Slide 1

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Insulin Pumps Secrets & Settings for Great Glucose Control

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Tuesday, March 17, 2015

Slide 2

Disclosure

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

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Slide 3

Pump Lingo

- **TDD** – total daily dose (all basals and boluses) of insulin
- **Basal** –background insulin released around the clock
- **Bolus** – a quick release of insulin – Carb boluses cover carbs and Correction boluses lower high readings
- **Bolus Calculator (BC)** – calculates bolus recommendations
- **Correction Target** – the BG a correction bolus aims for
- **Duration of Insulin Action (DIA)** – how long a bolus lowers the BG – used to calculate residual BOB activity
- **Bolus On Board (BOB)** – bolus insulin still active from recent boluses (active insulin, insulin on board)

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Outline

- Old and New Pumps & CGMs
- Pump Setup Tips
- Which DIA Do You Use?
- BOB and Insulin Stacking
- Limitations of the Bolus Calculator
- Troubleshooting the Infusion Set
- How CGMs Can Improve BGs
- Take homes

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Slide 5

Advantages of an Insulin Pump

- Avg. A1c reduction = 0.2%[1]
- Convenience
- Software calculates doses and tracks BOB
- Easier to match varying needs
- Less insulin stacking, less severe hypoglycemia, less BG variability [2]
- Freedom of lifestyle
- Better data for clinicians, pumpers, and parents

[1] Hsin-Chieh Y, et al: Ann Intern Med. 2012;157(5):336-347.
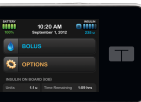[2] Pickup JC, Sutton AJ: Diabet Med 2008 Jul;25(7):765-74.

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Slide 6

21st Century Line Pumps

Accu-Chek Aviva Combo

Animas Ping or Vibe

Medtronic Revel or 530G

Asante Snap

Tandem t:slim

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21st Century Patch Pumps

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Advantages of a CGM

- Average A1c reduction = 0.7%[1]
- Reads glucose every 5 min
- Gives alarms for lows and highs
- Security for wearer and family
- Trend line and arrows guide bolus doses
- 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.

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21st Century CGM's

For comparison, 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

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CGM into Pumps and Beyond

CGM:	Pump:	Available
Dexcom	Animas	Now
	Asante	2015?
	Tandem	2015?
	Omnipod	2015?
Medtronic	Medtronic	Now
Accu-Check	Accu-Check	2016?
Connectivity via		2015?
Bluetooth Low Energy		Remote bolusing + data collection from multiple devices

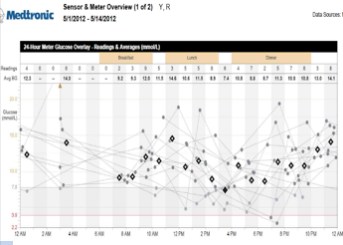typeonenation

How To Improve Insulin Doses

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APP Study – TDD, Basals, and Carbs

Glucose, Insulin and Carb Data		
Group:	Low BG Third	High BG Third
Avg. Meter BG	144 mg/dL	227 mg/dL
BG Tests/Day	4.73	4.01
TDD	47.9	51.1
Basal %	47.6%	47.8%
CarbBolus U/d	20.9 u	19.8 u
CarbBolus/Day	4.07	4.14
CarbGram/Day	185.2	187.9

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

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Slide 1: APP Study – Importance of the TDD

Sensor & Meter Overview (1 of 2)   Y, R
5/1/2012 - 5/14/2012   Data Sources: M

- Most people are not taking enough insulin
- Find an accurate TDD first – best guide to correct pump settings
- Pattern management starts AFTER TDD and settings are optimized

The TDD controls the frequency of lows, A1c, & Avg BG

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Slide 2: Pump Setup Tips

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Slide 3: Pump Setup

- Set Basals from TDD
- Set Bolus Factors from TDD
  - CarbF (carbohydrate factor)
  - CorrF (correction or "sensitivity" factor)
- Set target BG
- Set DIA (4.5 hrs or longer)
- Repeat when necessary

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Slide 4: Use the TDD to Select Pump Settings[1]

Basal insulin = ~ Half of the TDD

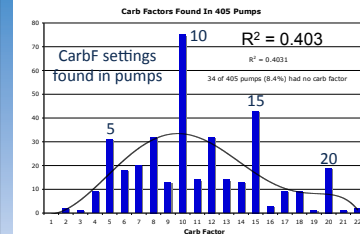$$CarbF = 2.6 \times \frac{Wt(lbs)}{TDD}$$

$$CorrF = \frac{1960}{TDD}$$

CorrF is inversely related to TDD and to avg. BG
Poor control = need for a smaller CorrF

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

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Slide 5: Pump Settings Are Frequently Wrong [1,2]

Carb Factors Found In 405 Pumps

CarbF settings found in pumps

$R^2 = 0.403$
$R^2 = 0.4031$
34 of 405 pumps (8.4%) had no carb factor

Don't use "magic" numbers!

