Advanced Pump Workshop

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View slides at www.diabetesnet.com/diabetes-resources/diabetes-presentations

Disclosure

- Book sales – all pump companies
- Advisory Boards – Tandem Diabetes, Convatec, Halozyme, AgaMatrix, PicoLife Technologies
- Consultant – Bayer, Roche, BD, Abbott, Tandem Diabetes, Acon Laboratories
- Speakers Bureau – Tandem Diabetes, Animus
- Sub-Investigator – Glaxo Smith Kline, Animus, Sanofi-Aventis, Bayer, Biodel, Dexcom, Novo Nordisk, Halozyme
- Pump Trainer – Accu-Chek, Animas, Medtronic, Omnipod, Tandem
- Web Advertising – Sanofi-Aventis, Sooil, Medtronic, Animas, Accu-Chek, Abbott, etc.

What We'll Cover

- Glucose Management – Slide 12
- Actual Pump Practices Study Results – Side 18
- Tuning the Bolus Calculator – Slide 30
- Special Issues
  - DIA, BOB, and Insulin Stacking – Slide 79
  - Infusion Sets – Slide 103
- Continuous Glucose Monitors – Slide 116

Terms

- **TDD** – total daily dose (all basals and boluses) of insulin
- **Basal** –background insulin released slowly through the day
- **Bolus** – a quick release of insulin – Carb boluses cover carbs and Correction boluses lower high readings
- **Bolus Calculator (BC)** – what calculates bolus recommendations
- **Correction Target** – the BG aimed for with correction bolus
- **Bolus On Board (BOB)** – bolus insulin still active from recent boluses, active insulin, insulin on board
- **Duration of Insulin Action (DIA)** – how long a bolus will lower the BG – used to measure BOB

Pump Advantages

- More reliable insulin action, better control, lower TDD
- Precise basal delivery – 0.05 u compared to 0.5 u
- Automatic dose calculations with accurate boluses
- Avoids common problem of insulin stacking
- Fewer missed/skipped doses

Why People Choose Them

- Convenience
- Better lifestyle
- Less hypoglycemia
- Improved sense of well being
- Flexible insulin delivery – exercise, skipping meals

- Less hassle and anxiety with erratic schedule, shiftwork, travel, time zones

Why Physicians Recommend Them

- Poor control, high A1c, wide BG excursions
- Nocturnal or frequent lows,
  hypo unawareness
- Frequent hospitalization/DKA
- Increased insulin sensitivity
- Varied or intense exercise/activity
- Dawn phenomenon, gastroparesis, pregnancy
- Varied work or school schedule, travel
- Insulin resistance, Type 2 diabetes, teens

Infusion Line Pumps

Accu-Chek Combo

Animas Ping

Medtronic Revel

Patch Pumps

Valeritas V-Go

Omnipod Eros

Accu-Chek Solo

Calibra Finesse

Debiotech Jewel

Also: Medtronic

Remote Controls

- Integrated glucose meter allows convenient testing
- Carb and correction boluses can be discreetly given
- Basal adjustments from some remotes

Omnipod remote must be present to give boluses

Pump plus CGM Options

CGM:		Pump:	Available
Dexcom 4G	↔	Animas	2013?
	↔	Tandem	2013?
Paradigm Enlight	↔	Medtronic	Now

Glucose Management

ADA Glucose Guidelines

Therapeutic goals for glycemic control

- Adults:
  - Goal of therapy: <7.0% HbA1c
  - Action suggested: >8.0% HbA1c
- Pediatric patients:
  - Toddlers and preschoolers: <8.5 % (but >7.5%
  - School age (6–12 years): <8%
  - Adolescents and young adults (13–19 years): <7.5%

Canadian/European Pediatric Guidelines

- Pediatric patients:
  - Toddlers and preschoolers: <8.5 % (but >7.5%)
  - School age (6–12 years): <8.0%
  - Adolescents and young adults (13–19 years): <7.0%
- Internat. Society for Pediatric & Adolescent Diabetes:
  - Everyone: <7.5%, close to 7% without problematic hypos

Tips –
Dose For Success

1. Stop lows first
2. Find an iTDD – for normal, stable BGs
3. Set & test basals – keeps overnight readings level
4. Set & test CarbF – fine-tune premeal BGs
5. Lower post meal BGs – bolus early, low GI foods, Symlin, etc.
6. Set & test CorrF – to bring highs down safely

Enjoy good control or return to #1

Brittle diabetes or frequent highs? Usually = the wrong settings!

Don’t Compound Errors

Each error **MAGNIFIES** the total dosing error!

Eliminate errors:

In the Pump:

- Basal rates
- CarbF
- CorrF
- DIA/insulin stacking
- Correction target
- Meter accuracy

By the Wearer:

- Carb counts
- Glucose monitoring
- Accounting for BOB
- Adjustments for activity, menses, stress, pain, etc.

The “Other Things” Needed

- Check glucose 6 x a day or wear a CGM
- Use the bolus calculator for all boluses
- Cover all carbs with a bolus before eating, unless there’s a good reason not to
- When low, don’t over-treat with carbs
- When high, don’t over-treat with insulin
- Don’t give blind boluses

The Actual Pump Practices Study

In the APP Study, we looked retrospectively at over a thousand pump wearers across the U.S. to find:

- How pumps are actually used and
- What influences success

APP Study Background

- Data from Deltec Cozmo insulin pumps were down-loaded during a routine software upgrade in 2007
- 396 pumps had BG values directly entered from an attached CozMonitor Freestyle meter were chosen
- These pumps averaged over 73 days of data and over 300 glucose tests per pump.
- Pumps were divided into thirds by average glucose

Walsh J, Roberts R, Bailey T. Guidelines for Optimal Bolus Calculator Settings in Adults. J Diabetes Sci Technol 5(1): 1711-1717, 2011.

APP Study

- Two types of results
  - Typical behaviors of all pumpers
  - Behaviors and data from third with lowest avg BG
- Basal %, CarbF and CorrF formulas were derived from the third with the lowest avg. BG
- 92.7% of pump wearers used the BC to cover carbs (> 2 meals a day)
- 96.5% used the BC to correct high readings

1. J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010

Which Way Do You Adjust Settings?

12.6 Which Way Do You Change Your Pump Settings?			
If you are having:	This is the direction to change your:		
	Basal Rates	Carb Factor	Corr Factor
Frequent lows	↓	↑	↑
Frequent highs	↑	↓	↓

The CarbF and CorrF are inversely related to glucose. That is, when the avg. glucose is high, these factors are lowered, and vice versa.

APP Study – BGs and Basal Rates

Glucose, Insulin and Carb Data				
Group:	All 396 Pumps	Low Third	Mid Third	High Third
Avg. Meter BG	184 mg/dL 10.2 mmol/L	144 mg/dL 8.0 mmol/L	181 mg/dL 10.0 mmol/L	227 mg/dL 12.6 mmol/L
BG Tests/Day	4.38	4.73	4.41	4.01
TDD	49.4	47.9	49.1	51.1
Basal %	47.6%	47.6%	47.2%	47.8%

1. J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010

APP Study – Carb Boluses and CarbFs

Glucose, Insulin and Carb Data				
Group:	All 396 Pumps	Low Third	Mid Third	High Third
Avg. Meter BG	184 mg/dL 10.2 mmol/L	144 mg/dL 8.0 mmol/L	181 mg/dL 10.0 mmol/L	227 mg/dL 12.6 mmol/L
CarbBolus U/d	20.4 u	20.9 u	20.4 u	19.8 u
CarbBolus/Day	4.14	4.07	4.20	4.14
CarbGram/Day	189.9	185.2	196.3	187.9
CarbF	11.4	10.8	12.2	11.2

1. J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010

APP Study – How Much More Insulin Is Needed?

Insulin Use In The APP Study				
Group:	All 396 Pumps	Low Third	Mid Third	High Third
Avg. Meter BG	184 mg/dL 10.2 mmol/L	144 mg/dL 8.0 mmol/L	181 mg/dL 10.0 mmol/L	227 mg/dL 12.6 mmol/L
TDD (u/day)	49.4 u	47.9 u	49.1 u	51.1 u
Improved iTDD	52.7 u	–	52.1 u	58.2 u
Extra units	+ 3.3 u	–	+ 3.0 u	+ 7.1 u

Add 1% to the TDD for each 0.3 mmol/L * drop in average glucose.

Use 7.8 mmol/L (140 mg/dl) as target glucose, unless there are other factors, like pregnancy, living alone, or hypoglycemia unawareness

* Or 1% for each 6 mg/dl

APP Study – Correction Bolus, CorrF

Correction Doses				
Group:	All 396 Pumps	Low Third	Mid Third	High Third
Avg. Meter BG	184 mg/dL 10.2 mmol/L	144 mg/dL 8.0 mmol/L	181 mg/dL 10.0 mmol/L	227 mg/dL 12.6 mmol/L
CorrBoluses/d	2.12	1.92	2.10	2.35
CorrBolus U/d	5.59 u	4.18 u	5.57 u	7.03 u
CorrBolus %	11.6%	9.0%	11.6%	14.2%
CorrF	55.7	53.6	61.1	52.5
CorrF x TDD	2160	1960	2360	2330

1. J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010

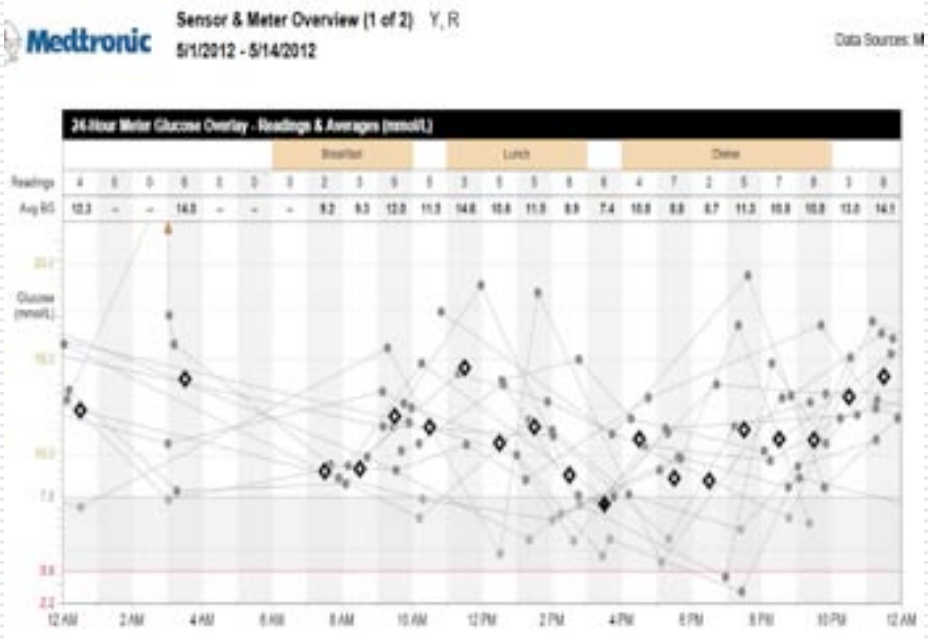
APP Study – Unexpected Results

- Basals averaged 48% in low, medium, and high glucose groups – no impact on glucose outcomes
- No difference in grams of carb eaten or number of carb boluses and correction boluses given per day
- Glucose tests per day showed "significance" but had no meaningful impact on glucose outcomes – the high BG group tested BGs almost as often as low
- Occlusions significantly raised avg BG
- Those with highest BGs used MORE insulin → they either need more insulin OR need to stop losing it

1. *J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010*

APP Study – Major Finding

- Find an accurate TDD
- Then get pump settings from it



Pattern management starts after TDD is accurate.

APP Study – Pump Setting Formulas[1]

Basal = ~ 48% of TDD

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

Corr. Factor = 110/TDD (mmol/L) or 2000/TDD (mg/dl)

The correction factor is inversely related to TDD and to avg. BG

Or use the Pump Settings Tool at
www.diabetesnet.com/diabetes_tools/pumpsettings/

*Lower this CorrF number for higher avg BGs

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

APP Study –
The Doses that Successful Pumpers Use

2. Optimal Insulin Use

Mean Values For Optimal Doses In Best Control Tertile

Insulin Source	% of TDD	Interquartile Range (%)
Basal	47.8%	39.6% to 54.9%
Carb Boluses	43.1%	35.6% to 51.2%
Corr Boluses	9.0%	6.2% to 11.3%

CorrF Rule Number* = 1960 mg/dl per unit (IQR = 1413 to 2151)

* CorrF Rule Number = Avg CorrF x Avg TDD

Insulin use in the third (132 pumps) with the lowest average glucose in APP Study

J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010

Tuning the Bolus Calculator

The BC helps user find bolus recommendations that better match carb intake and the current glucose while minimizing insulin stacking

Bolus Calculator Settings

This Setting	Assists
Basal rates	Safe sleep (~50% of TDD)
CarbF or I:C ratio	Cover carbs well
CorrF or ISF	Lower highs safely
Target glucose	Correct to specific goal
DIA	Accurately measure IOB to minimize insulin stacking

Average TDD – controls the frequency of low and high glucoses

BOB (IOB, active insulin) – units of glucose lowering activity left from recent boluses

Bolus Calculator

Input: Current glucose

Photo courtesy www.sixuntilme.com

Grams of carb

Photo courtesy emilyboller.com

Output: A recommended bolus with display of units for carbs, correction (if any), and remaining IOB (if any)

Set Correction Target with Care

Where In Correction Target Range Does The Pump Aim?	
Animas, Omnipod	Middle
Medtronic	Top or Bottom
Tandem	3.9 mmol/L (70 mg/dl)

BGs inside target range are ***not corrected***.

For range of 4-10 mmol/L (70 to 180 mg/dl), BGs of 4.1 to 9.9 mmol/L are ***not corrected***.

Bottom Line: Use a single correction target (ie, 110 mg/dl or 6.1 mmol/L), OR a narrow correction range (ie, 100-120 mg/dl or 5.6-6.7 mmol/L).

*

Size Up the Glucose Problem

- If it ain't broke, don't fix it!
- **Severe** – Reset the TDD to an improved TDD (iTDD) to correct problem and select new settings from this iTDD.
- **Moderate** – Reset to an iTDD if needed, and use pattern management to fine tune doses and pump settings
- **Mild** – tweak pump settings

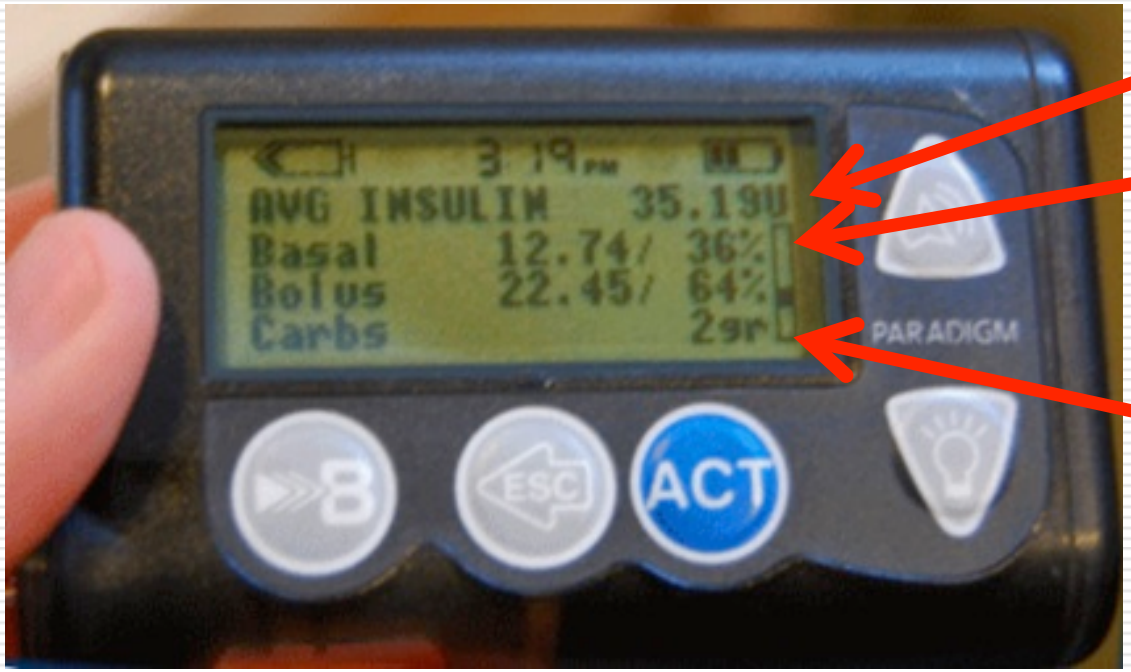
Adjust the TDD to an Improved TDD (iTDD)

iTDD = TDD (avg. of basal + all boluses, 10-30 d)

1. Lowered by 5% to 10% for:
    - Frequent lows, OR for highs and lows IF lows come first
    - Raised with the iTDD Table for high A1c or high meter average with few lows, OR increase TDD by 1% for each 0.33 mmol/L (6 mg/dl) drop desired in avg BG

Avg BG on pumps is 184 mg/dl (10.2 mmol) – most need larger TDD.

Critical Pump Data – Avg. TDD and Basal/Bolus Balance



TDD = 35.19 u

Basal % is low at 36%

2 grams of carb/day means bolus calculator is not used

Find the Current TDD

Statistics	5/3 - 5/16	
Avg BG (mmol/L)	12.3 ± 5.0	
BG Readings	86	7.6/day
Readings Above Target	66	77%
Readings Below Target	2	2%
Sensor Avg (mmol/L)	10.3 ± 3.7	
Avg AUC > 7.8 (mmol/L)	2.94	4d 17h
Avg AUC < 3.9 (mmol/L)	0.01	4d 17h
Avg Daily Carbs (g)	*101* ± *39*	
Carbs/Bolus Insulin (g/U)	6.8	
Avg Total Daily Insulin (U)	35.5 ± 5.5	
Avg Daily Basal (U)	20.8	58%
Avg Daily Bolus (U)	14.8	42%

With an avg BG of 12.3 mmol/L (221 mg/dl), the **TDD** of 35.5 u is too low

Basal % is OK (or slightly high) at 58%

Stop Frequent Lows –

- ***You cannot tell how much excess insulin there is!***
- Start with a 5% or 10% reduction in the TDD
- Compare the current TDD to an "ideal" TDD for weight.
  - Divide weight(kgs) by 1.8 to see what TDD would use if they have an average sensitivity to insulin

Example: Someone who weighs 72 kg would be expected to have a TDD of 40 units (72/1.8 = 4.0).

