Continuous Glucose Monitoring: Lessons Learned

Bruce Buckingham, MD
Professor of Pediatric Endocrinology
Stanford Medical Center
Conflict of Interest

- Medtronic Minimed
  - Medical Advisory Board
  - Research Support
- Abbott Diabetes Care
  - Research Support
- NovoNordisk
  - Medical Advisory Board
- Animas
  - Medical Advisory Board
- Unomedical
  - Medical Advisory Board
- Dexcom
  - Research Support
- Bayer
  - Medical Advisory Board
Websites

• JAEB/JDRF
  http://cgmteaching.jaeb.org

• Medtronic Minimed
  – Pump School
Online Teaching Tool

- Teaches how and when to calibrate each sensor
- Issues with interstitial lag time
- How to use a sensor in real time
- Set hyper and hypoglycemic alarms
- Adjust insulin doses in real time
- Use downloaded reports for retrospective analysis
Please choose what you would like to learn about!

*Diabetes is different for everyone, and by choosing your CGM, type of insulin, and how you want to use the information.*

1. **Choose a CGM device you are interested in:**
   - Abbott FreeStyle Navigator
   - DexCom Seven STS
   - Medtronic Mini-Med Guardian REAL-Time
   - Medtronic Mini-Med Paradigm

2. **Choose an insulin delivery method:**
   - Injection
   - Pump

3. **Choose a key concept to learn about:**
   - How to Interpret and Make Use of Your CGM’s Alarms
   - Use of Your CGM’s Realtime Information (looking at your device)
   - Use of Your CGM’s Retrospective Information (downloading information from your device to the computer and analyzing)

Submit
Abbott FreeStyle Navigator Sensor

Sensor Delivery Unit, Transmitter, Receiver

Sensor

Image of Abbott FreeStyle Navigator Sensor
Medtronic Paradigm REAL-Time
DexCom 7+ Sensor
Side View Showing Needle Sensors
# Accuracy of Meters and Sensors

<table>
<thead>
<tr>
<th>Measurement Device for Reference Glucose</th>
<th>YSI Beckman ISTAT</th>
<th>Ultra Meter</th>
<th>FreeStyle</th>
<th>Guardian RT</th>
<th>Dexcom 7+</th>
<th>Navigator</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>353</td>
<td>1,103</td>
<td>1,103</td>
<td>5,401</td>
<td>1,927</td>
<td>20,362</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Median ARD%</td>
<td>6%</td>
<td>5%</td>
<td>5%</td>
<td>11%</td>
<td>13%</td>
<td>9%</td>
</tr>
<tr>
<td>Mean ARD%</td>
<td>6%</td>
<td>6%</td>
<td>6%</td>
<td>15%</td>
<td>16%</td>
<td>13%</td>
</tr>
<tr>
<td>% within ISO criteria</td>
<td>95%</td>
<td>99%</td>
<td>98%</td>
<td>76%</td>
<td>76%</td>
<td>82%</td>
</tr>
</tbody>
</table>
JDRF data on Sensor Glucose Values in Non-Diabetic Subjects

Fox, Diabetes Care epub 3/2010

- Seventy-four healthy, non-obese children, adolescents, and adults
- Normal OGTT
- 9-65 years old
- Blinded Navigator or Guardian CGM for 3 to 7 days
Mean glucose values by time of day in Normals

JDRF CGM Study Group, ADA, 2009
## CGM values in Non-Diabetics

<table>
<thead>
<tr>
<th>Glucose Values</th>
<th>Daytime (6 AM – MN)</th>
<th>Nighttime (MN-6AM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>71-120 mg/dl</td>
<td>90.4%</td>
<td>90.3%</td>
</tr>
<tr>
<td>≤ 70 mg/dl</td>
<td>1.1%</td>
<td>2.2%</td>
</tr>
<tr>
<td>≤ 60 mg/dl</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>&gt; 140 mg/dl</td>
<td>0.5%</td>
<td>0.0%</td>
</tr>
<tr>
<td>Standard Deviation (mg/dl)</td>
<td>13.5</td>
<td>10.9</td>
</tr>
<tr>
<td>Absolute Rate of Change (mg/dl-min)</td>
<td>0.37</td>
<td>0.26</td>
</tr>
</tbody>
</table>
The Initial CGM Set-up

