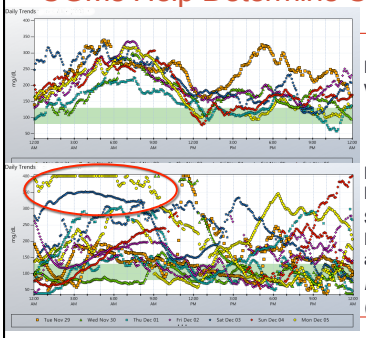
1. J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010
2. J. Walsh, D. Wroblewski, and TS Bailey: Insulin Pump Settings – A Major Source For Insulin Dose Errors, Diabetes Technology Meeting 2007

5 Paths to Better Readings



1) Optimize the average TDD and derive pump settings from it
2) Change pump settings from basal and bolus testing.
3) Adjust pump settings from glucose patterns.
4) Increase time in target range with real-time CGM micro-carbing and micro-bolusing.
5) Monitor basal/carb bolus balance.

CGMs Help Determine Solutions



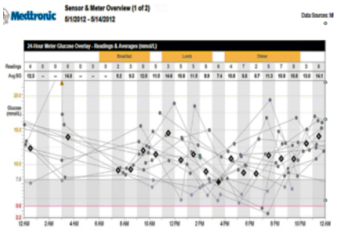
Pattern management works here

No patterns here! Reduce TDD s

Select new settings. Emphasize carb counting and pre-meal bolusing.

Inquire about set failures (red oval)

CGMs Help Find an Optimal TDD



Most people do not get enough insulin

Some get too much

Find an accurate TDD first – **your <u>best guide to good pump settings</u>**

Pattern management is simpler after TDD and settings are optimized

CGMs Help Stop Frequent Lows

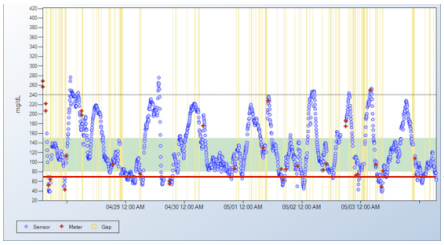
You cannot tell how much excess insulin there is!

- Start with a 5% or 10% reduction in TDD
- Or compare current TDD to an "ideal" TDD for weight.
  - Multiply weight(kgs) by 0.55 (lbs x 0.24) for TDD of someone with an average sensitivity to insulin[1,2]

Example: Someone who weighs 73 kg (160 lbs) would be expected to have a TDD of 40 units (73 x 0.55 = 40).

1. Davidson PC, Hebblewhite HR, Steed RD, Bode BW. Analysis of guidelines for basal-bolus dosing: basal insulin, correction factor, and carbohydrate-to-insulin ratio. Endocr Pract. 2008;14(9):1095–101.
2. Adamsson U, Lins PE. Clinical views on insulin resistance in type-1 diabetes. Agardh CD, Berne C, Östman J. Diabetes. Stockholm: Almqvist & Wiksell; 1992, 142–50.

Excess Lows? – Lower the TDD!



~ 2 Lows-to-Highs per day

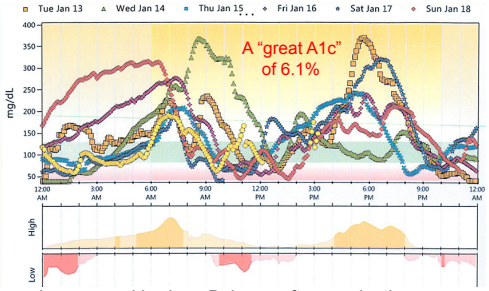
3.9 mmol/L 70 mg/dl

28 yo female – Wt: 55 kgs (120 lbs)

Current TDD = 43.6 u/day

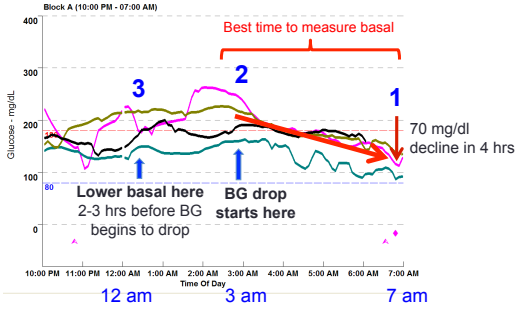
Wt 55 kg x 0.55 = 30.0 u/day

Low BGs with a Pattern in 71 yo Type 1



Pumping gas and brakes. Boluses after meals, then overcorrects –> lower TDD, reselect settings, always bolus before eating.