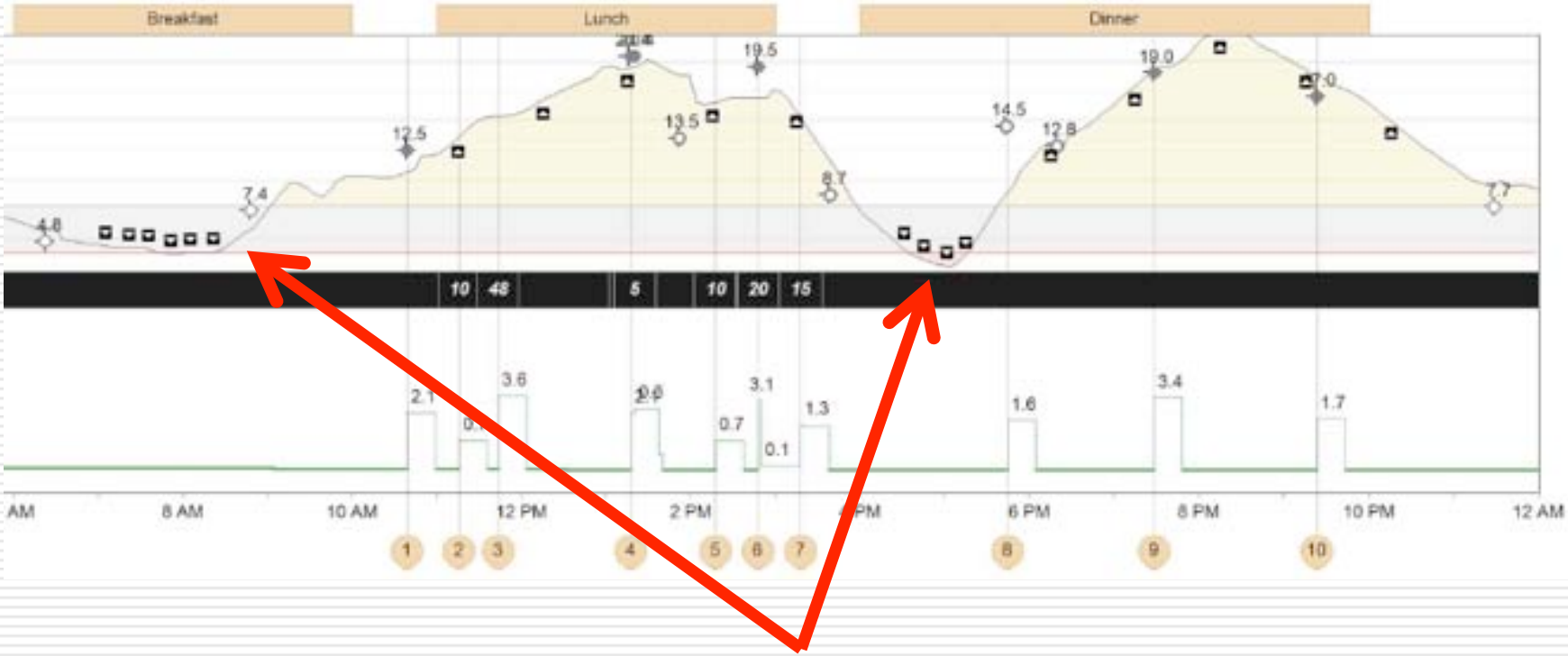
Example – Hypoglycemia

41 yo female with A1c = 6.9%

156lb/4 = 38.0 u/d

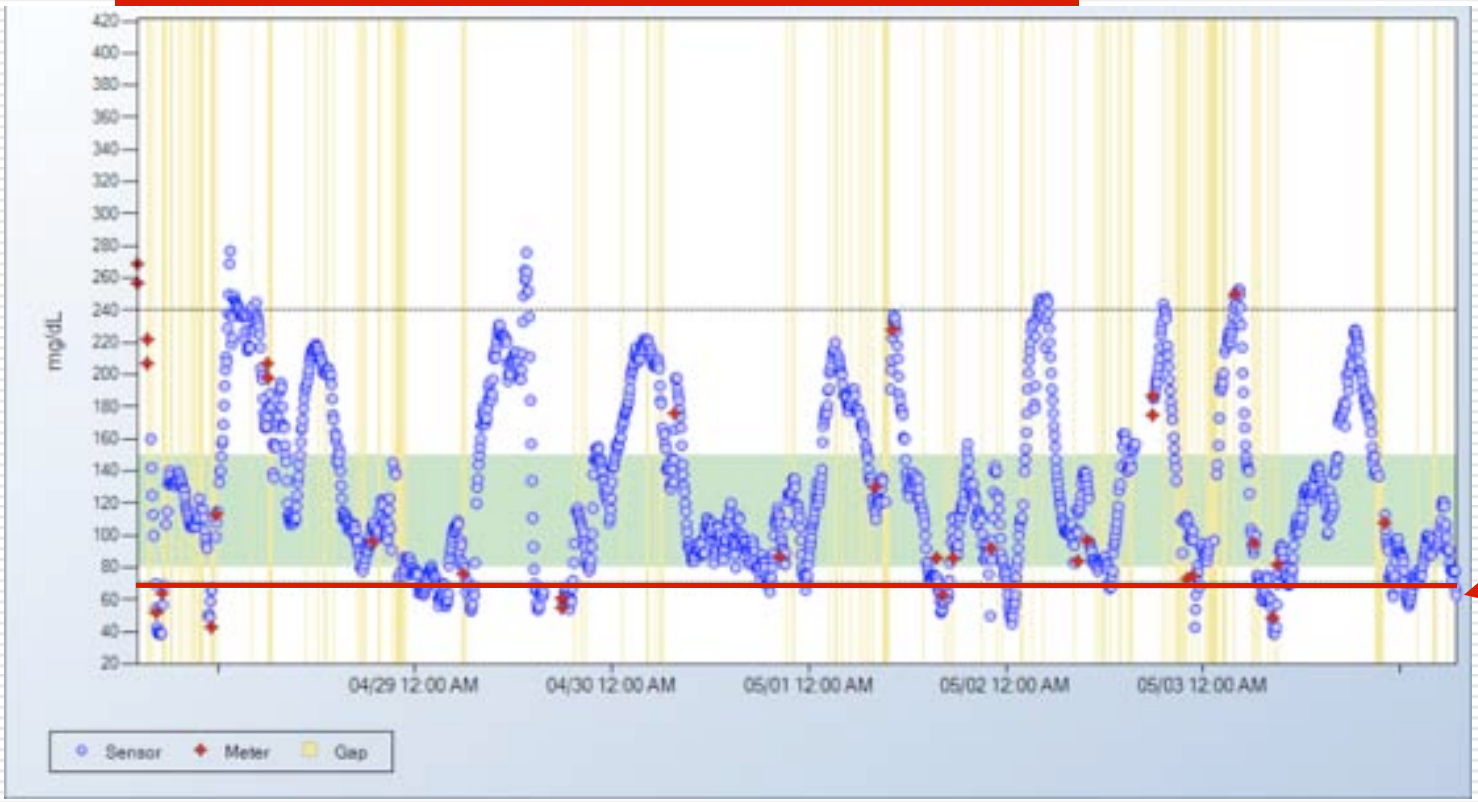
Actual TDD = 50.5 u/d

Not All Lows Show Up On a BG Meter



This person felt low, ate, but never tested with a meter. There is no record of these lows without the CGM!

What To Do?



~ 2 Lows-to-Highs per day

70 mg/dl (3.9 mmol)

Frequent lows → lower the average TDD

Clever Pump Trick –
How Many Carbs for a Low?

1. 10 grams for each 35 kg or 80 lb of weight
2. **PLUS** grams = current BOB* x CarbF

Example:

- Amy weighs 70 kg (20 grams of carb)
- And she has 2 units of BOB with a CarbF of 8 grams/unit
  2 u x 8 g/u = 16 grams
- So, for the low she needs:
  20 g + 16 g = 36 grams

Add extra carbs as needed for recent or planned exercise.

*** To get an accurate BOB,**
the pump's DIA time setting must be accurate.

Stop Frequent Highs –

When average BG is high with few lows:

Raise TDD by 1% to lower the average glucose by 0.33 mmol/L (6 mg/dl) or the A1c by 0.2%

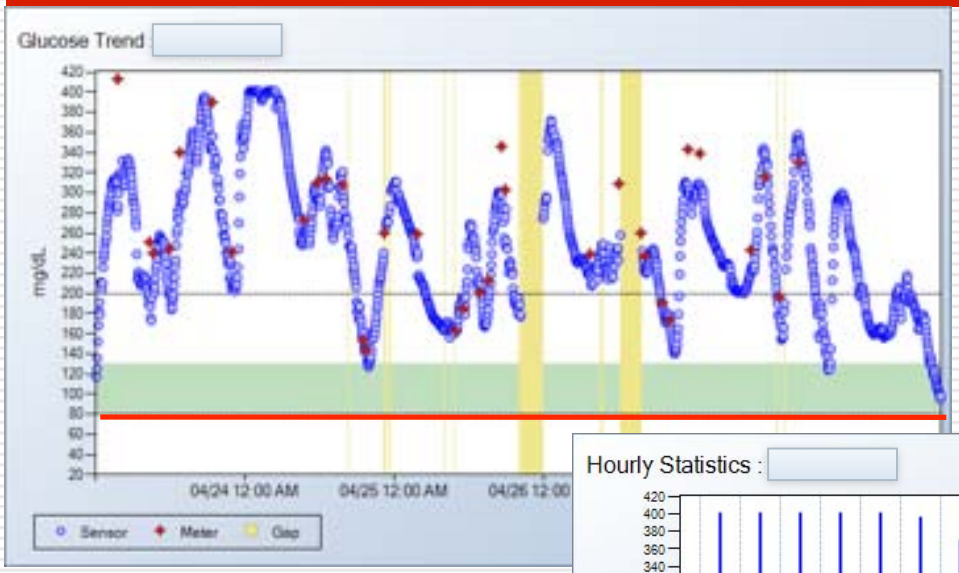
Example: Amy's avg TDD is 40 u/day, avg BG is 12 mmol/L (217 mg/dl) with few lows, and her BG goal is 8 mmol/L (145 mg/dl):

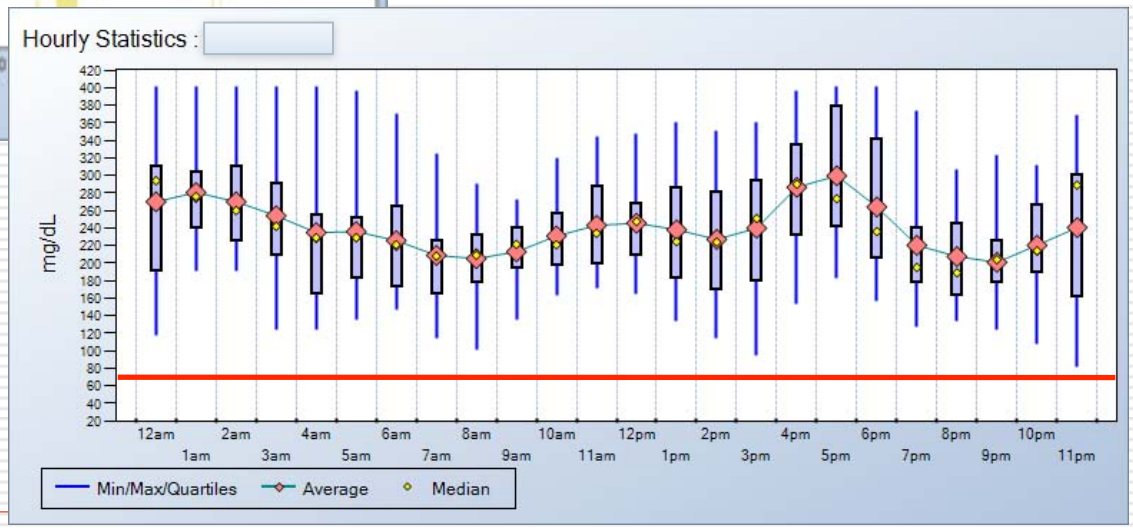
12 mmol/L – 8 mmol/L = 4 mmol/L

4 mmol/L ÷ 0.33 = 12% rise needed in TDD

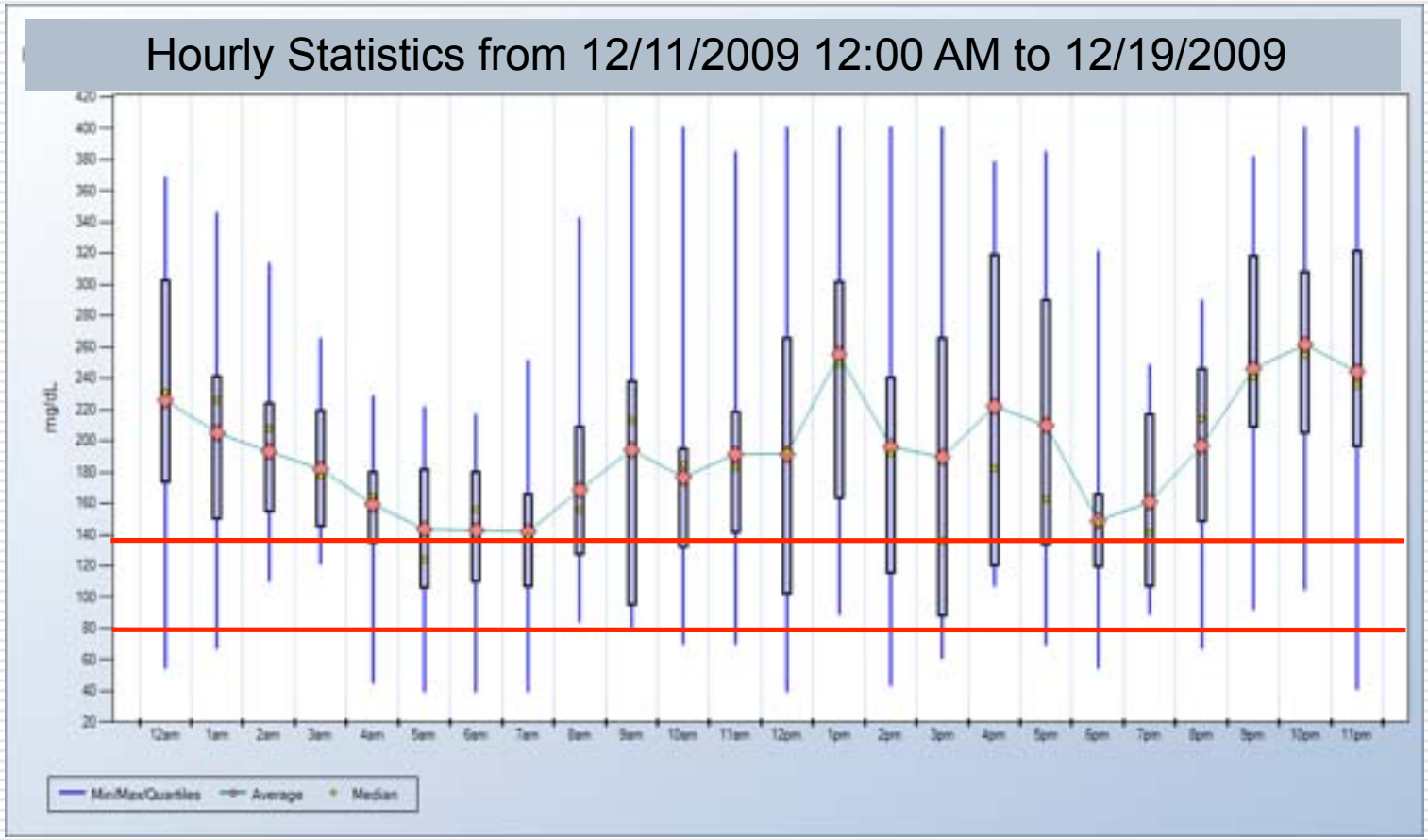
40 units x 1.12 = 44.8 units

What To Do?


Glucose Trend
mg/dL
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
04/24 12:00 AM
04/25 12:00 AM
04/26 12:00
Sensor
Meter
Gap


Hourly Statistics :
mg/dL
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
12am
1am
2am
3am
4am
5am
6am
7am
8am
9am
10am
11am
12pm
1pm
2pm
3pm
4pm
5pm
6pm
7pm
8pm
9pm
10pm
11pm
Min/Max/Quartiles
Average
Median

What To Do?


Hourly Statistics from 12/11/2009 12:00 AM to 12/19/2009
mg/dL
420
400
380
360
340
320
300
280
260
240
220
200
180
160
140
120
100
80
60
40
20
12am
1am
2am
3am
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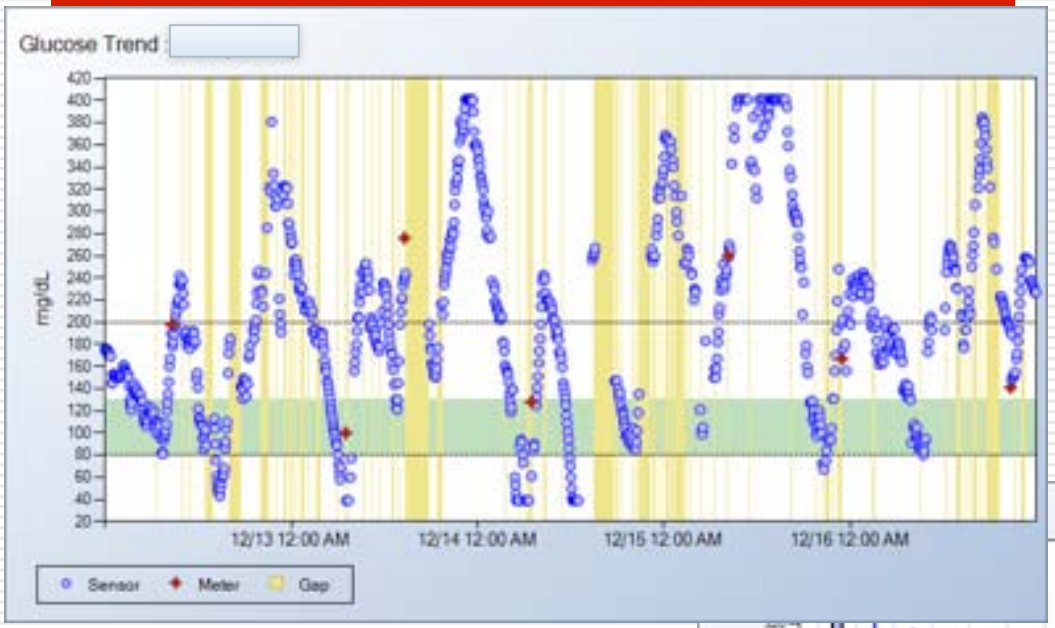
10am
11am
12pm
1pm
2pm
3pm
4pm
5pm
6pm
7pm
8pm
9pm
10pm
11pm
Min/Max/Quartiles
Average
Median

Highs And Lows – With A Pattern

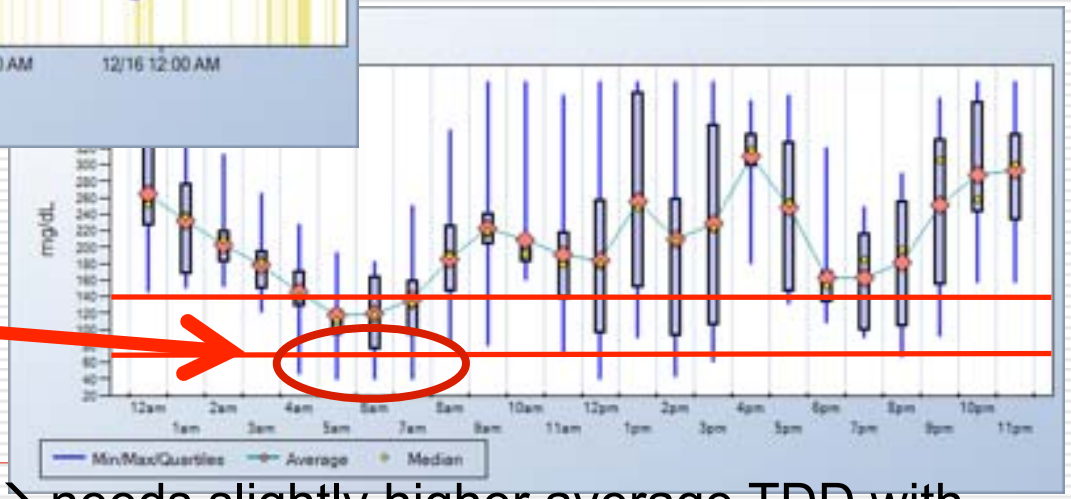


5 day average:

Avg BG: 11.3 (203)

Range: 2.2 to 22.3 (39 to 401)

SD: 89.9 ← highly variable



Low BGs between 5 am and 7 am

Frequent lows and highs → needs slightly higher average TDD with either a lower night basal or smaller correction boluses at night