• Setting alarms
• Choosing a good insertion site
• Doing the first calibration
JDRF RCT Nocturnal Hypoglycemia
Beck, Diabetes Care epub 3/2010

• 36,000 nights with ≥ 4 hours of glucose readings from MN to 6 AM
  – Guardian and Navigator
  – 86% had the full 6 hours of data without any skips

• 176 subjects
  – Median of 217 nights/subject

• Hypoglycemia = 2 consecutive CGM readings ≤ 60 mg/dl
JDRF RCT Nocturnal Hypoglycemia

- Hypoglycemia occurred during 8.5% of nights
- Maximum % of nights with hypoglycemia - 28%
- 3% of subjects had no hypoglycemia
JDRF RCT Nocturnal Hypoglycemia

- Mean duration of hypoglycemia = 81 minutes
- 47% of nights had at least 1 hour of hypoglycemia
- 23% had at least 2 hours
- 11% had at least 3 hours
Alarm at 1:57 AM
Heaven Scent Paws
Partners in Diabetes™

"Helping is not our job. It's our Passion!™"

We specialize in Diabetic Alert Dogs
& Seizure Alert / Response Dogs

Our techniques are patent pending
# 60/639,948

Current Fundraiser

Our trained Diabetic Alert Dogs detect & alert their
diabetic partner and support team (parents, spouse,
friend, etc) to both low blood sugar (hypoglycemia) &
high blood sugar (hyperglycemia).

We offer two separate programs:

1. Pre-Trained Dog
2. Self Train Classes

- Cincinnati, OH - classes start June 4th

For more program information please contact us.

Email Us

or

(573) 493-2627

we accept inquiry calls from 8am - 10pm CST, M-F
Duration of Hypoglycemia versus Age

Average Minutes below 60 mg/dL in a 6-hour period from midnight to 6 a.m.
Hypoglycemia Prior to Seizures
Buckingham, Diabetes Care, 2009
‘DEAD-IN-BED’ SYNDROME

Patient actions (as recovered from CGMS and insulin pump):

Correction Boluses

Exercise
Meal / Food

Possible glycemic response to counter-regulatory hormones
Do pumpers have a lower incidence of nocturnal hypoglycemia when compared to patients on MDI therapy?

1. Yes
2. No
Incidence of Nocturnal Hypoglycemia - Pumpers vrs MDI

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>% nights with a hypo</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump</td>
<td>163</td>
<td>7.4%</td>
<td></td>
</tr>
<tr>
<td>MDI</td>
<td>13</td>
<td>5.1%</td>
<td>0.63</td>
</tr>
</tbody>
</table>
Does Fear Of Hypoglycemia Effect The Incidence Of Nocturnal Hypoglycemia?

1. Yes
2. No
### Relationship Between Fear Of Hypoglycemia Scores and the Incidence Of Nocturnal Hypoglycemia

<table>
<thead>
<tr>
<th>Hypoglycemic Fear Scale Score</th>
<th>N</th>
<th>% nights with a hypo</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;20</td>
<td>65</td>
<td>7.5%</td>
<td></td>
</tr>
<tr>
<td>20 ≤ 30</td>
<td>32</td>
<td>7.7%</td>
<td>0.07</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>78</td>
<td>7.0%</td>
<td></td>
</tr>
</tbody>
</table>
Does The Age Of The Patient Effect The Incidence Of Nocturnal Hypoglycemia?