CGMs Help Check Basal Rates



CGMs Help Stop Frequent Highs

When avg BG on CGM is high with few lows, use the 5-1-6 Rule:

Know How Much Insulin is Needed – Raise the TDD by

- **5% for each 1% reduction desired in the A1c**
- **1% for each 6 mg/dL (0.3 mmol/L) reduction desired in avg BG**

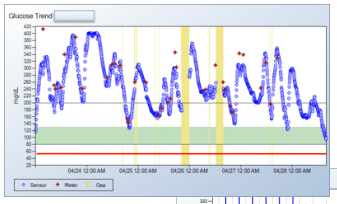
Example: Amy's avg TDD is 40 u/day, avg BG is 217 mg/dL (12 mmol/L) with few lows, and her goal is 145 mg/dL (8 mmol/L):

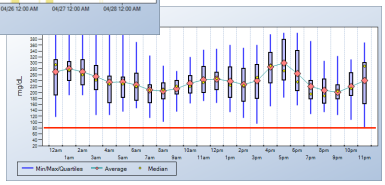
217 mg/dL – 145 mg/dL = 72 mg/dL

72 mg/dL / 6 = 12% rise needed in TDD

40 units x 1.12 = 44.8 units

High BGs? – Optimize the TDD!





From the A1c

27 yo male, A1c = 8.6%, TDD = 50 u/day

8.6% - 7.0% = 1.6% x 5 = an 8% increase in TDD

50u x 1.08 = 54u

High BGs? – Optimize the TDD

From an avg BG:
53 yo female
TDD = 36 u
Avg BG = 190 mg/dL (10.6)

190 – 140 = 50/6 = 8.3%

- Raise basal by 0.05 u/hr all day (+1.2 u/day)
- Lower CarbF from 1u/13g to 1u/12g (+1.8 u/day)

TDD = 39 u
an 8.3% increase

Use New TDD to Select Pump Settings[1]

Basal insulin = ~ half of the TDD (TDD x 0.02 = u/hr)

CarbF = 2.6 x $\frac{\text{Wt(lbs)}}{\text{TDD}}$ *or* 5.7 x $\frac{\text{Wt(kgs)}}{\text{TDD}}$

CorrF = $\frac{2000 \text{ mg/dL}}{\text{TDD}}$ or $\frac{110 \text{ mmol/L}}{\text{TDD}}$

Use 1450 to 1600 (80 or 90 mmol) for high A1c (large basal/carb bolus deficits) and 2200 or 2400 (120 or 130 mmol) when most glucose readings are in target.

[1]J Walsh, R Roberts, T Bailey: J Diab Science Tech 2010, Vol 4, #5, Sept 2010

The CorrF is Inversely Related to the A1c

3. Use Larger CorrF with Lower A1c		
With a Recent A1c of:	Use this Corr Factor Formula for mg/dL	for mmol/L
>10%	CorrF = 1450/TDD	CorrF = 80/TDD
8% to 10%	= 1500 to 1700/TDD	= 83 to 94/TDD
7% to 8%	= 1800 to 1900/TDD	= 100 to 106/TDD
6.6% to 7%	= 2000 to 2100/TDD	= 111 to 117/TDD
< 6.6%	= 2200 to 2400/TDD	=122 to 133/TDD

Case Study of Decision Support Software

JD is a 20 yo DM1 college student referred to clinic.
Wt 180 lb (84 kg), TDD = 80 u (78-83 u/day), avg BG = 194 mg/dL (10.8 mmol/L).

- Basal rate: 1.8 u/hr
- CarbF 10 gr
- CorrF 45 mg/dL (2.5 mmol/L)
- DIA 4 hrs
- **A1c 8.4%**

Select & Improve Pump Settings with Decision Support Software

Enter Your Information:

Units: English | Metric

Weight: 84 kgs

Avg TDD(?): 80 u/day

Current Avg BG:(?): 194 mg/dl

Target Avg BG(?): 140 mg/dl

Submit

Settings For Target BG (?)