The iTDD Table For High Avg. BGs

10.3 Raise Your TDD when Glucoses Are Mostly High

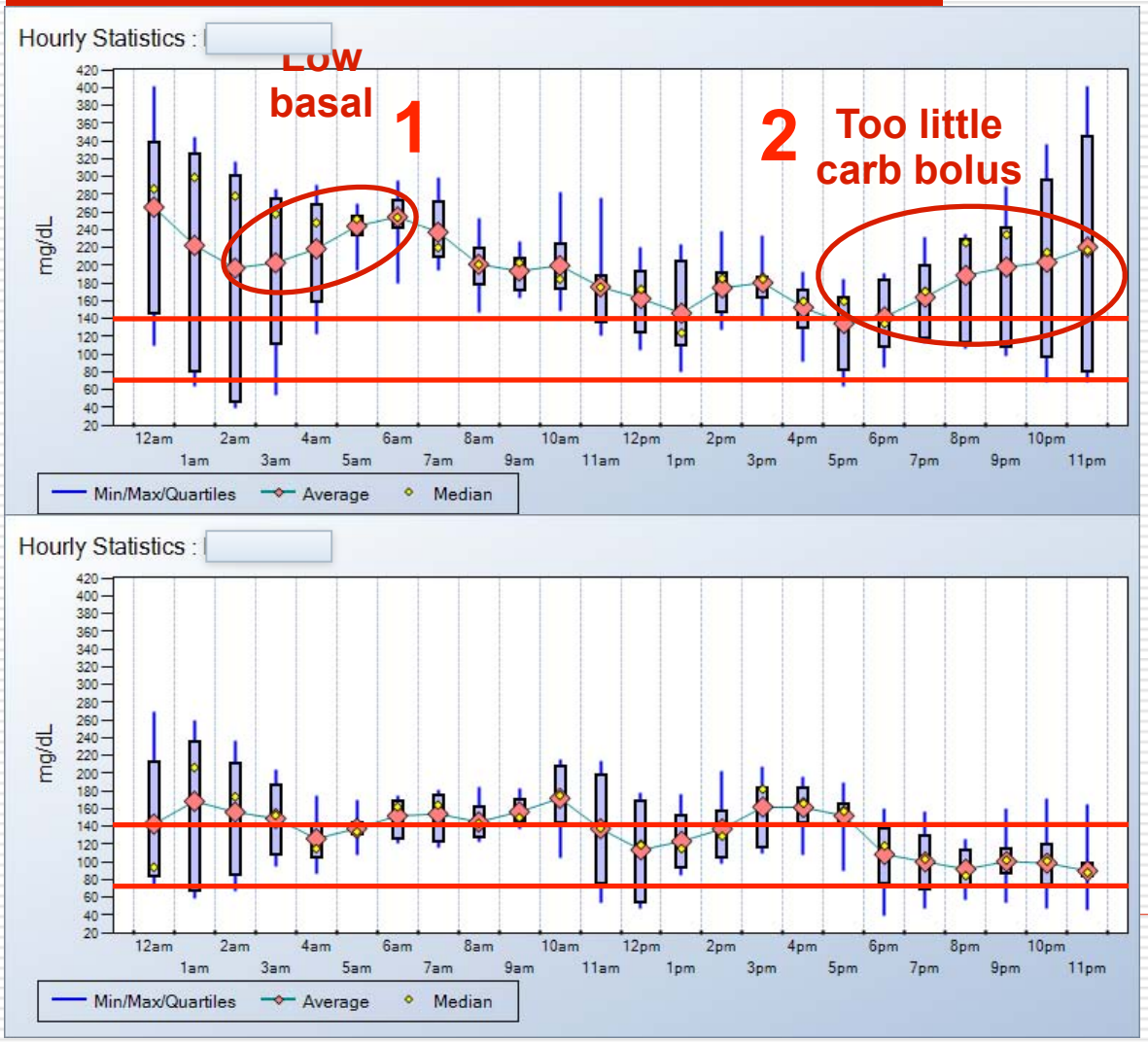
		Your New Improved TDD (iTDD)								
	14 Day BG mg/dl (mmol/L)	155 (8.6)	169 (9.4)	183 (10.2)	197 (10.9)	212 (11.8)	226 (12.6)	240 (13.3)	255 (14.2)	269 (14.9)
	A1c	7.0	7.5	8.0	8.5	9.0	9.5	10.0	10.5	11.0
Your Current TDD	15 u	15.3	15.6	16.0	16.3	16.7	17.0	17.4	17.8	18.1
	20 u	20.3	20.8	21.3	21.7	22.2	22.7	23.2	23.7	24.1
	25 u	25.4	26.0	26.6	27.2	27.8	28.4	29.0	29.6	30.2
	30 u	30.5	31.2	31.9	32.6	33.4	34.1	34.8	35.5	36.2
	35 u	35.6	36.4	37.2	38.0	38.9	39.7	40.5	41.4	42.2
	40 u	40.7	41.6	42.5	43.5	44.5	45.4	46.3	47.3	48.3
	45 u	45.8	46.8	47.9	48.9	50.0	51.1	52.1	53.3	54.3
	50 u	50.8	52.0	53.2	54.3	55.6	56.8	57.9	59.2	60.3
	55 u	55.9	57.2	58.5	59.8	61.1	62.4	63.7	65.1	66.4
	60 u	61.0	62.4	63.8	65.2	66.7	68.1	69.5	71.0	72.4
	65 u	66.1	67.6	69.1	70.6	72.3	73.8	75.3	76.9	78.4
	70 u	71.2	72.8	74.4	76.1	77.8	79.5	81.1	82.8	84.5
	75 u	76.3	78.0	79.8	81.5	83.4	85.1	86.9	88.8	90.5
	80 u	81.3	83.2	85.1	86.9	88.9	90.8	92.7	94.7	96.5
	85 u	86.4	88.4	90.4	92.4	94.5	96.5	98.5	100.6	102.6
	90 u	91.5	93.6	95.7	97.8	100.1	102.2	104.3	106.5	108.6
	95 u	96.6	98.8	101.0	103.2	105.6	107.8	110.0	112.4	114.6
	100 u	101.7	104.0	106.3	108.7	111.2	113.5	115.8	118.3	120.7

Derived from the APP Study[69]

For frequent highs and few lows, this table suggests how much to increase the current TDD from meter 14 day average BG or a recent A1c

J Walsh and R Roberts:
Pumping Insulin (5th ed), 2012

BGs & TDD before & after Adjustment



Starting TDD = 36 u

- Raised basal by 0.05 u/hr all day (+1.2 u/day)
- Lowered carb factor from 1u/13g to 1u/12g (+1.8 u/day)

Ending TDD = 39 u

The TDD Must Change For:

- Frequent lows or frequent highs
- Going on or off a diet
- Loss or gain of weight
- Seasonal changes
- Change in activity or sports
- Vacation
- Growth spurts
- Puberty and menses

Don't wait until the next clinic visit!

APP Study –
Importance of the TDD

2. Optimal Insulin Use

Mean Values For Optimal Doses In Best Control Tertile

Insulin Source	% of TDD	Interquartile Range (%)
Basal	47.8%	39.6% to 54.9%
Carb Boluses	43.1%	35.6% to 51.2%
Corr Boluses	9.0%	6.2% to 11.3%

CorrF Rule Number* = 1960 mg/dl per unit (IQR = 1413 to 2151)

* CorrF Rule Number = Avg CorrF x Avg TDD

Insulin use in the third (132 pumps) with the lowest average glucose in APP Study

J Walsh, R Roberts, T Bailey: J Diab Science & Technology 2010, Vol 4, #5, Sept 2010

Use the TDD to Find Pump Settings

9.5 Master List for Bolus Calculator Settings: Find Your Basal Rates, CarbF, and CorrF from Your TDD (or iTDD) and Weight

TDD or iTDD u/day	Basal [1] u/day	Basal u/hr	Carb Factor[2] in grams/u									CorrF[3] (mg/dl) / u
			100 lbs 45.4 kg	110 lbs 49.9 kg	120 lbs 54.4 kg	130 lbs 60.0 kg	140 lbs 63.5 kg	150 lbs 68.0 kg	160 lbs 72.6 kg	170 lbs 77.1 kg	180 lbs 81.6 kg	
16	7.7	0.32	16.3	17.9	19.5	21.1	22.8					122
20	9.6	0.40	13.0	14.3	15.6	16.9	18.2	19.5	20.8			98.0
24	11.5	0.48	10.8	11.9	13.0	14.1	15.2	16.3	17.3	19.5	21.7	81.7
28	13.4	0.56	9.3	10.2	11.1	12.1	13.0	13.9	14.9	16.7	18.6	70.0
32	15.4	0.64	8.1	8.9	9.8	10.6	11.4	12.2	13.0	14.6	16.3	61.3
36	17.3	0.72	7.2	7.9	8.7	9.4	10.1	10.8	11.6	13.0	14.4	54.4
40	19.2	0.80	6.5	7.2	7.8	8.5	9.1	9.8	10.4	11.7	13.0	49.0
45	21.6	0.90	5.8	6.4	6.9	7.5	8.1	8.7	9.2	10.4	11.6	43.6
50	24.0	1.00	5.2	5.7	6.2	6.8	7.3	7.8	8.3	9.4	10.4	39.2
55	26.4	1.10	4.7	5.2	5.7	6.1	6.6	7.1	7.6	8.5	9.5	35.6
60	28.8	1.20	4.3	4.8	5.2	5.6	6.1	6.5	6.9	7.8	8.7	32.7
65	31.2	1.30	4.0	4.4	4.8	5.2	5.6	6.0	6.4	7.2	8.0	30.2
70	33.6	1.40	3.7	4.1	4.5	4.8	5.2	5.6	5.9	6.7	7.4	28.0
80	38.4	1.60	3.3	3.6	3.9	4.2	4.6	4.9	5.2	5.9	6.5	24.5
90	43.2	1.80	2.9	3.2	3.5	3.8	4.0	4.3	4.6	5.2	5.8	21.8
100	48.0	2.00	2.6	2.9	3.1	3.4	3.6	3.9	4.2	4.7	5.2	19.6

[1] Basal = TDD x 0.48 [2] Carb Factor = 10.8 x insulin sensitivity = (2.6 x Wt (lb))/TDD [3] Correction Factor = 1960/TDD

For exact calculations, use the Pump Setting Tool at opensourcediabetes.org

J Walsh and R Roberts: Pumping Insulin (5th ed), 2012

APP Study – Pump Setting Formulas[1]

Basal = ~ 48% of TDD

CarbF = $5.7 \times \frac{\text{Wt(kg)}}{\text{TDD}}$ or $2.6 \times \frac{\text{Wt(lbs)}}{\text{TDD}}$

Corr. Factor = 110/TDD (mmol/L) or 1960/TDD (mg/dl)

The correction factor is inversely related to TDD and to avg. BG

Or use the Pump Settings Tool at
www.diabetesnet.com/diabetes_tools/pumpsettings/

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

200 Unit or 300 Unit Reservoir?

- Most people change infusion sets every 2 to 3 days
- In the APP Study, 72% of pumpers (286 of 396) used less than 60 units of insulin a day (180 units over 3 days)
- Most people can use a 200 unit syringe

Basal Rates

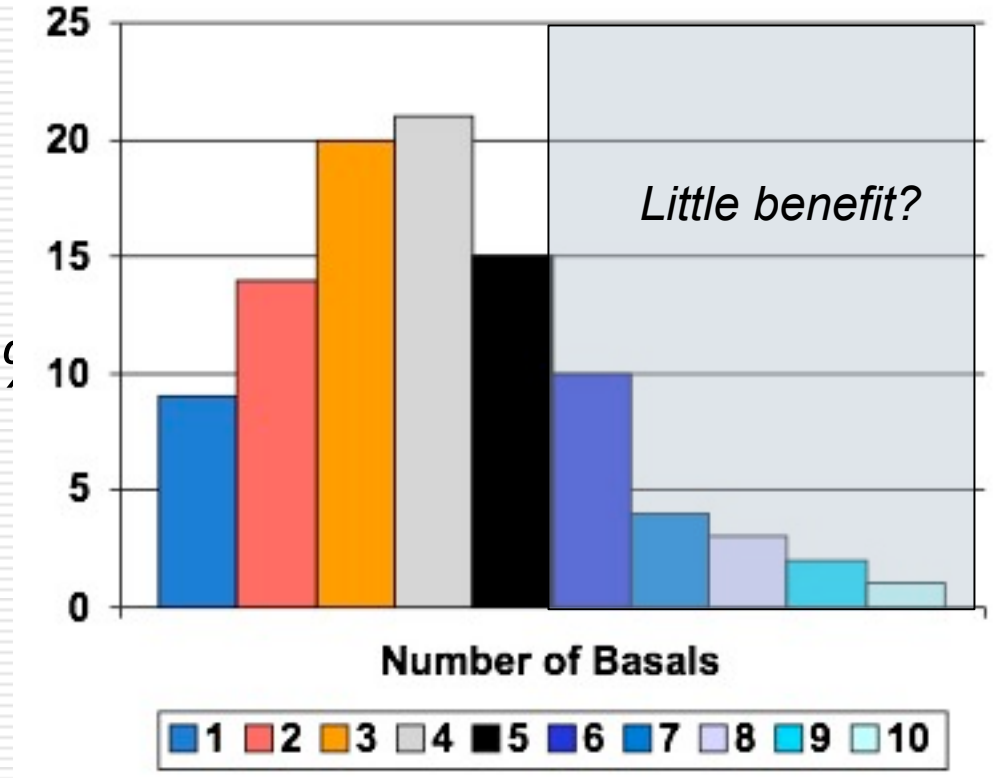
Optimal basal rates keep the glucose flat in a desired range when fasting.

Must be accurate before CarbF and CorrF can be tested.

Raise (or lower) basal rates a couple of hours before the glucose begins to rise (or fall) and 4-8 hours before the high or low glucose you want to avoid.

More than 4 or 5 basal rates a day usually makes no sense

How Many Basals?



Percentage of pumpers who use 1 to 10 basals per day from self reports of several hundred pumpers at insulin-pumpers.org

Basal changes take at least 3-5 hours to have their full effect* when basal rates are doubled, so >5 basals has dubious benefit

* Heinemann L, Nosek L, Kapitza C, et. al. Changes in basal insulin infusion: time until a change in metabolic effect is induced in patients with type 1 diabetes. Diabetes Care. 2009;32(8):1437–1439.

Pump Adjustments

Current Basal rate: 0.85 u/hr ICR: 12 CorrF: 2.5

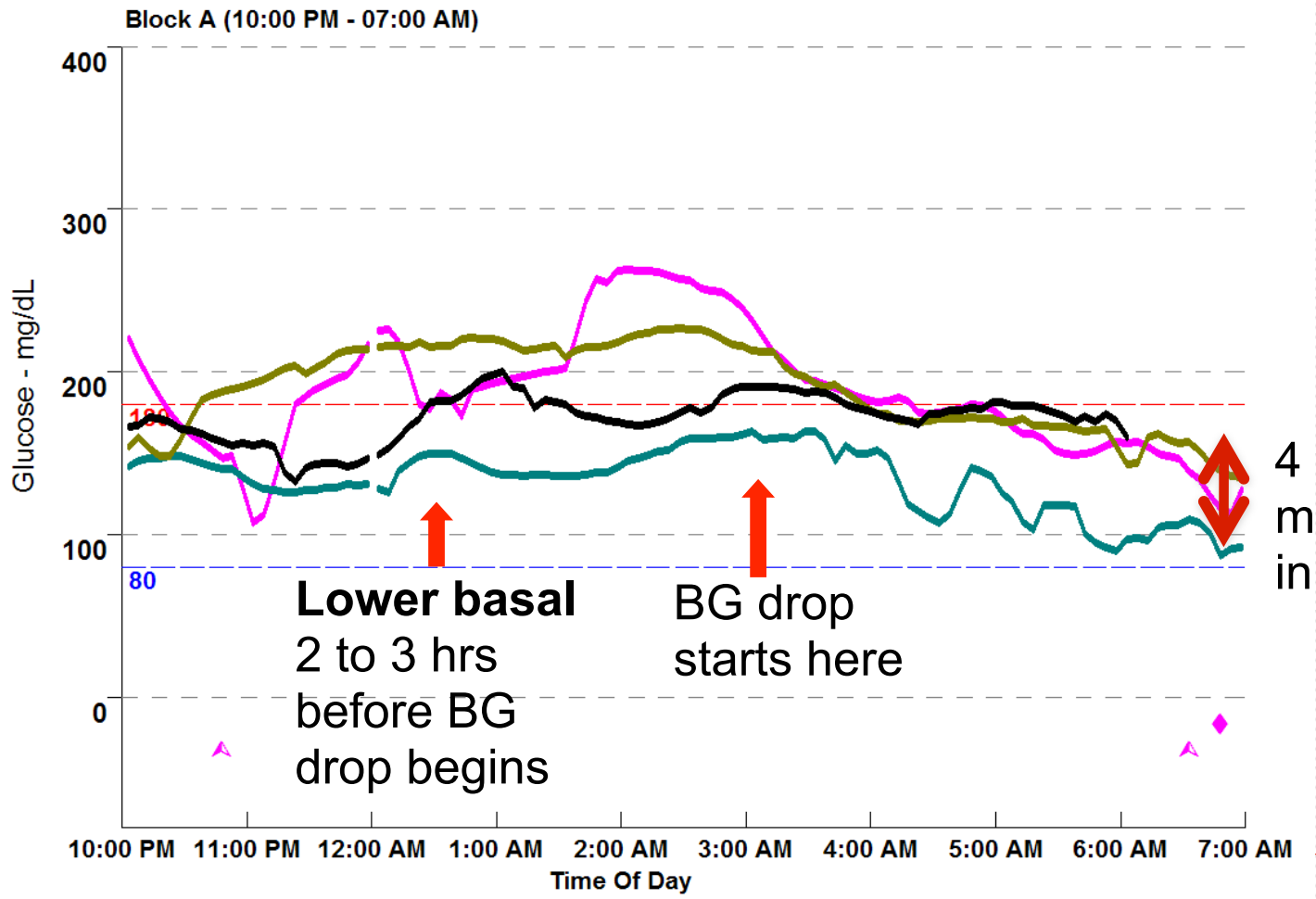
Day	Breakfast	Lunch	Dinner	HS	2 am
Monday	9.2	7.2	6.5	7.0	7.1
Tuesday	10.1	6.9	5.2	6.2	6.0
Wednesda	9.6	7.9	6.5	7.4	6.8

Does this patient need a basal or bolus adjustment?

What time would you change the basal rate?

How much would you change the rate?

Overnight Basal Check



Don’t Always Change One Setting!

- A pump user may change only basal rates or only CarbFs (or CorrF or DIA) to fix all control problems
- This often throws off basal/carb bolus balance
- Periodically review basal/carb bolus balance!

Clever Pump Trick – Never Stop A Pump!

- It's too easy to not turn it back on
- It's rarely needed
- It doesn't help a low glucose until 60-90 min. later

Instead, use a temp basal reduction for 30 to 60 min so pump restarts on time with no followup highs.

For more than an hour off pump, give bolus to cover some missing basal, then disconnect (~4 hrs max).