1. Yes
2. No
Age and Incidence Of Nocturnal Hypoglycemia

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>% nights with a hypo</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-14</td>
<td>64</td>
<td>6.3%</td>
<td></td>
</tr>
<tr>
<td>15-25</td>
<td>42</td>
<td>8.8%</td>
<td>0.05</td>
</tr>
<tr>
<td>≥ 25</td>
<td>70</td>
<td>7.4%</td>
<td></td>
</tr>
</tbody>
</table>
Are A1c Levels Related To The Incidence Of Nocturnal Hypoglycemia?

1. Yes
2. No
A1c Levels and The Incidence Of Nocturnal Hypoglycemia

<table>
<thead>
<tr>
<th>A1c Level</th>
<th>N</th>
<th>% Nights with a hypo</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 7%</td>
<td>57</td>
<td>9.0%</td>
<td></td>
</tr>
<tr>
<td>7% &lt; 8%</td>
<td>72</td>
<td>8.2%</td>
<td>0.001</td>
</tr>
<tr>
<td>≥ 8%</td>
<td>47</td>
<td>3.9%</td>
<td></td>
</tr>
</tbody>
</table>
Severe Hypoglycemia Events in JDRF CGS

Hypoglycemia event rate per 100 person-years

- 0-6 months
- 7-12 months

Overall (N=83)
Baseline A1c >=7.0% (N=49)
Baseline A1c <7.0% (N=34)
Alarm Settings

• Need to be individualized
• Unless there is concern about hypoglycemia unawareness, set the alarms to avoid frequent “nuisance” alarms
  – low hypoglycemic threshold alarm of 60 mg/dl
  – Hyperglycemic threshold alarm of 240 mg/dl
  – May turn off predictive alarms initially
  – May turn off rate of change alarms initially
The Initial CGM Set-up

• Setting alarms
• **Choosing a good insertion site**
• Doing the first calibration
The Initial CGM Set-up

- Setting alarms
- Choosing a good insertion site
- Doing the first calibration
Sensor Lag

Time (minutes)  (0 = start if meal)

-40 -20 0 20 40 60 80 100 120 140

Blood Glucose (mg/dl)

0
100
200
300
400
500

Freestyle
Sensor

Sensor Lag

Time (minutes)  (0 = start if meal)

-40 -20 0 20 40 60 80 100 120 140

Blood Glucose (mg/dl)

0
100
200
300
400
500

Freestyle
Sensor
Lag Time Teaching Points

- CGM is a trending and NOT a treatment device.
- Use BG tests for treatment decisions:
  - Insulin doses
  - To verify symptoms of hypoglycemia
  - To verify correction of hypoglycemia
  - Before driving
- The sensor is not perfect. It will not detect every low or high event.
Projected Glucose Levels in 20 Minutes with Arrows

Blood Glucose (mg/dL) vs. Time (minutes)

-1 mg/dL-min
-2 mg/dL-min
-3 mg/dL-min
Using Rate of Change Arrows

• If you are projected to be low in 20 minutes, take 10 grams of CHO to prevent the low
  – Example: Hypoglycemic alarm goes off, actual meter glucose is 85 mg/dL, but there is a down arrow

• Adjust insulin dose based on arrows
  – For 1 arrow or 45° arrow, change by 10%
  – For 2 arrows or 90° arrow, change by 20%

Topics

- Exercise
- Meal Behavior
- Nighttime
- Wearability/Usage
  - Toddlers
  - Children
  - Adolescents
Actical Measurement of Activity and CGM tracing
Eva Tsalikian, DirecNet
14 y.o. male A1c = 6.6%, Crews (rowing team) in PM
Exercise and Nocturnal Hypoglycemia
(Glucose < 60 mg/dl)
DirecNet, J Pediatr 2005;147:528-34