From adjusted TDD to reach target

TDD: 85.5 u/day

Avg Basal: 1.708 u/hr

Carb Factor: 5.5 grams per unit

Correction Factor: 22.9 mg/dl per unit

Relative Insulin Sensitivity: 51%

www.opensourcediabetes.org

Improved Outcome From Decision Support Suggestions

JD's Pump Settings:

	Original	New
TDD	80 u	85 u
Basal rate:	1.8 u/hr	1.7 u/hr
CarbF	10	5.6
CorrF	45	24
DIA	4 hrs	5 hrs
A1c	**8.4%**	**6.9%**

www.opensourcediabetes.org

Don't Make Bolus Decisions from the CGM

- During at least the initial 2 weeks of use
- When a CGM reading is more than 20 to 30 mg/dL (1.1 to 1.7 mmol/L) different from the meter reading
- When skips or gaps occur in glucose readings
- When the glucose is rapidly changing
- During times of change in diet, stress, or exercise

Using the CGM to make bolus decisions is not FDA approved. Approved in Europe and under review here.

Better Readings from Real Time CGM

CGM Data
Real Time Screen vs Download

RT Trend Lines show:

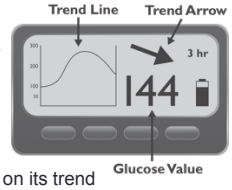
- Last 1-24 hrs readings
- One night's basal profile
- Profile of 1-2 meals
- A limited picture for immediate solutions
- Harder to see patterns

Download Data shows:

- Many days readings
- Frequent highs, frequent lows
- Postmeal spiking
- A complete picture for comprehensive solutions
- Easier to see patterns

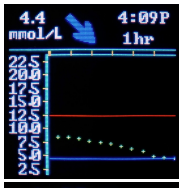
CGM Real Time Screen Information

- **Glucose value** – updated every 5 min
- **Trend line** – direction of glucose change
- **Trend arrow** – rate of change: one arrow = 3.3 to 6.7 mmol/L, two arrows = 6.7 to 10 mmol/L
- **Alerts**
  - High and low thresholds
  - Prediction
  - Rate of changen
- **BOB** – on pumps



The risk of a glucose depends on its trend

CGM Real Time –

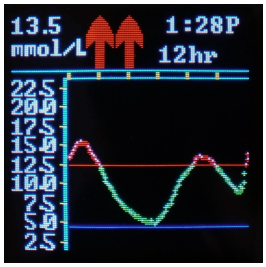


79 mg/dL (4.4 mmol/L) with down arrow and trend line

79 mg/dL with down arrow and BOB – ***Screen showing BOB is more helpful!!!***

Down arrow + BOB = caution

CGM Real Time –



243 mg/dL (13.5 mmol/L) with 2 up arrows (>120 or 180 mg/dL per hour) and trend line

High target at 220 mg/dL (12.5 mmol/L) gives LATE notice* for high readings! ***Intervention can begin earlier when high target is LOWER.***

**** CGM Bad Practice #1***

Adjustment from CGM Arrows

- Recommended dose adjustments from DirectNet and JDRF compared with actual dose adjustments from survey of 222 pump wearers in right column[3] when the glucose is 220 mg/dL
- Wide variation in individual adjustments

	Indication	Recommended Insulin Dosage Adjustment[†]	Participants' Reported Insulin Dosage Adjustment[3]
→	**Constant:** Glucose is steady – not increasing/decreasing more than 1 md/dL per minute	No change	N/A
↗	**Slowly Rising**: Glucose is rising 1-2 mg/dL per minute	10% Higher	
↑	**Rising**: Glucose is rising 2-3 mg/dL per minute	20% higher	111% higher
⇈	**Rapidly Rising**: Glucose is rising more than 3 mg/dL per minute	20% higher	140% higher
↘	**Slowly Falling**: Glucose is falling 1-2 mg/dL per minute	10% lower	
↓	**Falling**: Glucose is falling 2-3 mg/dL per minute	20% lower	40% lower
⇊	**Rapidly Falling**: Glucose is falling more than 3 mg/dL per minute	20% lower	42% lower

[†] Diabetes Research In Children Network (DirecNet) Study Group. Pediatric Diabetes 2008;9:142-147.[†] The Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Diabetes Technol Ther 2008;10(4):310-321.