Temp Basal Rates

- Temp basal reductions are great for physical activity
- Temp basal increases are great for illness, fever, menses

Carb Factor and Carb Boluses

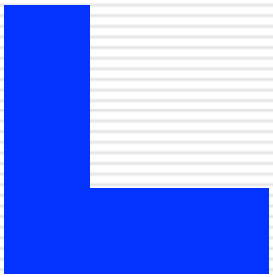
CarbF = How many mmol/L (or mg/dl) one unit of insulin lowers the glucose.

$$\text{CarbF} = \frac{\text{Wt(kg) x 5.7}}{\text{TDD}} \text{ or } \frac{\text{Wt(lb) x 2.6}}{\text{TDD}}$$

Types of Carb Boluses

Regular

- Taken immediately – for most meals



Combo / dual wave

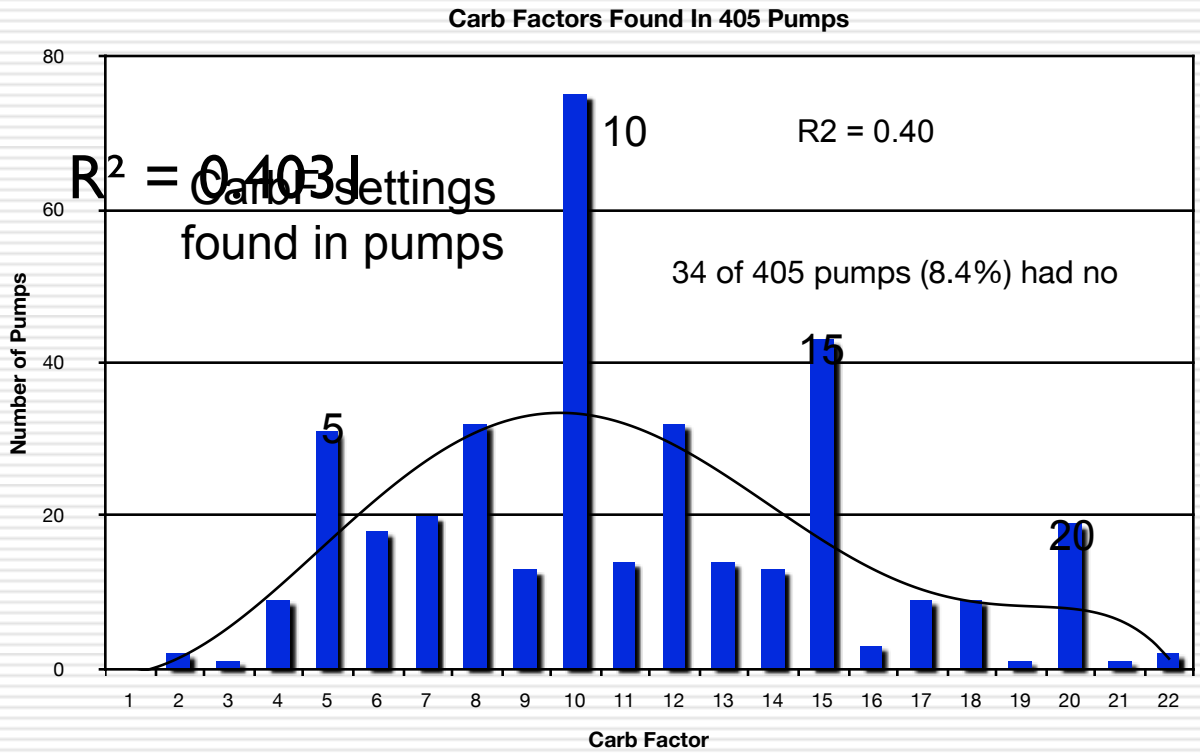
- Some now, some later – bean burrito, some pastas and pizzas, Symlin

Extended / square wave

- Extended over time – gastroparesis

Don’t take combo/extended boluses without a clear reason.

APP Study – CarbF Settings In Pumps[1,2]



In APP Study, the carb factors were not evenly distributed.

"Magic" numbers – like 5, 10, 15, and 20 g/unit – are preferred.

Use formulas for settings –> much 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

Pump Adjustments

Current Basal rate: 0.85 u/hr CarbF: 12 CorrF: 2.5

Day	Breakfast	2 hr post	Lunch	2 hrs post	Dinner
Monday	6.7	8.9	6.6	12.2	9.4
Tuesday	6.4	8.0	5.3	10.6	8.8
Wednesday	5.5	7.6	6.5	10.9	9.9

Does this patient need a basal or bolus adjustment?

At what meal would you change the CarbF?

How much would you change the CarbF?

CarbF Change = Large BG Change

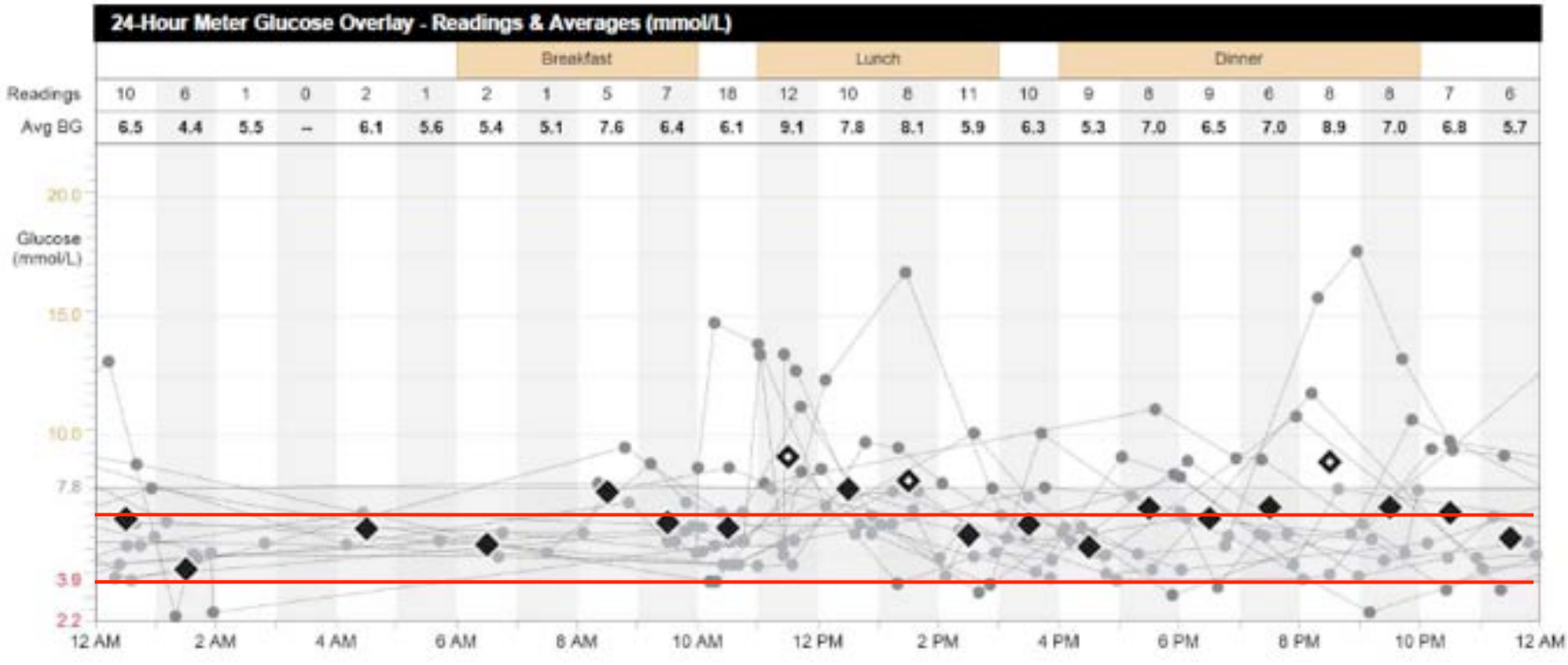
When CarbF is lowered from 1/10 to 1/9 for TDD = 40 u and Corr F = 2.7 mmol/L per u		
Meal Size	**Extra bolus u from CarbF**	**Fall in BG/meal ***
60 grams	**0.67u**	**x 2.7 = – 1.8 mmol/L**
100 grams	**1.1u**	**x 2.7 = – 3.0 mmol/L**

*** Calculated as** $\left[\frac{\text{carbs in meal}}{\text{new carb factor}} - \frac{\text{carbs in meal}}{\text{old carb factor}}\right] \times \frac{110}{\text{TDD}}$

CarbF and CorrF Accuracy Is Important

- Do not use “magic” numbers for CarbFs and CorrFs
- Always use formulas to select the CarbF and CorrF

Pregnancy



BGs are relatively flat, but slightly high for pregnancy (red lines).
A slightly higher day basal and lower carb factor may help.

Clever Pump Trick – Stop Post Meal Spikes

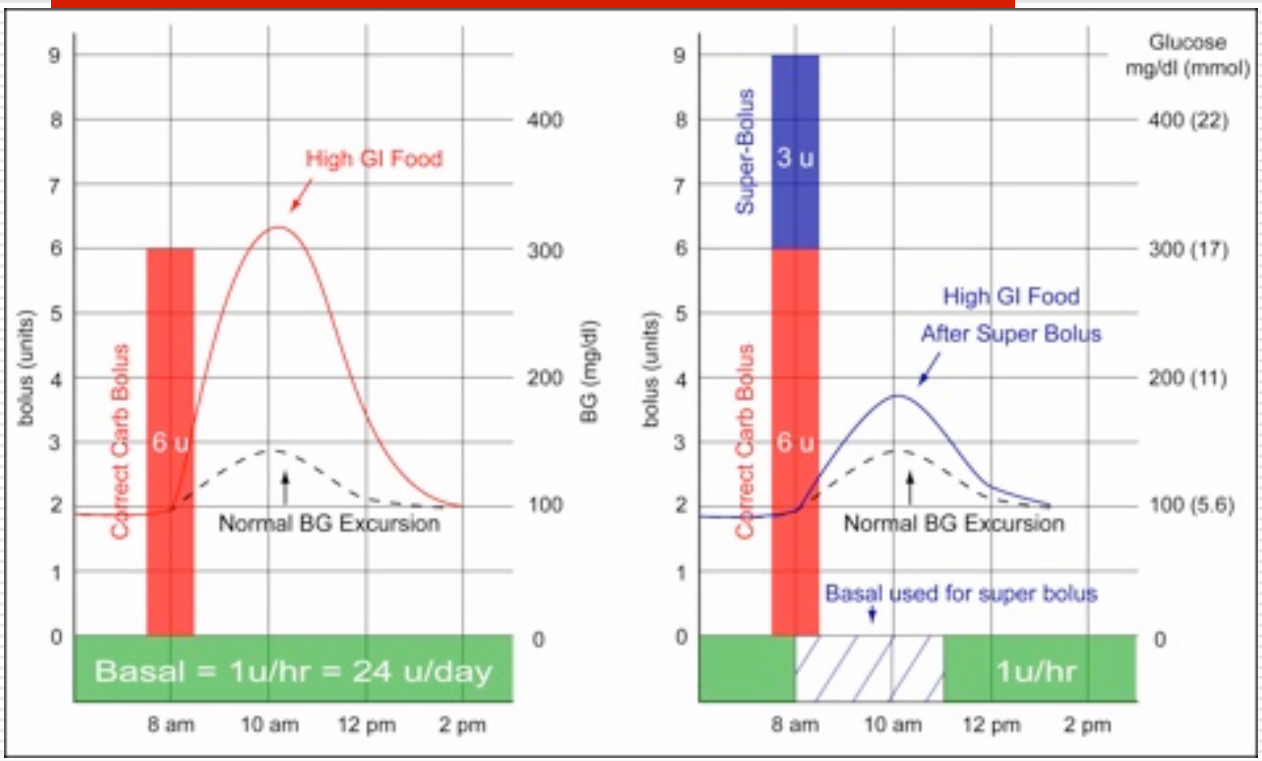
- Count carbs carefully
- Bolus 15 to 30 min before meals when possible
- Use combo bolus (part now/part later) with picky eaters
- When high, wait till below 8 mmol/L (144) before eating
- Eat low GI foods, fewer carbs
- Add fiber/psyllium/acarbose/Symlin/GLP-1 agonist
- Exercise after meals
- Use a Super Bolus

Carb Overload

Large carb meals (95 grams) cause postmeal spiking.

A lower CarbF cannot stop this!

Clever Pump Trick –
Super Bolus – Shift Basal To Bolus



Helps when eating over 30 to 40 grams of carb

Max carbs/meal = Wt(lb) X 0.36 to stay in control [2]

Future: Super Bolus shifts part of the next 2 to 3.5 hrs of basal insulin into the bolus with less risk of a low later.[1,2]

[1] J. Walsh: http://www.diabetesnet.com/diabetes_presentations/super-bolus.html September, 2004

[2] J. Bondia, E. Dassau, H. Zisser, R. Calm. J. Vehí, L. Jovanovic, F.J. Doyle III, Coordinated basal-bolus for tighter postprandial glucose control in insulin pump therapy, Journal of Diabetes Science and Technology, 3(1), 89-97, 2008

Clever Pump Trick –
Measure Insulin Sensitivity*

Insulin Sensitivity = $\frac{\text{Wt(kg) x 0.53}}{\text{TDD}}$ or $\frac{\text{Wt(lb) x 0.24}}{\text{TDD}}$

Or use www.diabetesnet.com/diabetes_tools/pumpsettings/

*NOT the correction factor (CorrF)

Correction Boluses

- These doses make up for deficits in basal rates or carb boluses
- Ideally, correction doses are ≤ 9% of TDD

CorrF Formula[1]

Corr. Factor = 110/TDD (mmol/L)
or 1960/TDD (mg/dl)

The CorrF is inversely related to TDD and to the A1c or the average BG

Or use the Pump Settings Tool at
www.diabetesnet.com/diabetes_tools/pumpsettings/

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

Secrets of the Correction Factor Rule Number

- A 110 Rule (ie, 110 / TDD = CorrF for mmol/L, or 2000 / TDD = CorrF for mg/dl) works well for people in reasonable control
- Lower CarbF rule numbers (80 or 90 for mmol/L or 1500 or 1700 for mg/dl) are better when avg. BG is high due to larger deficits in basal or carb boluses
- Higher rule numbers (120 or 130 for mmol/L or 2200 or 2400 for mg/dl) are better when BGs are well controlled and there are smaller deficits in basal rates and carb boluses

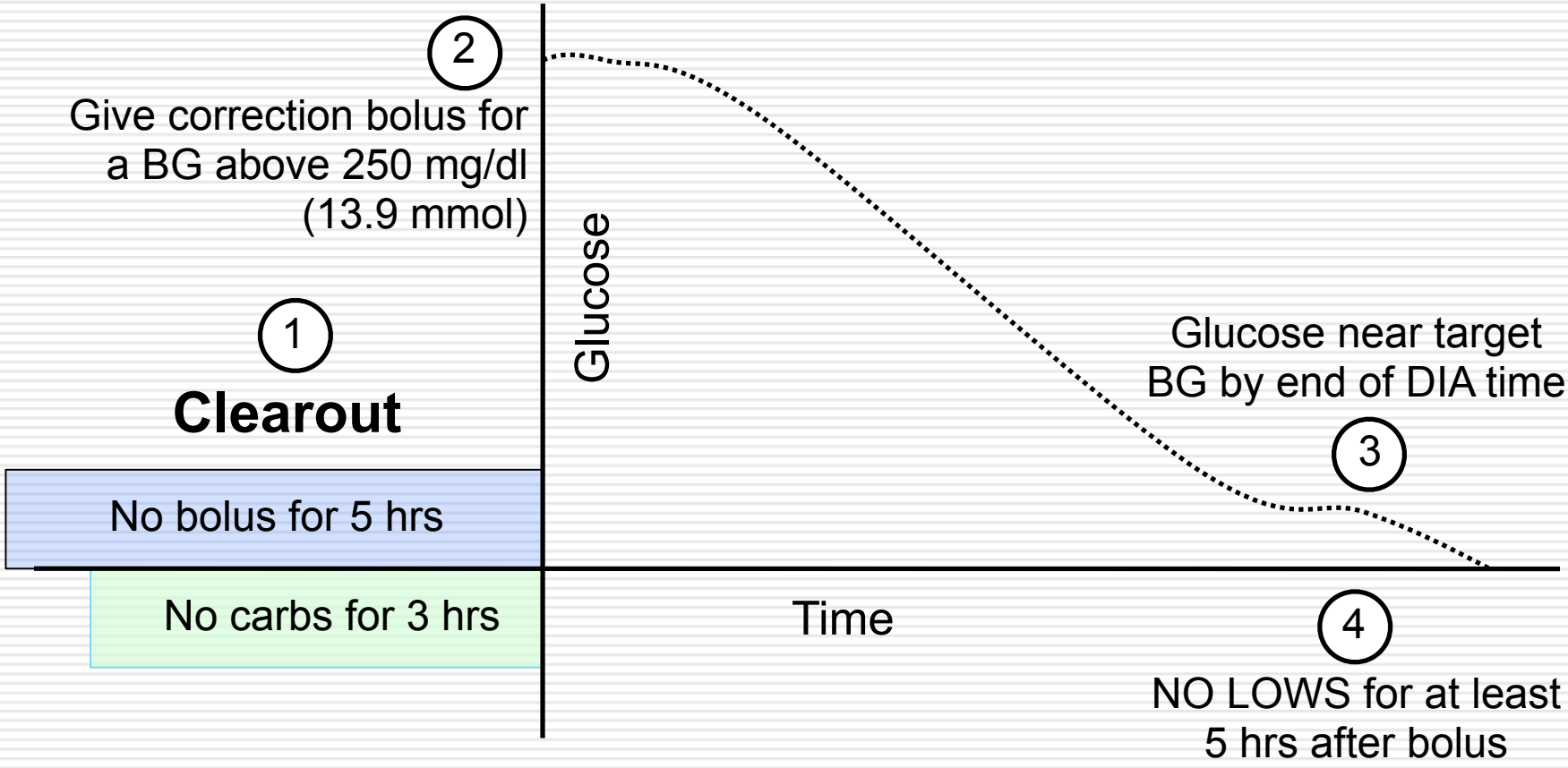
Pump Adjustments

Basal: 0.85 u/hr CarbF: 12 CorrF: 2.5 Target: 6.0 DIA: 5 hrs

Day	10 pm	12 am	3 am
Monday	14.0 (4.0 units)	7.0	3.0
Tuesday	16.0 (5.0 units)	8.0	2.8

1) What does this tell you about this patient's CorrF?
2) How much does BG drop per unit of insulin?
3) How would you adjust the CorrF?
4) What if their DIA were set to 3 hrs?

Test the Correction Factor (and the DIA)



CGM helps check both correction factor and DIA time

Not All High Readings Are Identical

Cause	Corr. Dose Needed
Jelly on the finger	None (wash, repeat test)
Forgot to bolus	Corr dose **only**
Infusion set failure	Corr + basal replacement
Hypo rebound from release of stress hormones	Corr + stress coverage .
Ketoacidosis or infection	**Raise TDD)basal and bolus) by 1.5 to 3 fold** + corrections until resolution

The Correction Target

Where in the Correction Target Range Does the Pump Aim?	
Animas	**Middle**
Medtronic	**Top and**
Omnipod	**Middle**

A glucose inside the correction target range will not be corrected.

For a range of 4-10 mmol/L (72 to 180 mg/dl), a BG of 4.1 or 9.9 (73 or 179 mg/dl) is not adjusted for.

Use a single correction target, like 6.1 mmol/L (110 mg/dl), or narrow correction range, like 5.6-6.7 mmol/L (100-120 mg/dl).