16% of sedentary nights
42% of exercise nights
Bedtime Glucose and Nocturnal Hypoglycemia
DirecNet, J Pediatr 2005;147:528-34
Change in Blood glucose with Exercise
DirecNet, Diabetes Care 29: 20, 2006
Baseline vs Nadir Blood glucose with Exercise

DirecNet, Diabetes Care 29: 20, 2006

- Treated for Low Glucose

Hypoglycemia defined as ≤60 mg/dL
Topics

- Exercise
- Meal Behavior
- Nighttime
- Wearability/Usage
  - Toddlers
  - Children
  - Adolescents
Glucose Trends: CT

- Post-breakfast excursion
- Nocturnal lows
Insulin Action after a SQ Insulin Pump Bolus
At Study Onset A1c = 8.2
And Persistent Postprandial Hyperglycemia, Especially After Breakfast
At 3 Month Visit A1c = 6.2 And Has Eliminated Carbohydrates At Breakfast And Gives A Pre-bolus Before Lunch And Dinner
Bolus Immediately Before Eating....

(7 days)

HbA1c: No Data

Pump: Paradigm 722
Sensor: In use
#414689

Overlay by Meal Event (mg/dL)

<table>
<thead>
<tr>
<th>Meal</th>
<th>Sleep 3:00 AM - 6:00 AM</th>
<th>Before Breakfast</th>
<th>After Breakfast</th>
<th>Before Lunch</th>
<th>After Lunch</th>
<th>Before Dinner</th>
<th>After Dinner</th>
<th>Evening 11:00 PM - 3:00 AM</th>
<th>All Time Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range</td>
<td>100 - 150</td>
<td>70 - 130</td>
<td>100 - 160</td>
<td>70 - 130</td>
<td>100 - 160</td>
<td>70 - 130</td>
<td>100 - 160</td>
<td>100 - 150</td>
<td></td>
</tr>
<tr>
<td>Average SG</td>
<td>202</td>
<td>150</td>
<td>230</td>
<td>123</td>
<td>192</td>
<td>135</td>
<td>140</td>
<td>142</td>
<td>168</td>
</tr>
<tr>
<td>High SG</td>
<td>368</td>
<td>274</td>
<td>400</td>
<td>296</td>
<td>302</td>
<td>306</td>
<td>222</td>
<td>370</td>
<td>400</td>
</tr>
<tr>
<td>Low SG</td>
<td>58</td>
<td>80</td>
<td>128</td>
<td>46</td>
<td>78</td>
<td>70</td>
<td>76</td>
<td>44</td>
<td>44</td>
</tr>
</tbody>
</table>
Boluses 5-15 min Pre-Meal Unless Low..
Breakfast of Sugar Pop Cereal
Egg and Pancake Breakfast
Cereal for Breakfast
Sausage and Egg Breakfast

Glucose Modal Day Report

Time Period
Pre-Dinner Post-Dinner Bed Sleep

Pre-Bkfst Post-Bkfst Pre-Lunch Post-Lunch

Glucose (mg/dL)

6:00 AM 12:00 PM 6:00 PM 12:00 AM
• It is not just the amount of insulin but the timing or a pre-meal bolus.

• It is not just the amount of carbohydrates but their complexity and how much protein and fat is in the meal.
Rate of Change of Glucose following completion of meal

- 35 Kg, 104 CHO, 24 Fat, 26 Protein
- 45 Kg, 54 CHO, 12 Fat, 9 Protein
- 74 Kg, 35 CHO, 12 Fat, 9 Protein
- 24 Kg, 42 CHO, 10 Fat, 19 Pro
- 35 Kg, 37 CHO, Fat 9, Pro 10
Missed meal bolus

Glucose (mg/dL)

Insulin Delivery

Carbohydrates and Exercise

Carbs in grams 🌸

Exercise Intensity 🌸

High

Med

Low
Missed Meal Bolus
Burdick, Chase, Pediatrics 113: e221, 2004

• 65% missed more than 1 meal bolus/week
• 2 missed meal bolus/week associated with A1c increase of ½%
Drill Bit Through Thumb
Drill Bit Through Thumb