[3] Pettus J, Price DA, Edelman SV. Endocr Pract. 2015 Jun;21(6):613-20.

Real Time Trends And Predictions

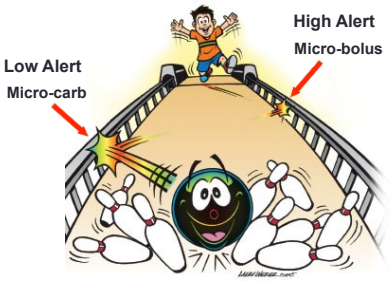
- Great for:
  - Security
  - Driving, sports, etc.
  - Basal and bolus testing
  - Overriding bolus recommendations
- Helps increase time "between the lines"
- Do not set alarms high – **ACT** on the alarms
- Turn alarm fatigue into better readings and fewer alarms

Real Time Basal & Bolus Testing on CGM

- Start with a clear-out period
  - No bolus in the last 5 hours
  - No food in the last 3 hours
- Record/graph what happens – no history without this!
- Basal test – trend line should stay flat or go down no more than 20 mg/dL over the next 6 hours.
- Carb factor test – give bolus 20 min before eating and eat carbs = half your weight in lbs. Be at target 4-5 hrs later with no lows.
- Correction factor test – take correction bolus and be at target 4-5 hrs later with no lows.

Use CGM Alerts to Increase In-Target Time

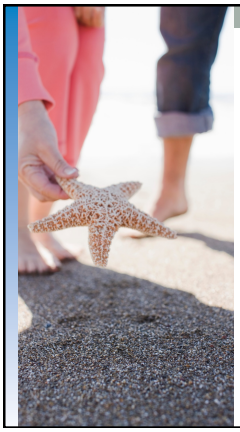
More time in target from micro-carbing and micro-bolusing



Adjusting from Trend Line

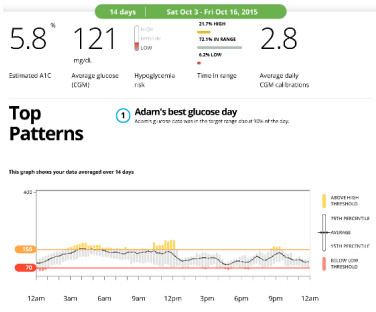
Type 1 Chef (DM x 13 yr, C-peptide <0.5)

Use of the CGM's Real Time screen can modify behavior!!!



CGM Downloads Help Find Patterns

Dexcom Clarity Evaluation



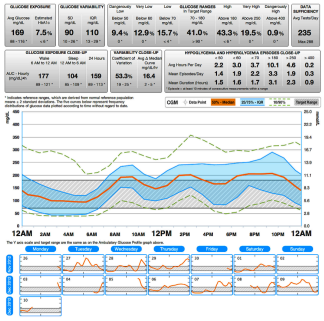
14 day average shows very good control 121 mg/dL (6.7 mmol/L)

72% in range

Low risk for hypoglycemia.

Some excess highs between 3 am and noon, possibly caused by lows at midnight.

Ambulatory Glucose Profile Standard



- Here, avg BG of 169 hides excessive variability (CV of 53.2%, ie 90/169)
- 9.4% of readings (2.2 hours a day) are less than 50 mg/dL (2.8 mmol/L) – No need for this many lows!
- Select a lower TDD, derive new pump settings, from it and retrain carb counting

How Do Patients Use CGMs?

Of 222 survey respondents with Type 1 diabetes:

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

Poor compliance?
Poor engineering?
Lack of training?

J Pettus, DA Price, SV Edelman. How patients with Type 1 diabetes translate continuous glucose monitoring data into diabetes management decisions. DOI:10.4158/EP14520.OR © 2015 AACE.