*

DIA, BOB, and Insulin Stacking

Duration Of Insulin Action (DIA)

How long a bolus lower the glucose

Bolus On Board (BOB)

Bolus insulin still active from recent boluses

Insulin Stacking

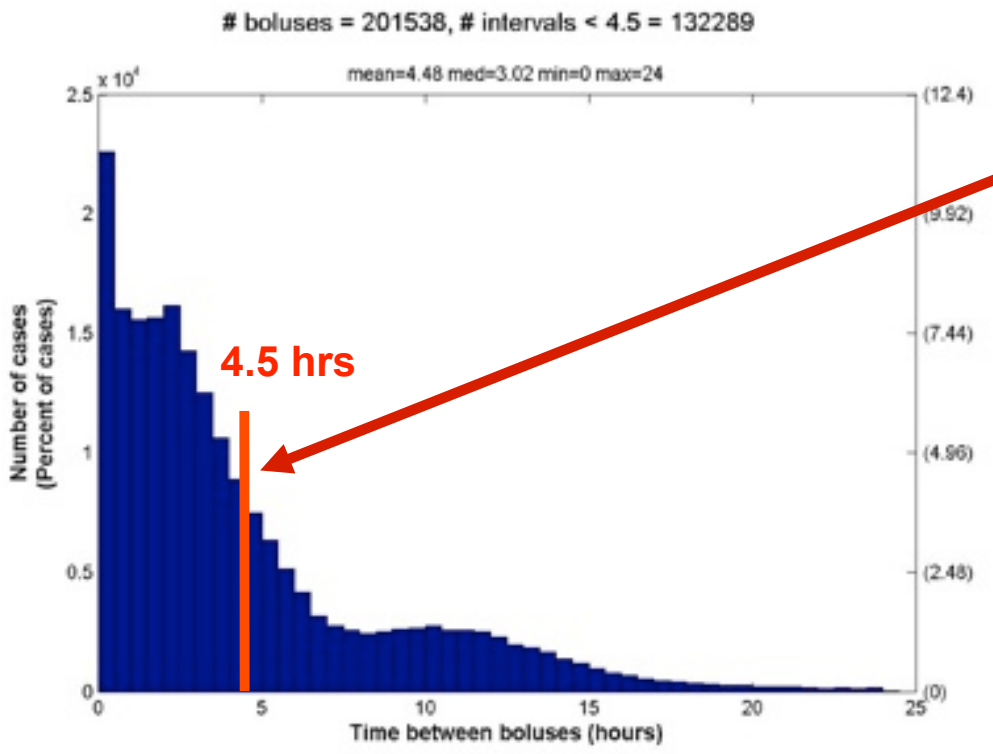
Buildup of active bolus insulin

Concerns about the Bolus Calculator

- Most boluses are given within 4.5 to 5 hours of each other and involve insulin stacking
- The DIA has to be accurate to account for stacking – 4.25 to 6.25 hours
- Most BCs calculate BOB well, but differ in how they subtract BOB to get a bolus recommendation

All current BCs can
can recommend excessive bolus doses

BOB Is Present In 65% Of Boluses



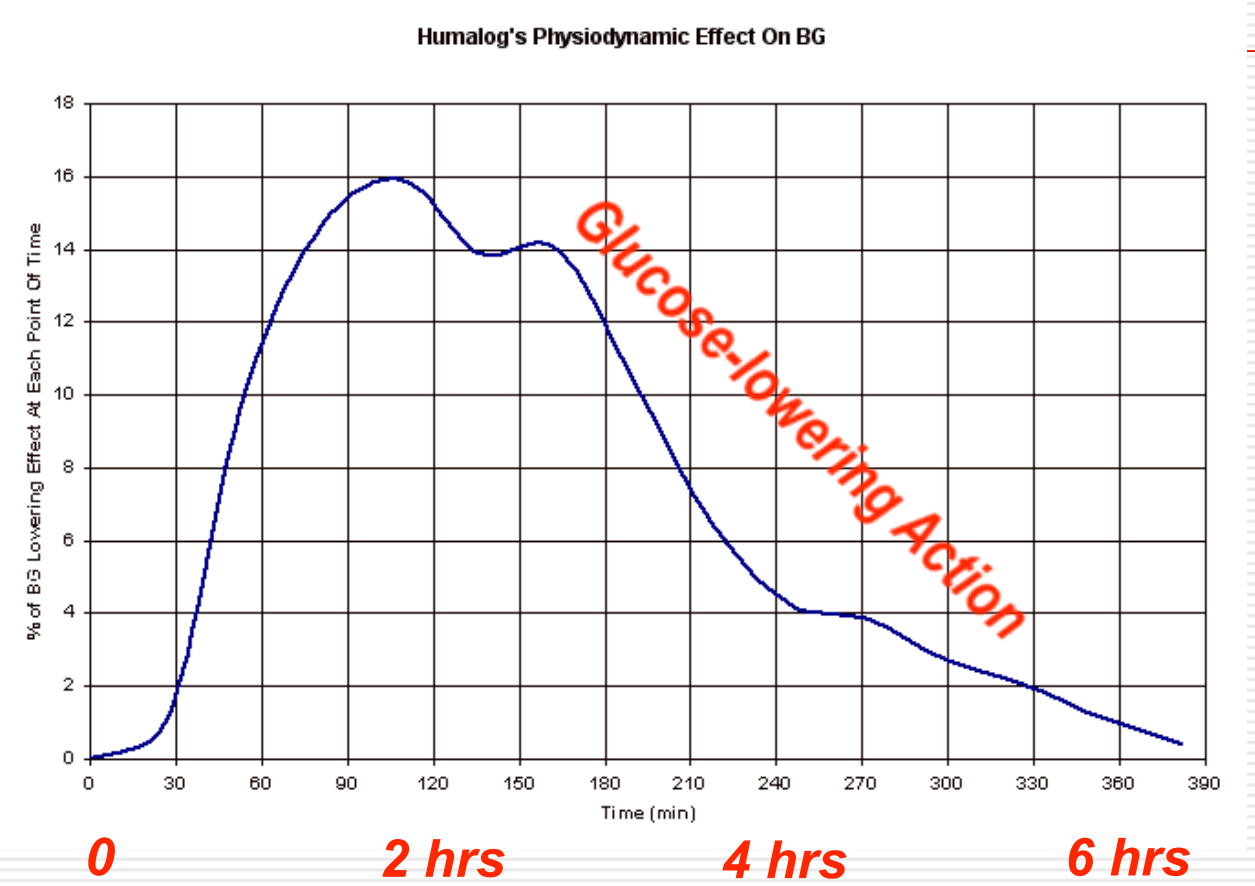
APP Study Results

Of 201,538 boluses, 65% were given within 4.5 hrs of a prior bolus

Insulin stacking is common in most boluses taken after breakfast

J. Walsh, D. Wroblewski, and TS Bailey: Disparate Bolus Recommendations In Insulin Pump Therapy. AACE Meeting 2007

Duration Of Insulin Action (DIA)



Rapid insulin lowers the glucose for 4.5 to 6.5 hrs. This is physiologic – it DOES NOT CHANGE in the body when the DIA is changed in the pump!

Typical Carb Digestion Times

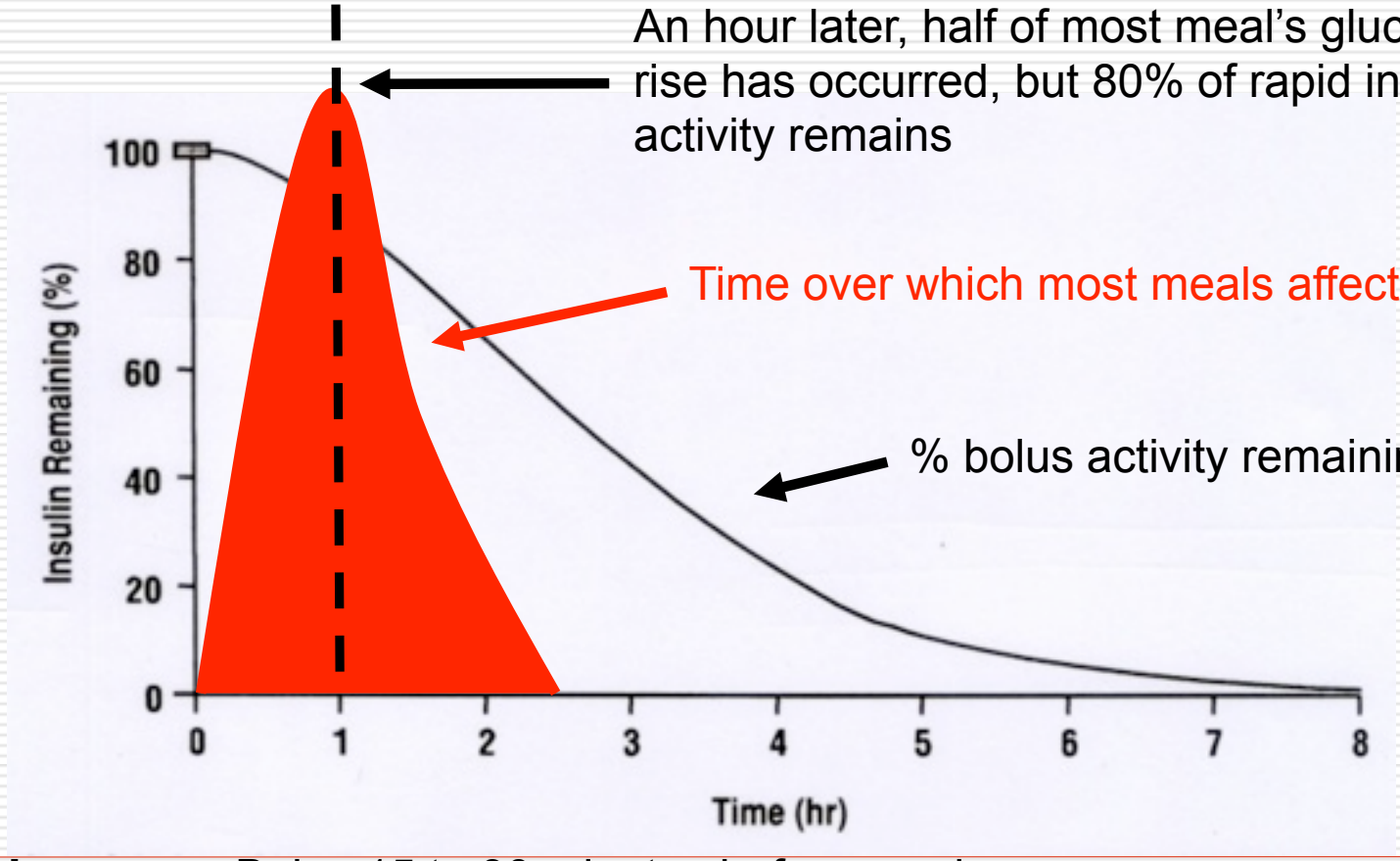
Food	Digestion Time
water	0 m
fruit/veg juice	5-20 m
fruit/veg salad	20-40 m
melons/oranges	30 m
apples/pears	40 m
broccoli/caulif	45 m
raw carots/beets	50 m
potatoes/yams	60 m
cornmeal/oats	90 m

Food	Digestion Time
fish	30-60 m
milk/cot cheese	90 m
legumes/beans	2 hr
egg	45 m
chicken	1.5-2 hr
seeds/nuts	2.5-3 hr
beef/lamb	3-4 hr
cheese	4-5 hr

Take Home: Choose combo foods to lengthen carb digestion time

Problem

Most Carbs Are Faster Than "Rapid" Insulin



Take Home: Bolus 15 to 30 minutes before meals

Use extended and combo boluses sparingly

From ***Pumping Insulin***

Clever Pump Trick – Bolus Early To Stop Meal Spiking

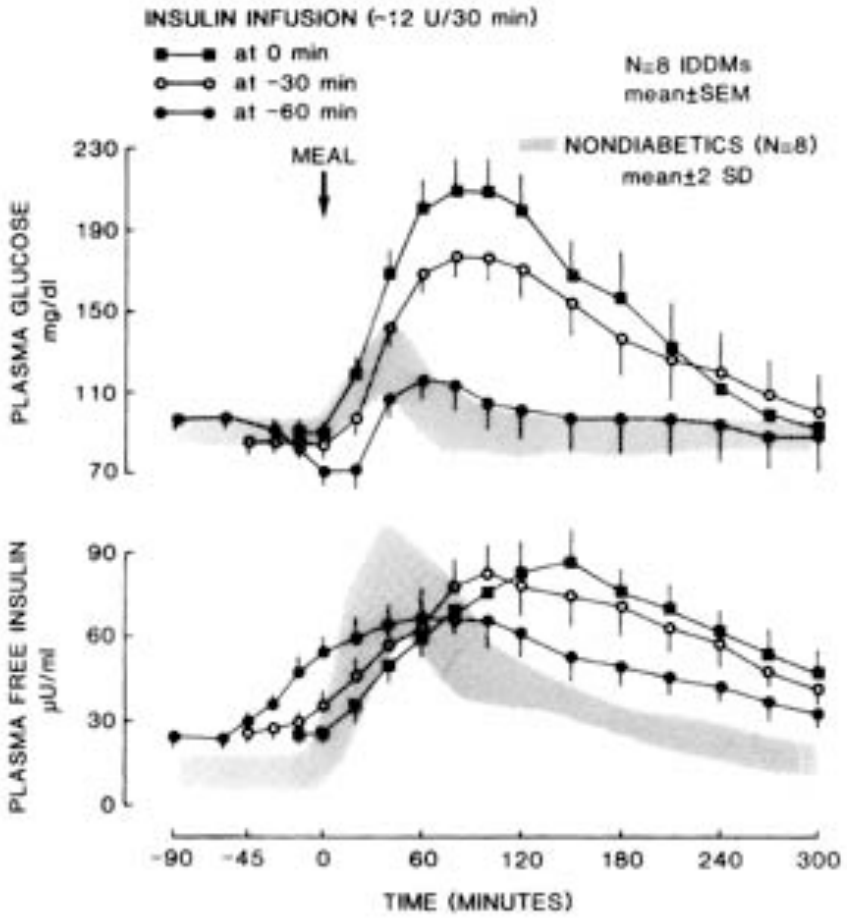


Figure shows Regular insulin injected 0, 30, or 60 min before a meal

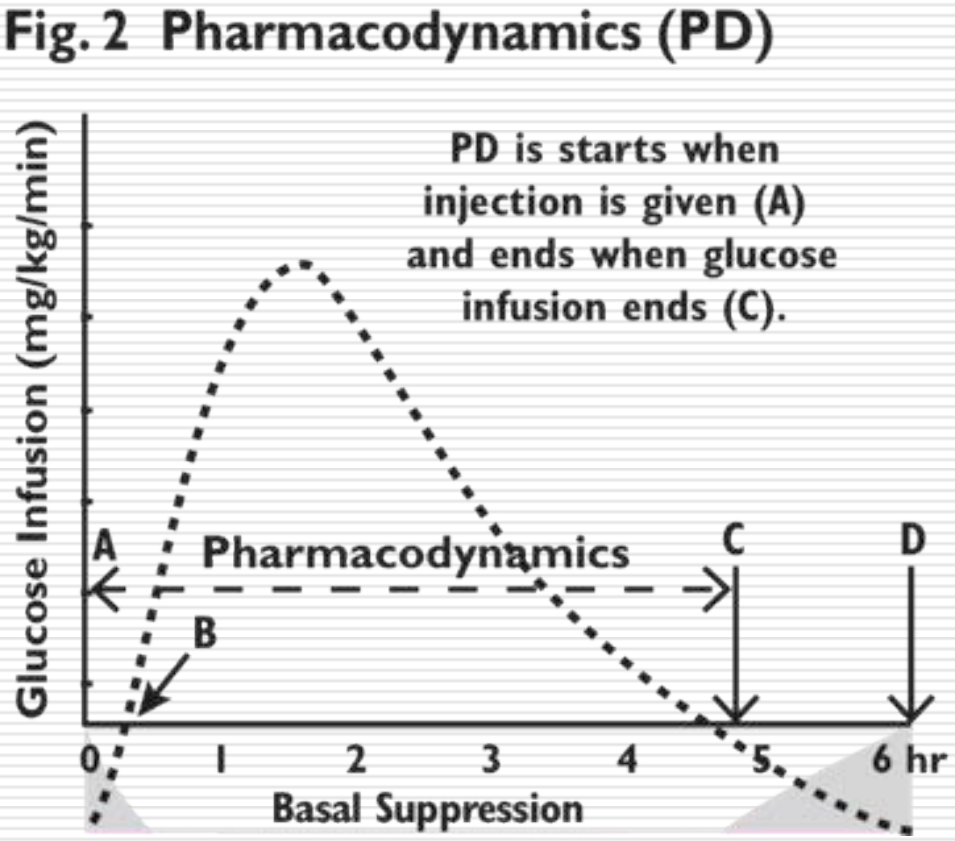
Normal glucose and insulin profiles in the shaded areas

Even though, best glucose occurred with 60 minute bolus – **too risky to recommend!!!**

Early boluses – the best-kept secret for better control

GD Dimitriadis and JE Gerich: Importance of Timing of Preprandial Subcutaneous Insulin Administration in the Management of Diabetes Mellitus.Diabetes Care 6:374-377, 1983.

Insulin Action Time from GIR* Studies
IAT – Compares One Insulin with Another



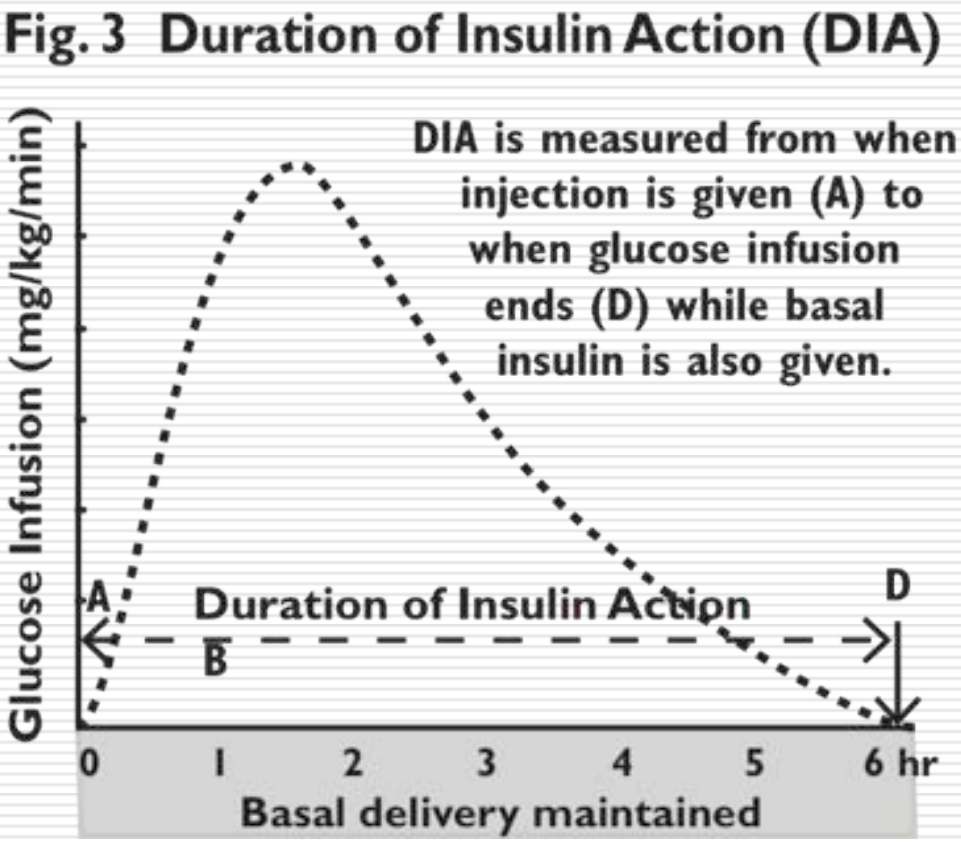
Pharmacodynamics starts when insulin is given (A) and ends when IV glucose infusion stops (C), but does not include time it takes for insulin to suppress or recover basal insulin output from a healthy pancreas.

Often quoted as “3 to 5 hours” in insulin handouts.