Glucose (mg/dL)

Insulin Delivery
Blunted Adrenalin Response to Hypoglycemia
Diabetes Care 32:1954-1959, 2009

- 30% of young children 3-8 years old and 12-18 years old failed to release adrenalin in response to hypoglycemia
- Parents blinded to their child’s glucose level failed to recognize hypoglycemia 71% of the time
- This reinforces the need for real-time continuous glucose monitoring
JDRF CGM Study Group
Primary Cohort
Six Month Outcome Data

NEJM and 44th EASD Annual Meeting Rome, Italy
September 8, 2008
Changes in A1c in ≥25 yr olds

*Error bars stand for 95% CI.
Changes in A1c in 15-24 yr olds

P-value = 0.52
Mean Hours of CGM Use by Age Group
The Teen Brain

- Myelination increases through childhood
- Axonal pruning increases coherent white matter bundles and cognitive function
- Prefrontal cortex does not reach adult levels until 21-25 years of age
Reaction Time Studies

• Is it a good idea to set your hair on fire?
• Is it a good idea to drink Drano?
• Is it a good idea to swim with sharks?

based on Baird & Fugelsang, 2004 and
Relationship Between Change in A1c and Frequency of CGM Use

- Change in glycated hemoglobin
- CGM Use
  - <4.0 days/week
  - 4.0-<6.0 days/week
  - ≥6.0 days/week

- Age ≥25
- Age 15-24
- Age 8-14
Baseline Factors for 8-24 year olds by CGM Use

(N=113)

<table>
<thead>
<tr>
<th></th>
<th>CGM &lt;4 days/week (n=18)</th>
<th>CGM 4-&lt;6 days/week (n=50)</th>
<th>CGM ≥6 days/week (n=45)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>61%</td>
<td>52%</td>
<td>44%</td>
</tr>
<tr>
<td>Injection Rx</td>
<td>39%</td>
<td>28%</td>
<td>16%</td>
</tr>
<tr>
<td>Daily SMBG</td>
<td>4.8 ± 1.4</td>
<td>5.9 ± 2.1</td>
<td>7.0 ± 2.0</td>
</tr>
</tbody>
</table>
1-Year Randomized Controlled Trial Comparing Sensor-Augmented Pump (SAP) and Multiple Daily Injection (MDI) Therapies: The STAR 3 Study

Richard M. Bergenstal, M.D., William V. Tamborlane, M.D., Andrew Ahmann, M.D., John B. Buse, M.D., Ph.D., George Dailey, M.D., Stephen N. Davis, M.D., Carol Joyce, M.D., Bruce A. Perkins, M.D., M.P.H., Steve M. Willi, M.D., Michael A. Wood, M.D.; for the STAR 3 Study Group

STAR 3 was sponsored by Medtronic Diabetes. Novo Nordisk supplied all insulin aspart used in the study. LifeScan, Bayer Healthcare, and Becton Dickinson supplied blood glucose meters used in the study.
STAR 3 Recruitment and Randomization

Assessed for eligibility (N=667)

Randomized (N=495)

SAP (N=247)

MDI (N=248)

n=244

n=241

n=224

n=219

Intent-to-Treat Population*

Observed Case Population

* Patients with ≥1 post-randomization A1C measurement with the last observation carried forward for the imputation of missing data.
Baseline Characteristics of SAP and MDI Groups