CGM User Experience

- Abbott Navigator 12 week study of 90 Type 1s, 56% female, avg. age 42 (18-64), T1 duration 23 yrs, 73% on pump.
  Study included CGM Training
  - 94% strongly felt they needed a CGM, 99% felt it would let them know if a BG is rising or falling (100% agreed with this after study)
  - 98% completed the study
  - 72% used the CGM for more than 75 of the 90 days
  - Subjects found 1 min glucose readings, high and low alarms, and trend arrows were most helpful
  - Hypoglycemia decreased from 1.3 to 1.0 episodes per day
  - A1c < 7.0% increased from 38% to 54%

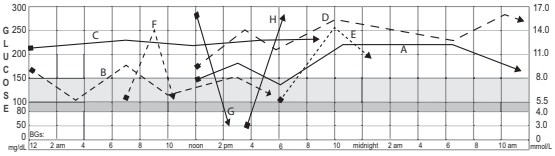
DK Bloomgarten, J Freeman, and E DeRobertis. *Diabetes Spectrum* 21(2), 128-133, %08.

CGM User Experience

- Abbott Navigator 12 week study continued:
  - **52% used CoPilot software**
  - **96% saying CoPilot was easy to use and 91% could identify glucose patterns.**
  - Glucose Modal Day and Glucose Average reports were most commonly used
  - "Like it very much" rose from 23% at day 30, to 44% at day 90.
  - 66% rated the CGM as a 5 or 6 on a 6 point Likert scale
  - 60.7% said they would pay for a CGM themselves if necessary

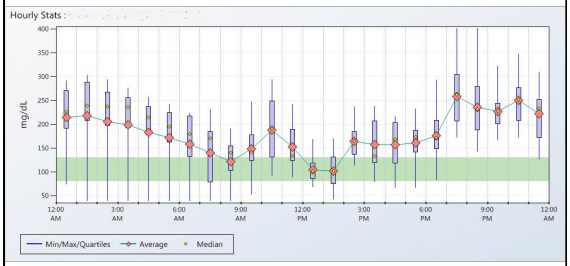
DK Bloomgarten, J Freeman, and E DeRobertis. *Diabetes Spectrum* 21(2), 128-133, %08.

CGM Downloads Identify Glucose Patterns



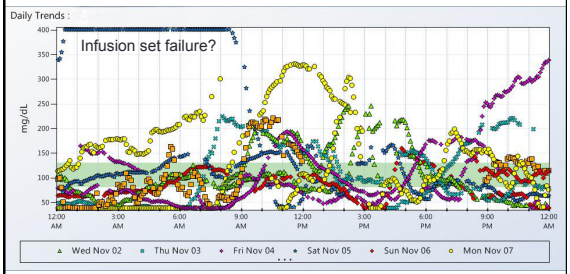
A) **most common pattern** (raise afternoon & evening basal, lower supper CarbF),
B) **frequent lows** (lower TDD by 5-10% & find new settings),
C) **high and flat most of the time** (raise basal rates),
D) **frequent highs with post-meal rise** (raise basal rates and lower CarbF/ICR),
E) **highs or lows at particular times of the day** (raise or lower prior basal rate or CarbF in previous meal),
F) **post-meal spiking** (bolus earlier, lower CarbF),
G) **over-correction of highs** (do not increase recommended bolus, raise the CorrF/ISF, set DIA to 4.5 hrs or longer),
H) **over-treatment of lows** (stop lows, don't overtreat). Several patterns often coexist. Adjust basals or boluses most responsible.

A – Most Common Glucose Pattern



Best readings during the day, higher after dinner into the night – raise afternoon and evening basal, lower CarbF for supper

B – Frequent Lows

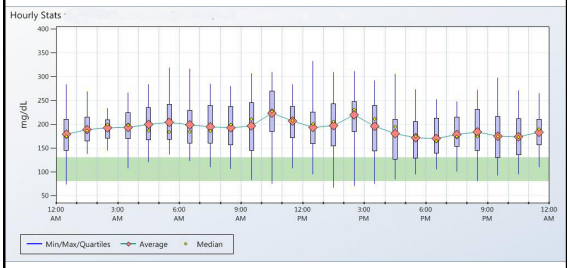


Lower TDD at least 10% and get new pump settings from it!