* Glucose infusion rate study

Adapted from Pumping Insulin, 5th ed

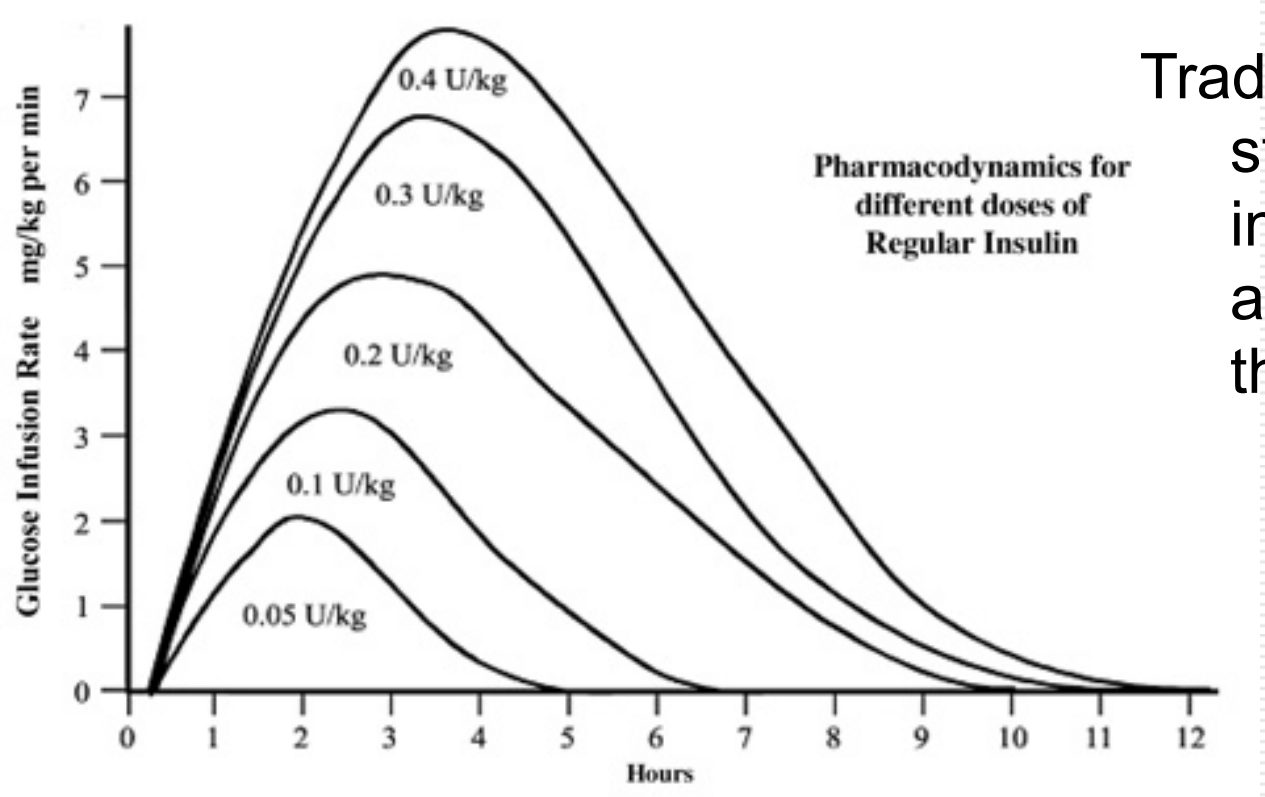
Duration of Insulin Action for Pumps
DIA – Needed to Give Accurate Boluses



DIA is measured from the time a pump bolus is given (A) to when the bolus insulin action ends(D) **while basal insulin is also delivered from an insulin pump.**

Adapted from Pumping Insulin, 5th ed

Does Dose Size Really Change DIA?

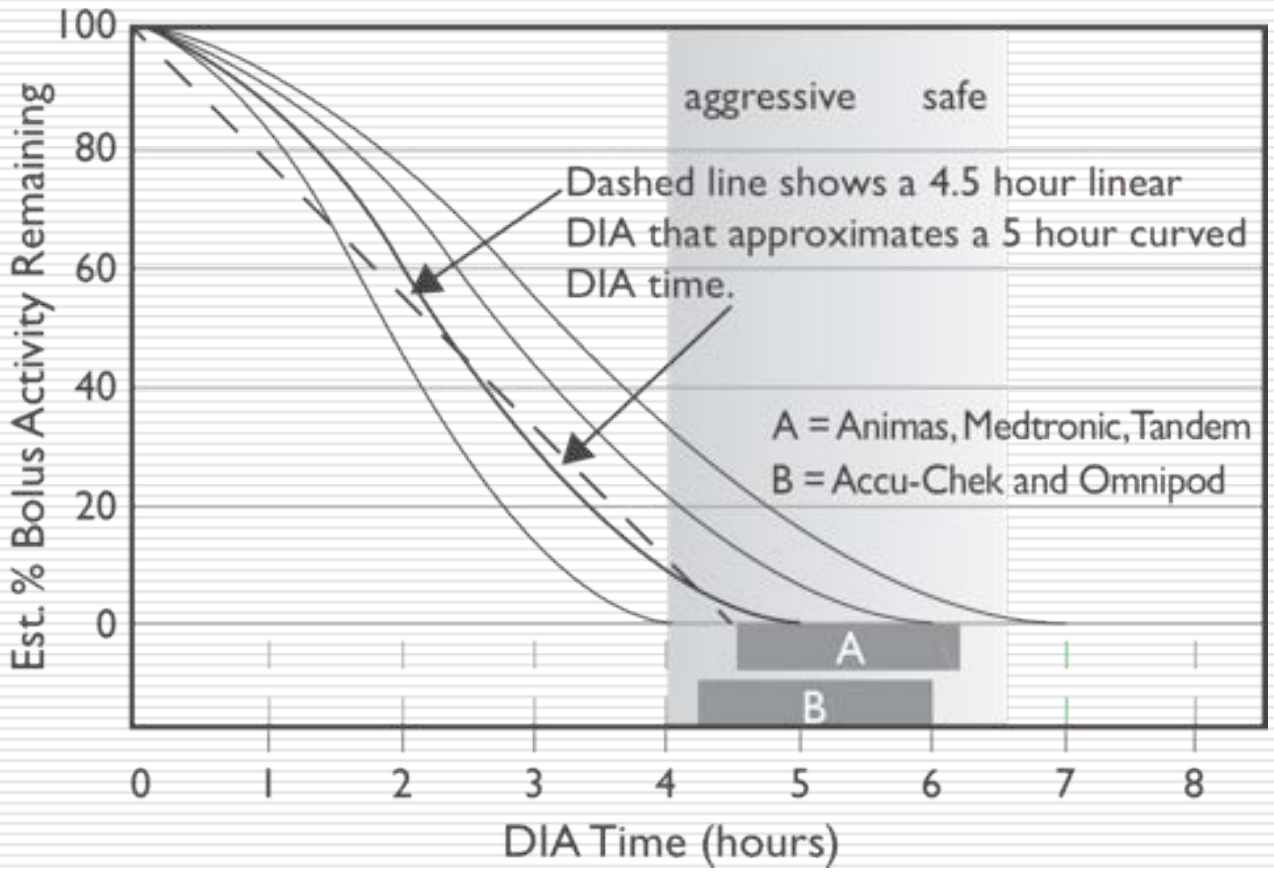


Traditional GIR studies make small insulin doses appear faster than they really are.

Don't believe "insulin action time = 3 to 5 hrs"

From: Heinemann L, Woodworth JR: Insulin Lispro; Chapter III: Pharmacokinetics and Metabolism of Insulin Lispro. Drugs of Today 34 (Suppl. C):23-36, 1998

Recommended DIA Times



Set DIA to 4.5 to 6.5 hrs to accurately calculate BOB and bolus doses

Pumping Insulin, 5th ed., adapted fom Mudaliar et al: Diabetes Care, 22: 1501, 1999

Bolus On Board (BOB)[1]

Glucose-lowering activity remaining from recent boluses

An accurate BOB

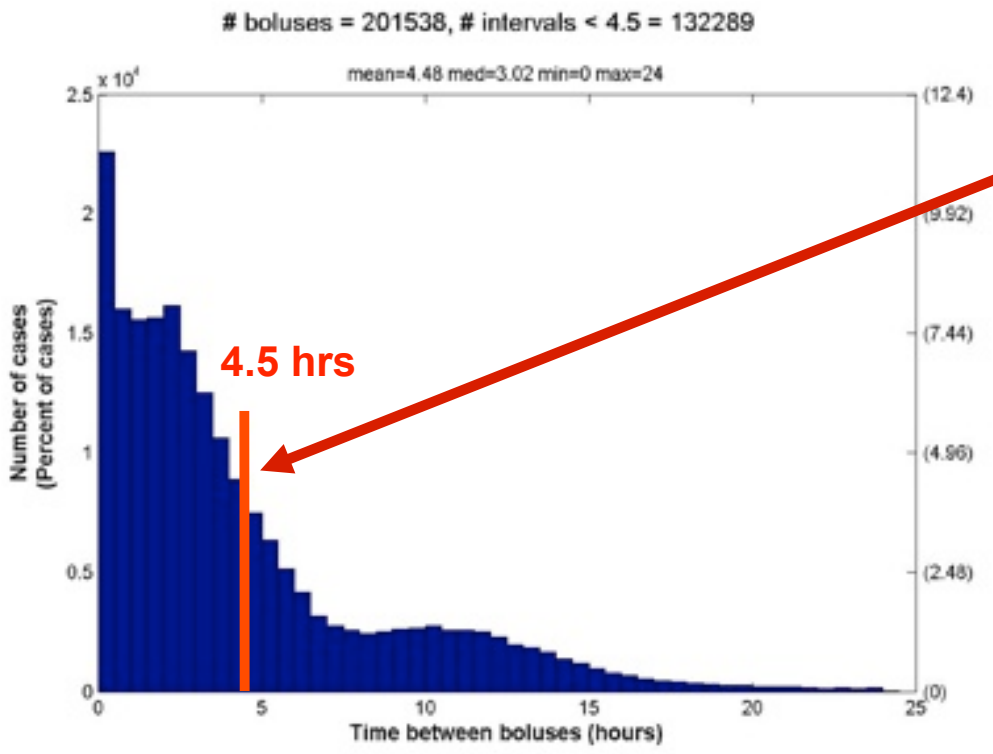
- *Reduces insulin stacking*
- *Improves bolus accuracy*
- *Reveals current carb or insulin deficit when BG test is done (HypoManager)*
- ***Depends on an accurate DIA***

Basal insulin is NOT included in BOB!

*aka: insulin on board, active insulin, unused insulin**

[1] *Introduced as The Unused Insulin Rule in Pumping Insulin, 1st ed, 1989, Chap 12, pgs 70-73*

BOB Is Present In 65% Of Boluses



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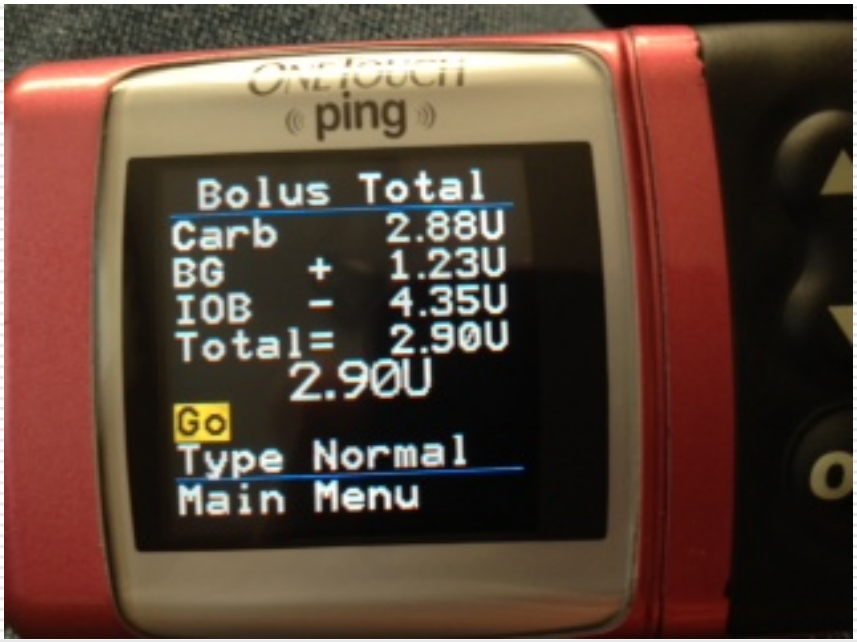
How Pumps Handle BOB

What's In BOB & What's It Applied Against?				
	BOB Includes this Bolus		BOB Is Subtracted from this Bolus	
	Carb	Correction	Carb	Correctio
Injections	No	No	No	No
Ideal	Yes	Yes	Yes	Yes
Animas, Omnipod, Medtronic, Tandem	Yes	Yes	No	Yes

** Except when BG is below target BG*

YES = Safer

Ping BOB Can Be Seen During Bolus



In this example, BOB of 4.35 u is larger than both corr bolus of 1.23 u AND carb bolus of 2.88 u.

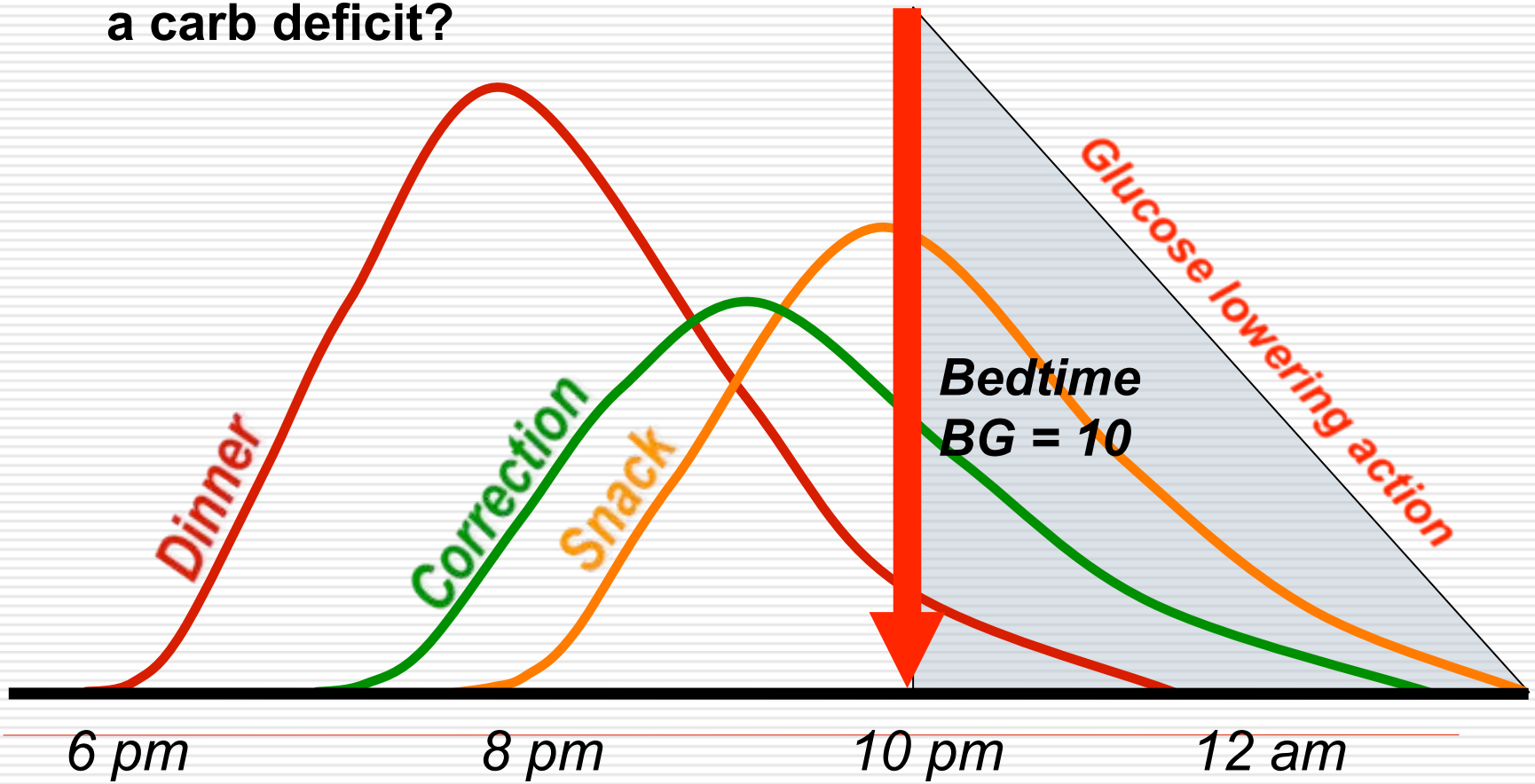
More carbs may be needed!

Insulin Stacking

- Happens anytime two or more boluses overlap
- Measured in pump as bolus on board (BOB, IOB, active insulin)
- Used in new bolus calculation **once a glucose is entered**
- Impact of a bolus can't be measured accurately against BG value until 90 to 120 minutes after it was given
- The safest way to minimize insulin stacking is to subtract BOB from correction bolus first, then from a carb bolus if there is BOB remaining

Insulin Stacking

Bedtime BG = 10 mmol/L (180 mg/dl) – is there an insulin or a carb deficit?



A Short DIA Hides Insulin Stacking

3 hours after a 10 unit bolus, this shows how much BOB a pump will think is left using different DIA times:

	Estimate Of Insulin On Board Remaining			
For a DIA setting =	3 hr	4.5 hr	5.0 hr	5.5 hr
Estimated IOB =	0 u	2.5 u	3.4 u	4.0 u

Always set the DIA from an insulin's real action time

Do not change DIA to fix control problems

Pump BCs May at Times Give Excess Bolus Recommendations

Two hours after dinner with 5 u of BOB left, a pump user eats a 50 gram dessert on 4 consecutive nights. Glucose and bolus recommendations are shown.

Pumps Give Different Bolus Recommendations			
Glucose	Actual Need	Animas	Other Pumps
Night 1: BG = 6.6 mmol/L	0 u	0 u	5 u
Night 2: BG = 6.8 mmol/L	0 u	5 u	5 u
Night 3: BG = 11.1 mmol/L	2 u	5 u	5 u
Night 4: BG = 16.7 mmol/L	4 u	5 u	5 u

CarbF = 10 gr/u; CorrF = 2.8 mmol/L; Target = 6.7; DIA = 5 hrs

What Would You Do?

Your daughter's glucose is 6.7 mmol/L (121 mg/dl) at bedtime and she wants a 40 gram snack with 4 units of BOB.

CarbF = 10 g/u, CorrF = 3 mmol/L (54 mg/dl)
Target = 6.7 mmol/L (120 mg/dl)

Would you:

A. Cover her bedtime carbs with a 4.0 u bolus?

B. Give a smaller bolus for these carbs?

C. Give no carb bolus?

Example: Bolus Recommendations from 2 Different Pumps on One Morning

Bolus Recommendation Differences between 2 Pumps						
Time	**BG**	**Carbs Eaten**	**Carb Bolus**	**Pump X**	**Pump Y**	**Bolus Differnce**
6:54 am	111 (6.2)	16	0	0 u	0 u	0 u
9:52 am	174 (9.7)	0	3.0 u *	4.3 u	4.3 u	0 u
10:35 am	140 (7.8)	50	5.0 u	5.0 u	2.15 u	+ 2.85 u
11:58 am	117 (6.5)	40	4.0 u	4.0 u	0.5 u	+ 3.5 u
1:12 pm	137 (7.6)	0	0	0 u	Eat 19 g	

6.35 more units recommended by Pump X in just 6 hours!