<table>
<thead>
<tr>
<th></th>
<th>SAP Group (N=244)</th>
<th>MDI Group (N=241)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yr)</td>
<td>32 ± 17.5</td>
<td>31.5 ± 16.5</td>
</tr>
<tr>
<td>Duration of diabetes (yr)</td>
<td>15.2 ± 12.5</td>
<td>15.4 ± 12.0</td>
</tr>
<tr>
<td>Male</td>
<td>57.4%</td>
<td>55.6%</td>
</tr>
<tr>
<td>White</td>
<td>90.6%</td>
<td>92.1%</td>
</tr>
<tr>
<td>Employed / volunteer</td>
<td>57.4%</td>
<td>53.1%</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>71.9 ± 25.3</td>
<td>73.0 ± 21.8</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>25.3 ± 6.0</td>
<td>25.6 ± 5.6</td>
</tr>
<tr>
<td>A1C (%)</td>
<td>8.3 ± 0.53</td>
<td>8.3 ± 0.53</td>
</tr>
</tbody>
</table>
A1C at 3, 6, 9, 12 months: All Patients

Values are means ± SE. Asterisks denote P<0.001 for comparisons between SAP group and MDI group at each time point.
A1C at 3, 6, 9, 12 months: Adults ≥ 19 years

Values are means ± SE. Asterisks denote P<0.001 for comparisons between SAP group and MDI group at each time point.
A1C at 3, 6, 9, 12 months: Pediatrics 7–18 years

Values are means ± SE. Asterisks denote P<0.001 for comparisons between SAP group and MDI group at each time point.
Relationship of Sensor Use and A1C at 1 year

Values are means ± SE.
Relationship of Sensor Use and A1C at 1 year

Values are means ± SE.

(N=7) Δ=−0.43

(N=27) Δ=−0.19
Relationship of Sensor Use and A1C at 1 year

Values are means ± SE.

- (N=7) Δ=-0.43
- (N=27) Δ=-0.19
- (N=46) Δ=-0.64
Relationship of Sensor Use and A1C at 1 year

Values are means ± SE.
Relationship of Sensor Use and A1C at 1 year

Values are means ± SE. P=0.003 for association between sensor wear and A1C reduction at 1 year.
Decreased Hypoglycemia with CGM Use
Battelino, Diabetes Care, April, 2011

- 120 Children (45%) and Adults (55%)
- A1c < 7.5% (mean 6.9%)
- Doing 5 SMBG tests each day
- Mean days of sensor wear/week: Pediatrics=5.6, Adults=4.9
Decreased Hypoglycemia with CGM Use

Battelino, Diabetes Care, April, 2011

**Figure 1**—Time spent below 63 mg/dL by month. Mean values ± SEs for hours per day spent <63 mg/dL over the 6-month study period in all patients. ●, continuous monitoring group; ▲, control group.
Decreased Hypoglycemia with CGM Use

Battelino, Diabetes Care, April, 2011
Real-Trend Study
Raccah, Diabetes Care, 32:2245, 2009

• MDI patients with A1c > 8% randomized to sensor augmented pump or pump (CSII)

• Intention to treat:
  – 55 assigned to real-time (22 children)
  – 60 assigned to CSII (24 children)

• Per Protocol (sensor use > 70% of time)
  – 32 patients (11 children)
  – 39 patients (24 children)
Real-Trend Study – Intention to Treat
Raccah, Diabetes Care, 32:2245, 2009

A

\[ \Delta \text{HbA1c: -0.57\%, p<0.001} \]

\[ \Delta \text{HbA1c: -0.57\%, p<0.001} \]

\[ \Delta \text{HbA1c: -0.81\%, p<0.001} \]

\[ \Delta \text{HbA1c: -1.14\%, p<0.001} \]

Screening  Baseline  3 Months  Study end

PRT
CSII
Real-Trend Study Per Protocol
Raccah, Diabetes Care, 32:2245, 2009
Use of RT-CGM in adults on MDI or CSII
Garg, Diabetes Care 34:574–579, 2011