B – Dexcom Studio - Lows

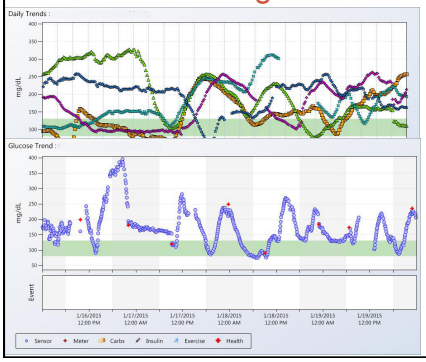
Avg BG 114 mg/dL (6.3 mmol/L) – ***17% low***

C – Consistent Highs



Raise TDD primarily with higher basal rates

F – Postmeal Highs



Bolus earlier, check basal/ carb bolus balance and lower the CarbF

G – Overtreatment of Highs

This person overtreated a high glucose of ~270 mg/dL (15 mmol/L) and dropped to 35 mg/dL (2 mmol/L) only 3.5 hrs later. Intentional excess? CorrF too low? Short DIA? Fortunately, they did NOT overtreat the low!

Pump Bolus Calculators Can Recommend Larger Boluses Than Needed

Bolus Doses Recommended by the BC			
Glucose	Actual Units Needed	Animas	Other Pumps
#1: 99 mg/dL	0 u	0 u	5 u
#2: 101 mg/dL	0 u	5 u	5 u
#3: 200 mg/dL	2 u	5 u	5 u
#4: 300 mg/dL	4 u	5 u	5 u

43 yo man eats 50 gram dessert 2 hrs after dinner with 5u of BOB on 4 consecutive nights. Each night's BG is shown (column 1), the actual bolus he needs (col 2), and what pumps recommend (cols 3 and 4).

CarbF = 10 gr/u; CorrF = 50 mg/dL; Target = 100; DIA = 5 hrs

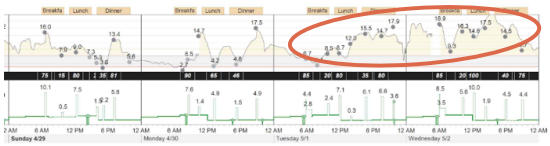
CGMs Help Spot Infusion Set Failure

Anytime there are 2 unexplained high glucose readings in a row that do not come down with correction boluses:

Give an injection by syringe and change infusion set

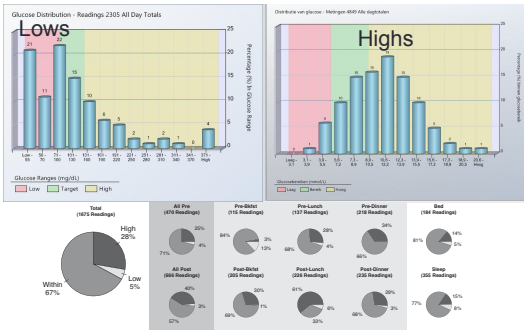
Slides courtesy textingmypancreas.com

CGMs Help Spot Infusion Set Failure



Infusion set problem started on afternoon of May 1st and lasted through the 2nd when the infusion set was changed.

Glucose Distribution and Pie Charts



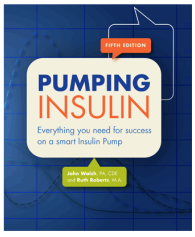
CGM Tips

- **Wear** the CGM at least 6 days a week
- **Look at the monitor** 10-20 times per day
- View trend lines not just individual BGs!
- A rapid rise usually means more insulin needed, BUT check BOB first – avoid frequent corrections until pattern is clear
- Lag times (normally 5-8 min) are longest after treating a low glucose – don't overtreat lows

CGM Calibration Tips

- Use a **VERY** accurate meter
- Use clean fingers and no expired strips
- Enter reading right away
- Do more calibrations on first day of use and when readings vary
- Calibrate up to 4 times a day preferably while the glucose is flat (no arrows) with a low BG and again with a high BG
- Calibrate before bed to improve accuracy and avoid nighttime calibration alert
- Replace sensor if readings do not improve after 2 calibrations

Diabetes Is Better When You Know More!



PI5 on Kindle, i-Pad, and Nook – $16.99

Slides at www.diabetesnet.com/diabetes-resources/diabetes-presentations
Books at www.diabetesnet.com/dmall/ or 800-988-4772