TDD = 38 u, carb factor = 10 g/u, corr factor = 3.6 mmol/L (65 mg/dl)

3.6 mmol/L x 6.35 u = 22.9 mmol (413 mg/dl) fall in BG from Pump X's advice

When to Override a Recommended Bolus

- A pump doesn't know everything – override a bolus recommendation when the situation demands
- Dr. Irl Hirsch suggests that about 25% of all bolus recommendations will be changed when the user knows what they're doing
- Look at the CGM's trend arrow and check the BOB for guidance on overrides

Clever Pump Trick – Get Accurate Boluses

1. If BOB is SMALLER than the correction bolus, pump's recommendation is CORRECT

2. If BOB is LARGER than the correction bolus, subtract BOB from the combined carb plus correction bolus

Example: Carb bolus = 4.0 u

Corr bolus = 1.0 u

BOB = 2.0 u ***BOB larger than Corr bolus***

Accurate bolus = 4 + 1 – 2 = 3 units

DIA Tips

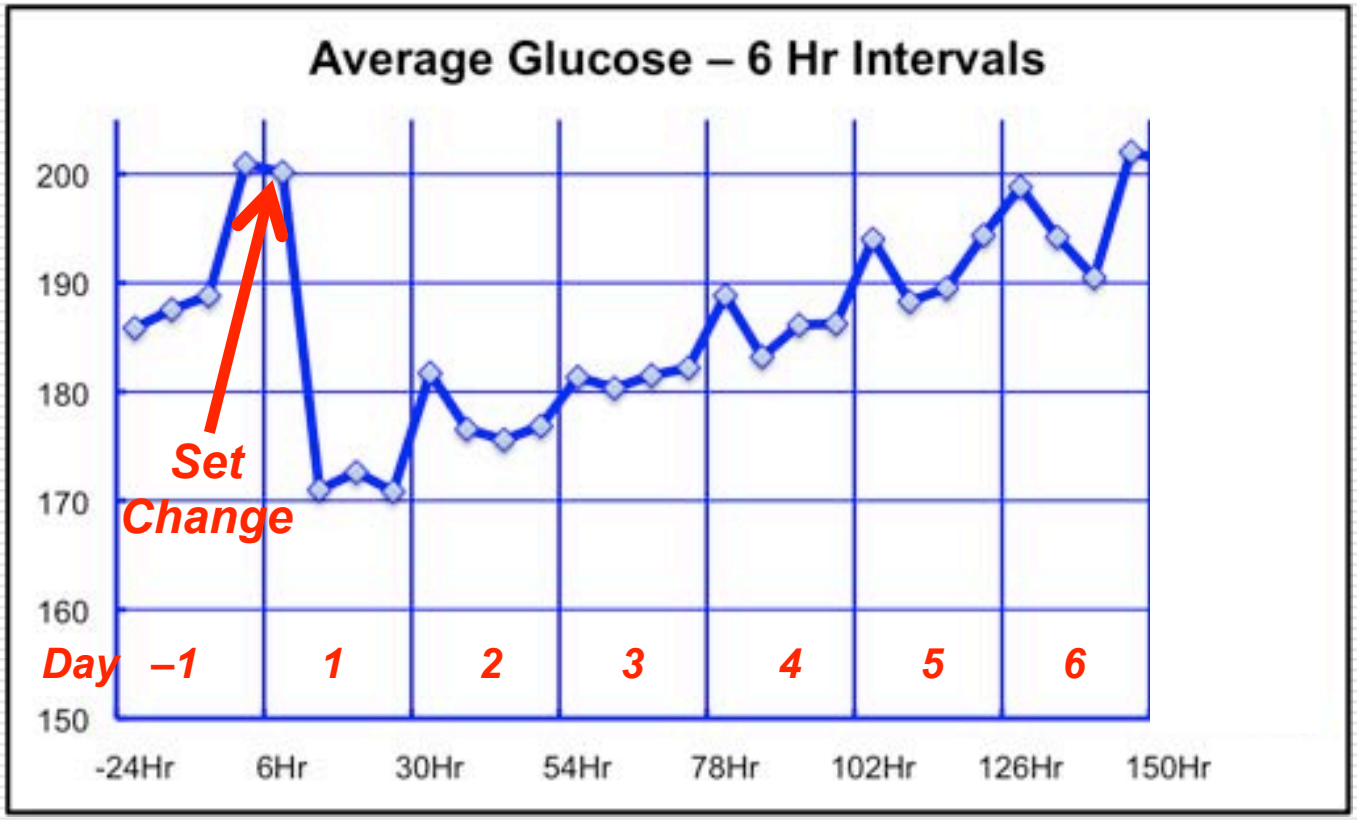
- Research studies show that DIA times are NOT different between children and adults
- If the pump does not “give enough bolus insulin”, do NOT shorten DIA to get larger boluses. Look for the real reason:
  - a basal rate that is too low
  - or carb factor that is too high
- Some things do shorten insulin’s action time:
  - Increased activity and exercise
  - Hot weather

But don’t shorten DIA for occasional events

Infusion Sets

The Achilles Heel of Pumps

Average BGs Before & After Set Change



Average BG levels during 6 hr intervals before and after infusion set change in 396 pumps with ~20 infusion set changes/pump.

Unpublished data from Actual Pump Practices Study by J Walsh, R Roberts, and T Bailey

Why Infusion Sets & Patch Pumps Fail

Infusion sets fail from:

- Partial or complete pullout
- Tugging (unanchored sets)
- Leaks along Teflon to skin (common)
- Loose hub
- Use of auto-inserter
- Pets & punctures
- Occlusions

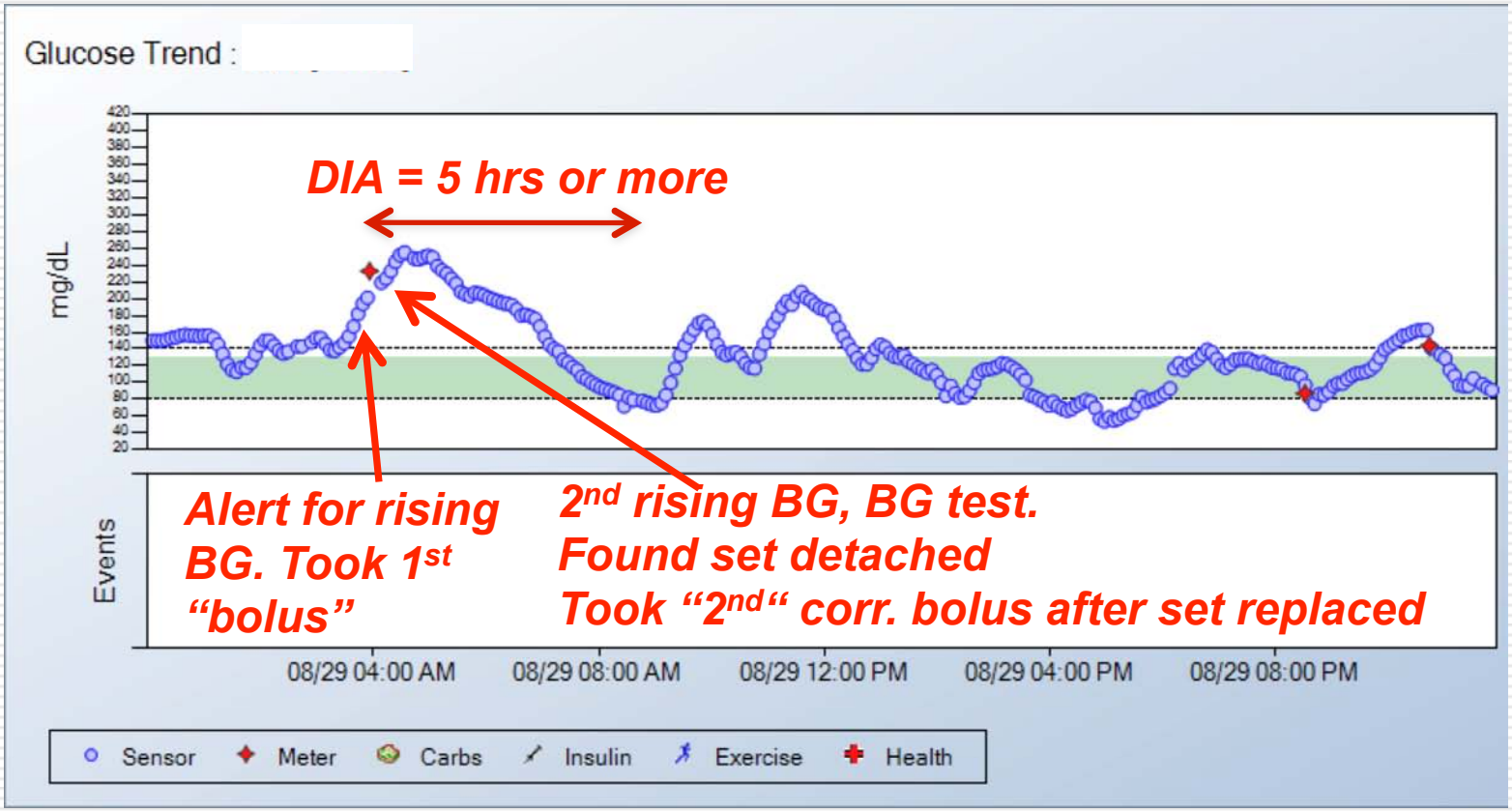
Is There an Infusion Set Problem? Ask:

- Do sites often “go bad”?
- Told you have “scarring” or “poor absorption”?
- Two or more “unexplained” highs in a row?
- Do highs correct when the infusion set is changed?
- Does this happen more than once a year?

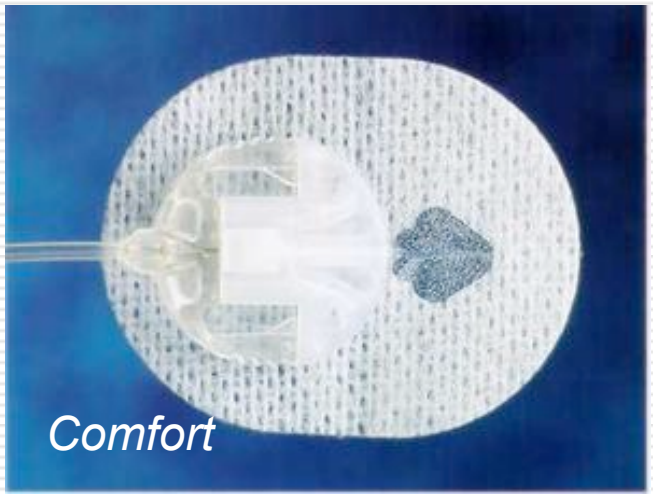
If the answer is yes:

- Anchor the infusion line with tape
- Review site prep technique
- Switch to a different brand of infusion set

Infusion Set Failure Shown On CGM



Use Reliable Infusion Sets



ALWAYS anchor the Comfort infusion line with 1” tape to minimize site irritation and reduce tugging that can cause leaks.

Anchors – Not Just For Boats!!!

1” tape on infusion line:

- Stops movement of Teflon under the skin
- Stops “unexplained highs” from insulin leaks to skin surface
- Less irritation
- Prevents pull outs
- Tugs on Teflon

Lose tape not insulin

Set Failure

Infusion set problem started on the afternoon of May 1st and lasted until late in the day on the 2nd when the infusion set was finally changed.

Is There an Infusion Set Problem? Ask:

- Do sites often “go bad”?
- Have “scarring” or “poor absorption”?
- Two or more “unexplained” highs in a row?
- Do highs correct when the infusion set is changed?
- Does this happen more than once a year?

If the answer is yes:

- Anchor the infusion line with tape
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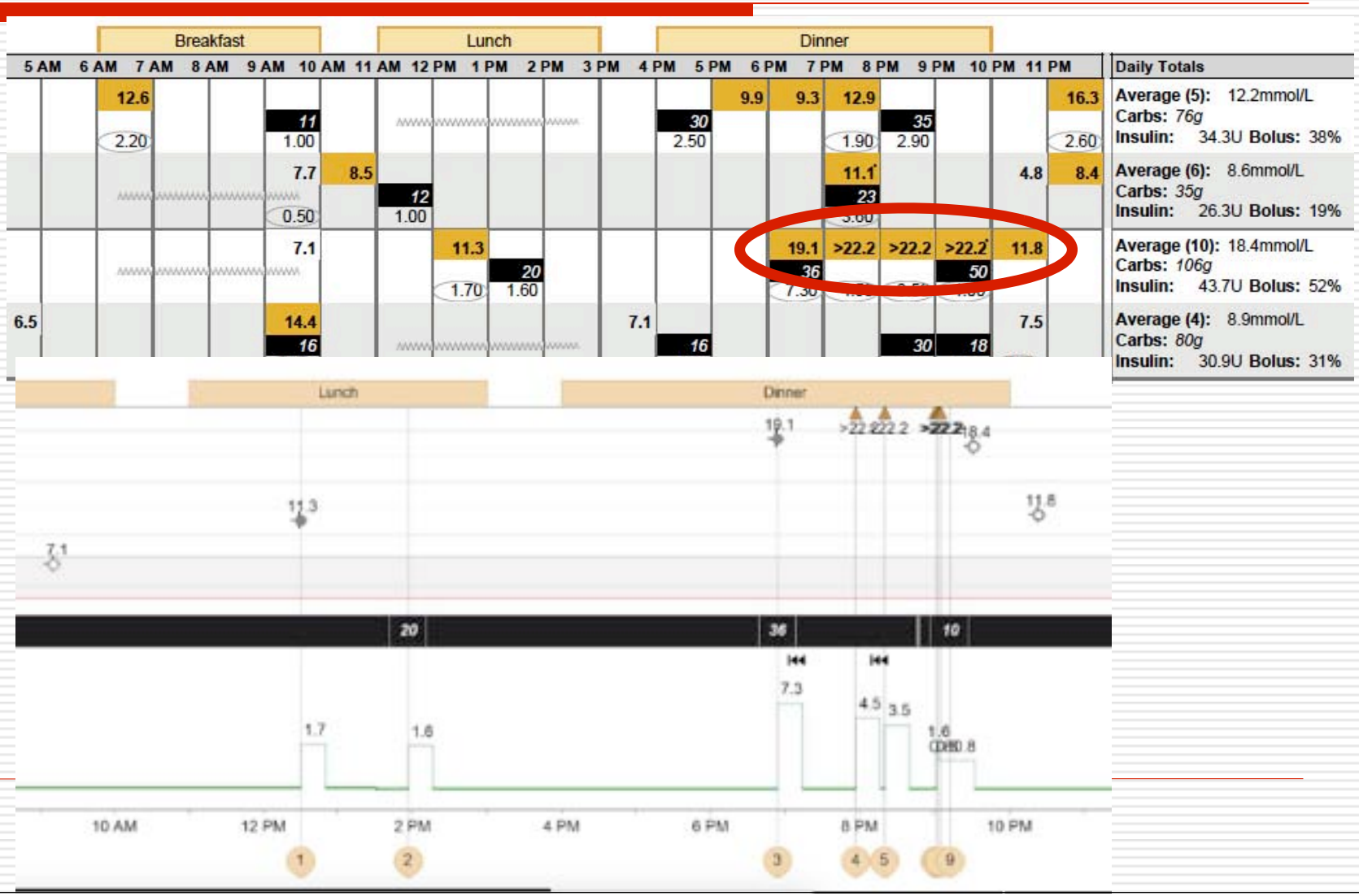
Infusion Set Failure – Patrice



APP – Occlusions Worsen Control

BG Tertile	Low	Middle	High
Avg BG	144 mg/dL 8.0 mmol/L	181 mg/dL 10.0 mmol/L	227 mg/dL 12.6 mmol/
Blocks/Month	1.36	3.04	3.57

Occlusions / Blockages

Should not happen!

More than once a month?

- *Change infusion set type*
- *Or brand of insulin (rare)*

Cost Savings on Tight Budgets

- Savings are derived from longer use of infusion sets
- Evaluate risks versus rewards first
- Staph carriers have a higher risk for infection – identify these individuals by history of ANY skin infection
- Emphasize sterile technique with extended use
- Anchor the infusion line to reduce irritation and loss
- Use lower cost metal infusion sets
- Avoid auto-inserters (close to 10% failure)

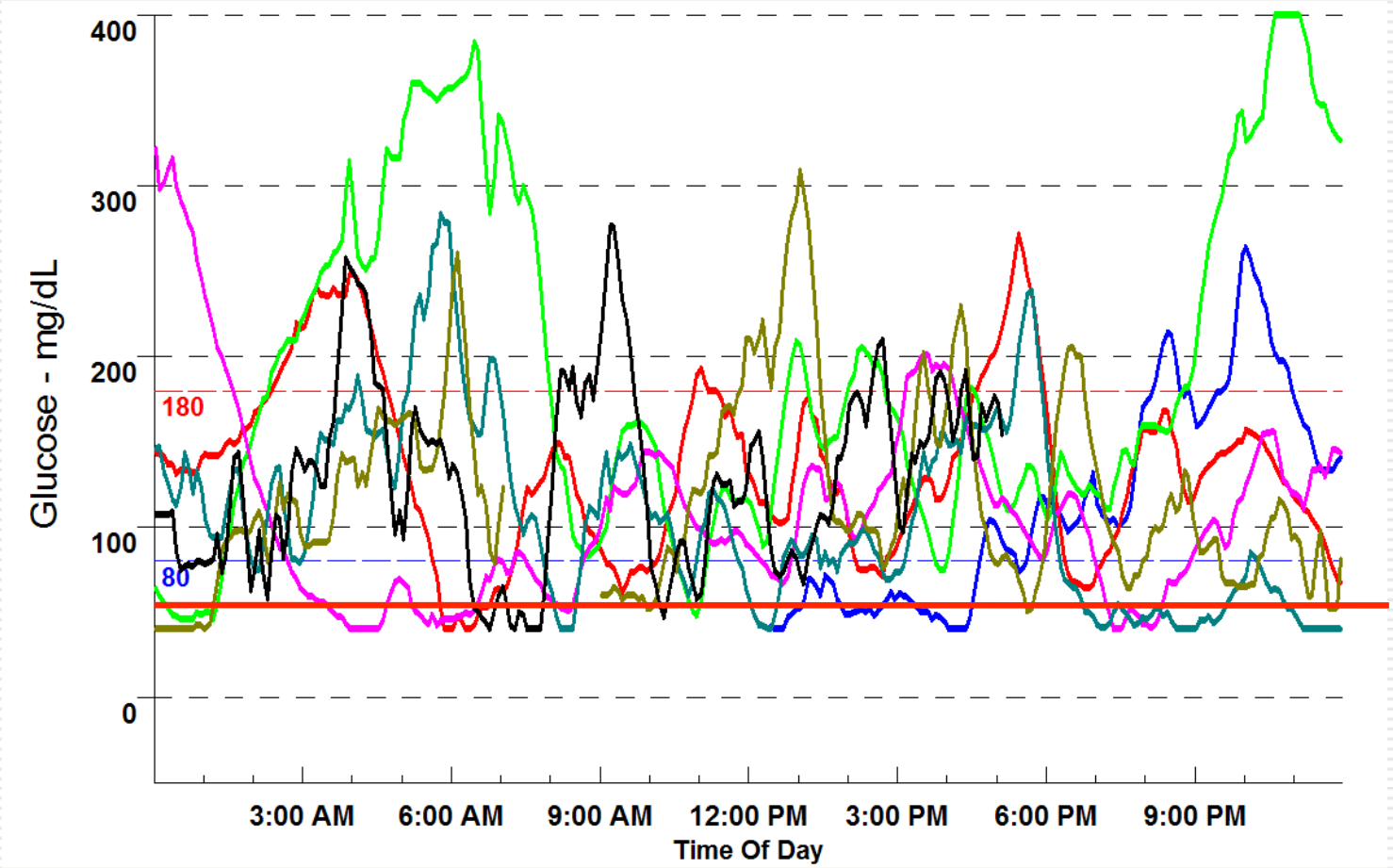
Continuous Glucose Monitors

The Next Step toward Total Control

CGM by Jackson Pollack

One Pollack painting sold for $140 million in 1996!

Make Your Own Jackson Pollack

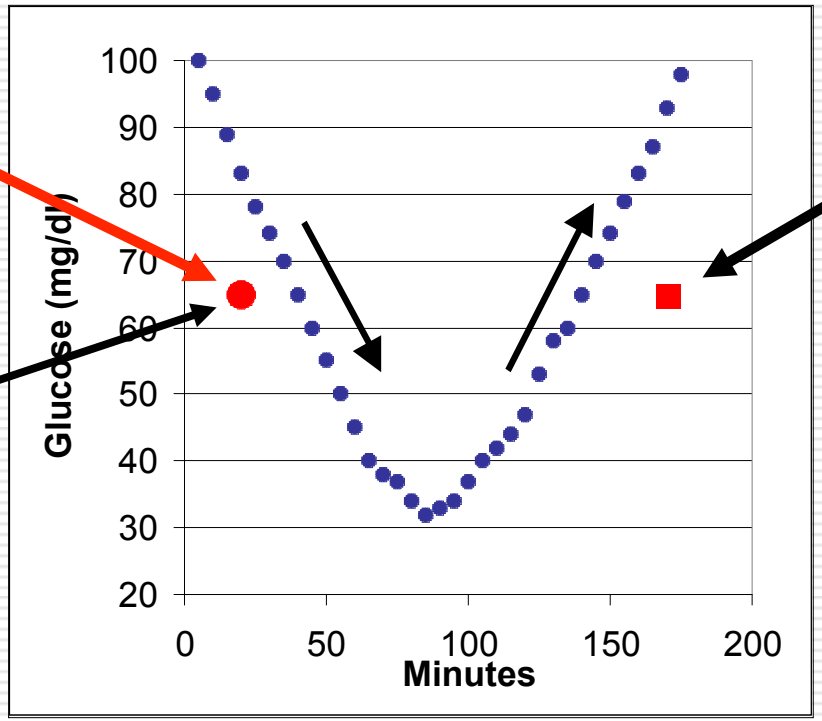


Create your own Pollack – Only $1,000!