- 60 Adults
  - 30 using MDI
  - 30 using CSII
- 4 weeks blinded Dexcom 7+ wear
- 20 weeks unblinded Dexcom 7+ wear
Figure 1—Changes in hypoglycemic excursions during the study period were similar in ITT (n = 60) (A) and per-protocol analysis (n = 34) (B).
Figure 2—Changes in hyperglycemic excursions during the study period were also similar in the ITT analysis (n = 60) (A). However, hyperglycemic excursions were significantly lower in the CSII group in the subgroup analysis (per-protocol analysis, n = 34, B).
Possible Candidates

- Are not at goal despite adequate BG testing.
- Have a fear of hypoglycemia.
- Have a history of hypoglycemia unawareness or severe hypoglycemia.
- Pregnancy/Preconception.
- Gastroparesis.
- Athletes.
- Patients on medications like pramlintide and exenatide.
- May wear the sensor intermittently to better understand their own diabetes.
Real-Time Data

• Constant feedback on how multiple variables impact glucose control.
  – The immediacy of the feedback helps identify causality.

• This ability offers both benefits and challenges.
  – Benefits:
    • How different foods impact BG is more readily apparent.
    • Data can be used to prevent or detect earlier extremes in glucose.
  – Challenges:
    • Concerns about insulin “stacking”
    • Patients need to feel empowered to utilize the data
PATIENCE is Important

Insulin Delivery

Carbohydrates and Exercise

Summary

<table>
<thead>
<tr>
<th>Glucose BG/SG</th>
<th>Insulin</th>
<th>Carbs</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average (mg/dL)</td>
<td>205.171</td>
<td>Total (U)</td>
<td>Total Carbs (grams)</td>
</tr>
<tr>
<td>High (mg/dL)</td>
<td>335/320</td>
<td>Basal (U)</td>
<td>Average Carbs (grams)</td>
</tr>
<tr>
<td>Low (mg/dL)</td>
<td>128/48</td>
<td>Bolus (U)</td>
<td># of Meals</td>
</tr>
<tr>
<td># of Readings</td>
<td>15/288</td>
<td>Normal (U)</td>
<td># of Episodes</td>
</tr>
<tr>
<td># of BG Hypos</td>
<td>0</td>
<td>Square (U)</td>
<td></td>
</tr>
<tr>
<td># Hypo Excursions</td>
<td>2</td>
<td>Suspended Minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Temp Basal Minutes</td>
<td>180</td>
</tr>
</tbody>
</table>
Major Positive Changes in Diabetes Management

• Changes in meal behavior
  – Less carbohydrates with breakfast
  – Giving insulin bolus 10-15 minutes before a meal
• Adjustment of overnight basal rates was easier
• Use of alarms, especially to give quick correction doses and treat pending hypoglycemia
Expectations Need To Be Realistic

- The sensor will not be as accurate as their meter, but will provide trend analysis
- There will be false positive and false negative alarms
- Patients will see fluctuations in their glucose levels they were not previously aware of
Principal Concepts

- Use sensor values in making real time decisions
- If using a pump always use the bolus calculator
- Download the sensor results every 3-6 days, and review the data
- Goal is to increase the number or percent of glucose levels within target ranges
Who Should Use CGM?

• There is no formula that will predict who may benefit from CGM use.

• People likely to benefit are those who:
  – Are prepared to see the data.
  – Are willing to make changes.
  – Are willing to wear the CGM system.
Education

• Perfection is not the goal.
• ISF vs BG
• Calibration should be done when the glucose is not changing rapidly.
• How to utilize trend data (real-time data)
• Insulin and other medication action profiles.
• Review retrospective data regularly to identify patterns that may require more “permanent changes”.
CGM Research Findings

• Overall patients who use real-time CGM at least 5 days a week:
  – Lower their A1c levels
  – Lower the time spent in hypoglycemia
  – Reduce glycemic variability
In Conclusion

- Real-time continuous monitoring is here to stay
- We need to learn how to obtain maximum benefit from this powerful tool
- There are advantages and disadvantages with each device
- Real-time monitoring is a behavior modification tool, it is only successful if behavior is modified (until we have a closed-loop)