Not All BGs Are Equal!

Greater Risk Going Down

3.6 mmol/L

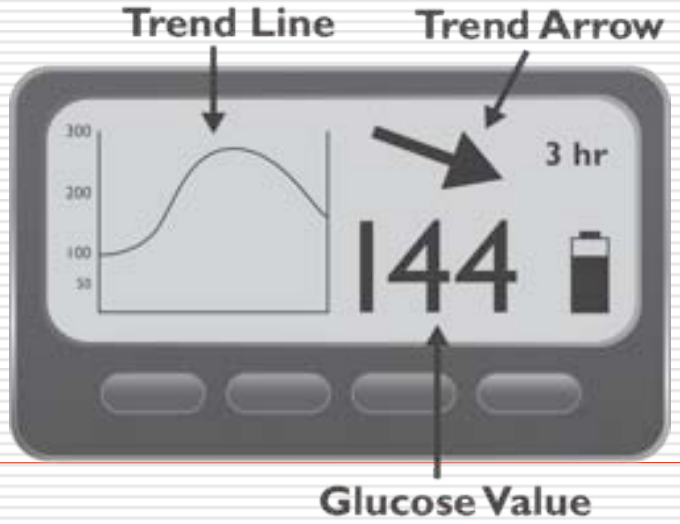


Less Risk Going Up

Level of a BG's risk depends on its trend

CGM 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
  - Prediciton



Where To Set Starting CGM Alerts

LOW: **4.4 mmol/L (80 mg/dl)**

Less than 4.4 in pregnancy

Higher for young children, high risk jobs

HIGH: **11.1 mmol/L (200 mg/dl)** to start

Gradually lower to 10, 8.9, 7.8

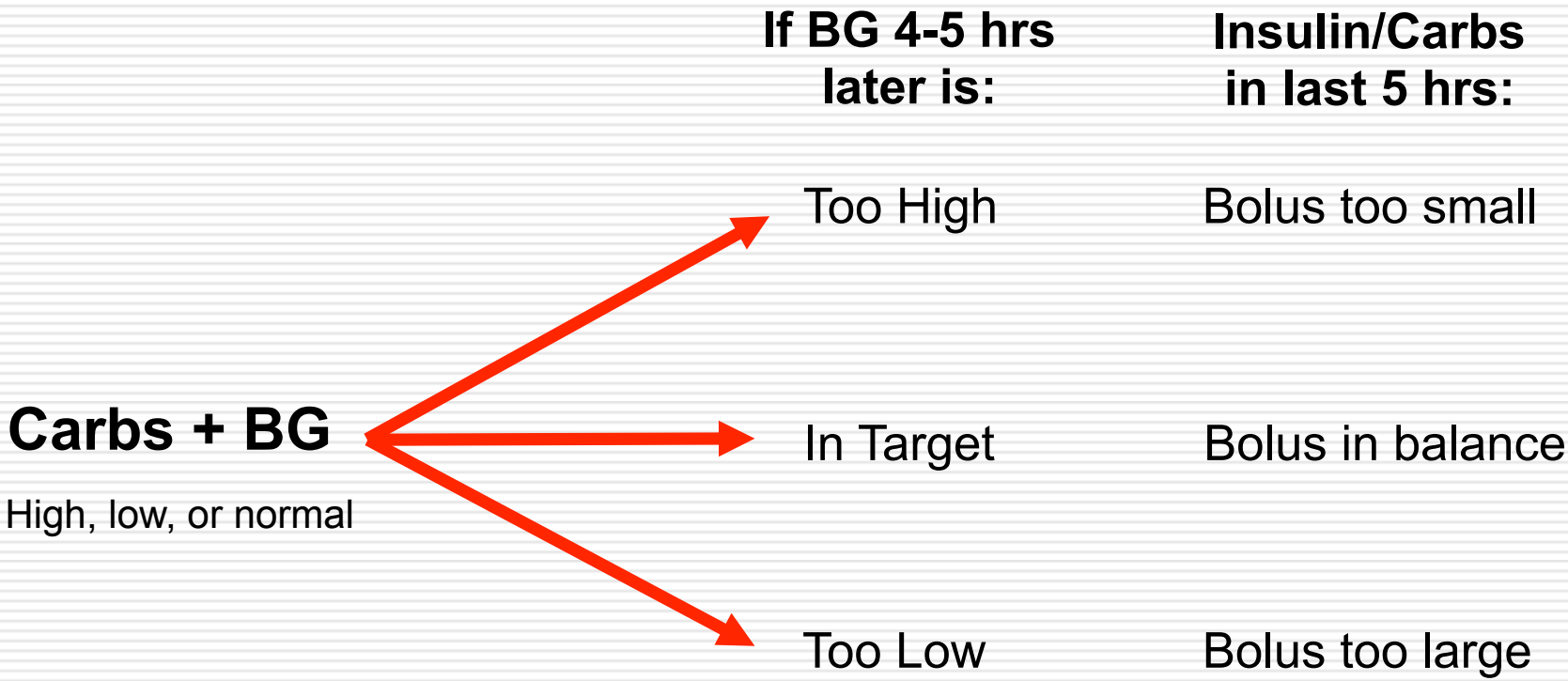
The lower the high alert is, the earlier the wearer gets alerted to a rising BG

Adapted from: Hirsch, et al. Clinical Application of Emerging Sensor Technologies in Diabetes Management: Consensus Guidelines for CGM. Diabetes Technology & Therapeutics, 10:4, 2008, 232-244.

Trends And Predictions

- Help minimize highs and lows
- Great for:
  - Driving
  - Sports
  - Basal tests
  - Reducing uncertainty
  - Overriding bolus recommendations

Analyze Last Bolus On CGM



This assumes that the basal rates are appropriate!

CGM Calibration Tips

- Use a **VERY** accurate meter
- Use good technique – clean fingers, no expired strips, enter reading right away
- Follow manufacturer's instructions
- Calibrate up to 4 times a day when the glucose is flat (no arrows)

Verify CGM with Fingerstick

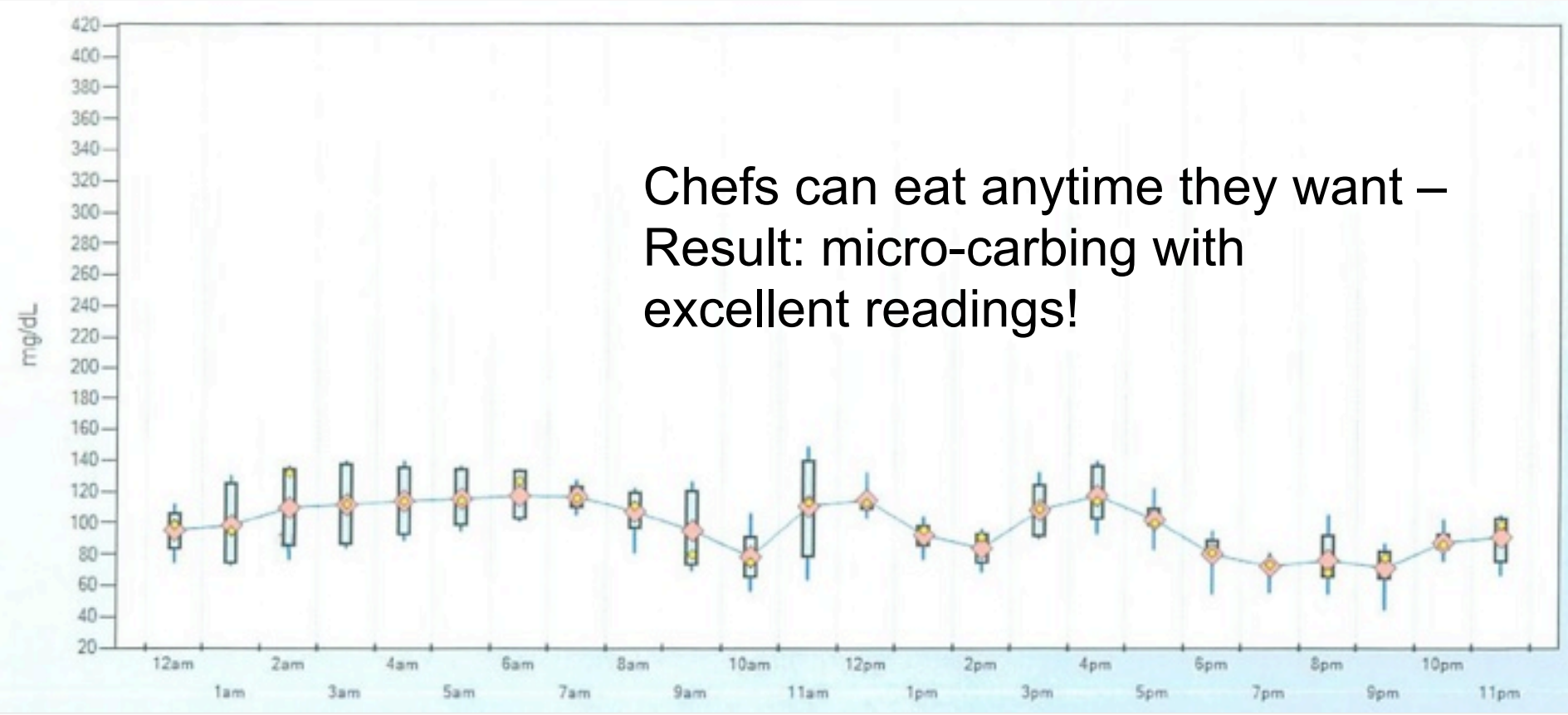
- For the first 12 to 24 hours
- When readings differ by 1.7 mmol/L (30 mg/dl) or more
- If CGM readings are erratic or don’t seem right
- Before driving
- If CGM remains low 20 or more min. after treating low
- When MAD (mean absolute difference) is above 20%
- Before treating unexplained highs

Adjust Boluses For the BG, the Trend, and the BOB

- BG Stable:
  Usual Bolus Dose
- BG Rising Gradually:
  ↑ bolus 10%
- BG Rising Sharply:
  ↑ bolus 20%
- BG Dropping Gradually:
  ↓ bolus 10%
- BG Dropping Sharply:
  ↓ bolus 20%

CGM As Behavior Mod Tool: A Chef's First Two Days On CGM

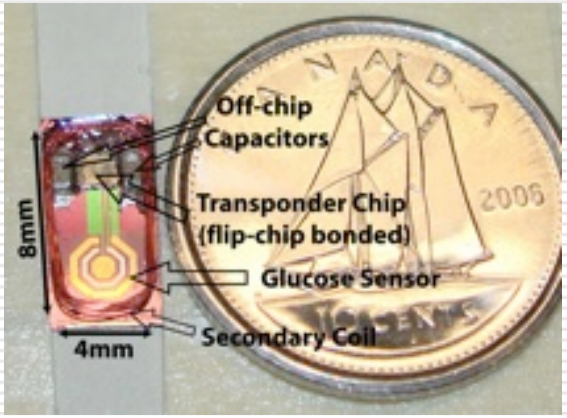
Chef's CGM Next Two Days



Chefs can eat anytime they want –
Result: micro-carbing with
excellent readings!

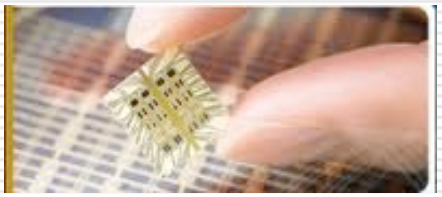
An Ideal Pump

Long-Lasting Implanted CGMs



- *Few disposables*
- *Minor surgery*
- *Funded as rental?*

Sensors For Medicine



MicroCHIPS Illume

GlySens

CGM – Implanted Fluorescent

Molecules fluoresce & change color as glucose rises or falls

- Small size, low power, low cost, long life, great accuracy
- Dual fluorescent chambers for low and high BGs

From Y. J. Heo et al: Institute of Industrial Science at the University of Tokyo

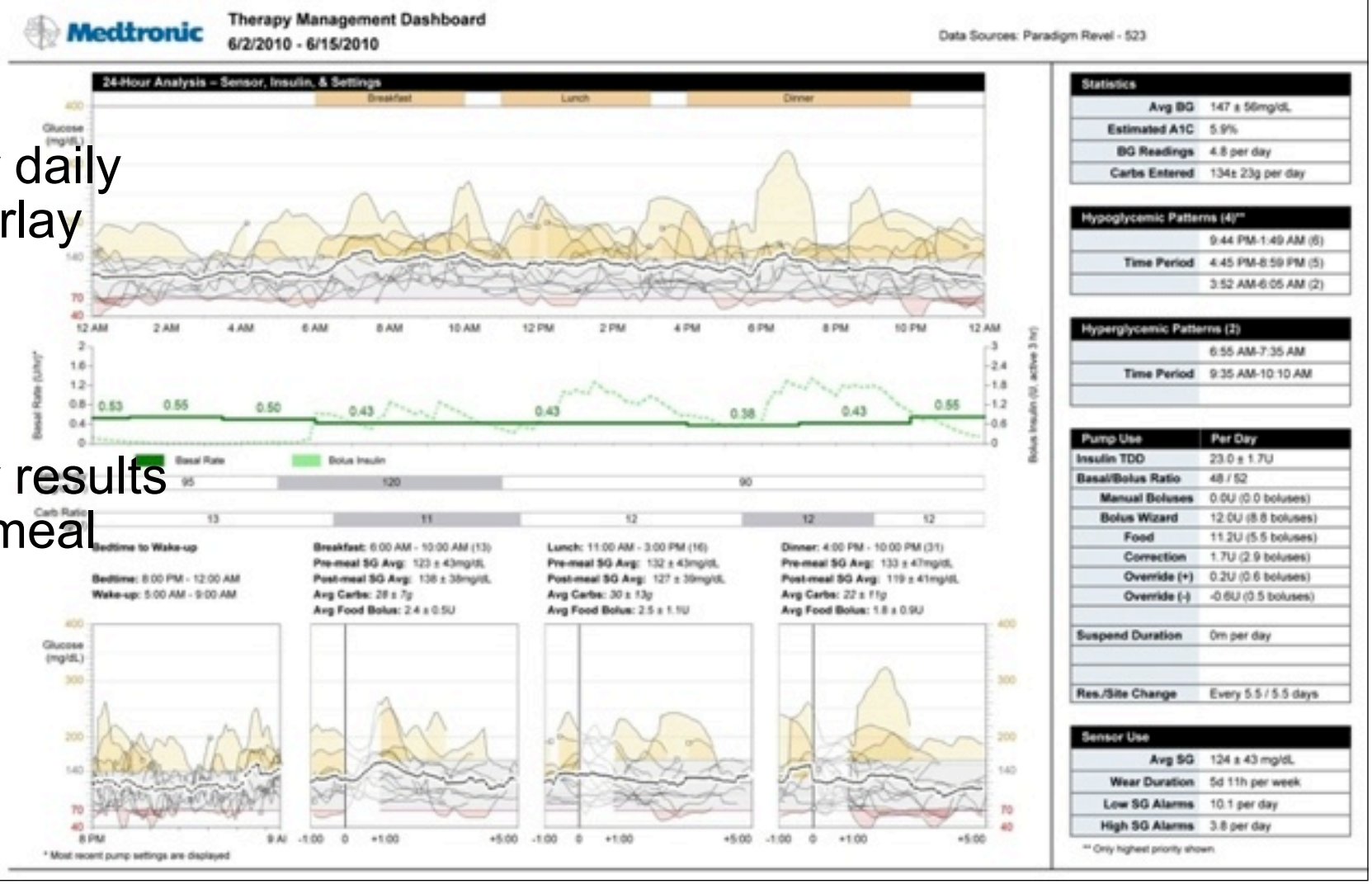
CGM Tips

- Wear the CGM at least 90% of the time
- Look at the monitor 10-20 times per day
- Look at trends not just individual values!
- Don’t over-react to data – Avoid frequent between meal corrections until pattern is clear
- A rapid rise usually means more insulin needed, BUT check BOB first!
- Lag times are longest when the glucose is changing direction from down to up or up to down
- Calibrate!

CareLink® 3.0 Online Reports

Sensor daily overlay

Sensor results by meal



Future Pump Features

- Show How A Setting Change Will Impact TDD & BG
- Temp Basal + Bolus Doses
- Super Bolus
- Meal Size Boluses
- Excess BOB Alert (bolusing without BG but ++BOB)
- Low BG Predictor Using Meter (HypoManager)
- Exercise Compensator
- Infusion Set Monitor – Leak Detector
- Automated Bolus and Basal Testing

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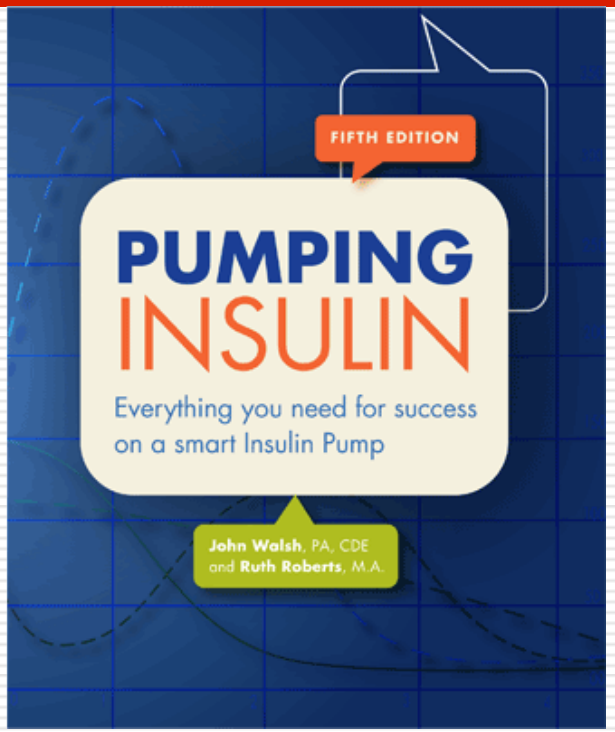
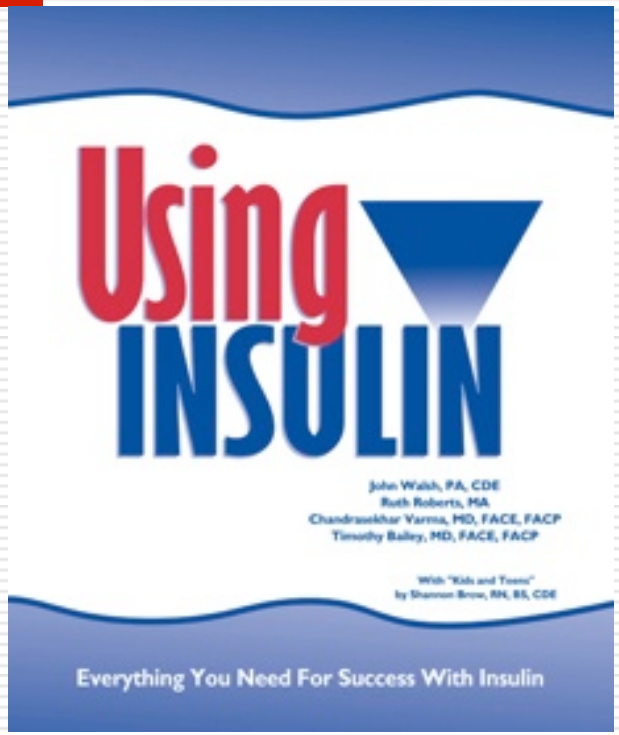
Life Is Easier When You Know More!





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