Only 40% of CarbFs have their expected value (not just the CarbFs!)

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

Use formulas for accurate settings –> far better than WAG!

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

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Slide 6: Bolus Calculator Settings

This Setting	Helps
Basal rates	Sound sleep
CarbF or I:C ratio	Cover carbs well
CorrF or ISF	Lower highs safely
Target glucose	BG goal 4-5 hrs after bolus
DIA	Minimize insulin stacking

The average TDD determines how often highs and lows occur

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Use TDD Table to Select 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   © 2012 Diabetes Services, Inc.

J Walsh and R Roberts: © 2013 Pumping Insulin (5th ed)   **typeone**nation

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Or Use Decision Support Software

- JD is a 20 yo college student DM1 referred to our clinic

  A1c 8.4% (avg BG 194 mg/dL), Wt 184, TDD = 80 u (78-83 u/day)

  - Basal: 1.8 u/hr (43.2 u/day)
  - CarbF   10
  - CorrF   45
  - DIA   4 hrs

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Decision Support Software

Enter Your Information:

Units: **English** | Metric

Weight: 180 lbs

Avg TDD(?) : 80 u/day

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

Target Avg BG(?) : 140 mg/dl

[Submit]

Settings For Current BG
From your current TDD

TDD: 80 u/day

Avg Basal: 1.600 u/hr

Carb Factor: 5.8 grams per unit

Correction Factor: 24.5 mg/dl per unit

Relative Insulin Sensitivity: 54%

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.diabetesnet.com/diabetes_tools/pumpsettings/
or www.opensourcediabetes.org

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From Decision Support Suggestions

- JD's New Pump Settings:
  - Basal rate: 1.7 u/hr   (originally 1.8 u/hr)
  - CarbF 5.6   (10)
  - CorrF 23   (45)
  - DIA 5 hrs   (4)
- A1c 3 mos later 6.9%   (8.4%)

  www.opensourcediabetes.org

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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	↑	↓	↓

Smaller factors = larger boluses

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Common Control Issues

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Common Pump User Issues

- Reactive vs proactive dosing ("The Rollercoaster")
- Too many basal rates
- Inaccurate CHO bolus / CHO counting
- Delayed boluses – high post meal BG
- Infusion site failures
- Lack of meaningful data – no pump/meter/CGM downloads
- Not adjusting pump settings
- Lack of clarity for when to override BC recommendations
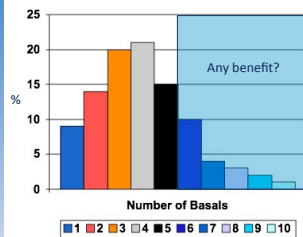
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Get Off The Rollercoaster

Be proactive! Don't overtreat highs and lows.

Adjust lifestyle or pump settings to improve control!

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Basal Rates

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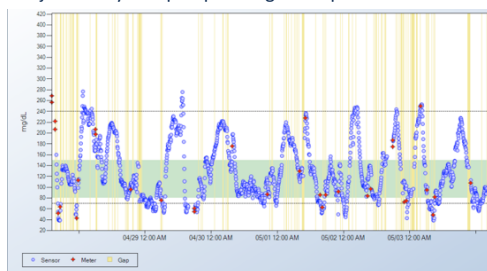
Optimal Number of Basal Rates?

Number of basal rates used per day from self-reports of hundreds of pumpers at insulin-pumpers.org

Once basal rate changes, it takes 4-5 hrs to have its full effect.*

Using more than 5 basals may have little 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.

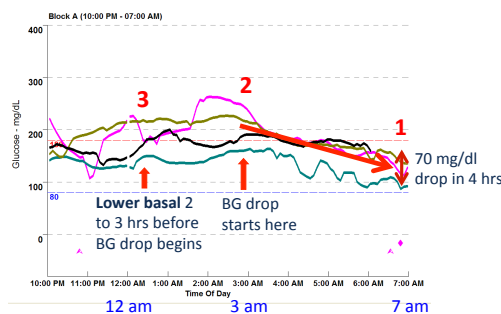typeonenation

Basal Tips – Avoid Over-Steering

- Basal rates are usually similar through day, such as between 0.5 to 0.8, or 1.0 to 1.5 u/hr
- Adjust basal rates in small steps (0.025 to 0.1 u/hr) **2 hours** before BG **starts** to rise or fall
- Or **5-8 hours** before a high or low reading typically happens
- Over 5 basals a day probably has little benefit.[1]

[1] 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.

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Overnight Basal Check

70 mg/dl drop in 4 hrs

Lower basal 2 to 3 hrs before BG drop begins

BG drop starts here

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Basal/Bolus Balance

Ideal Basal/Bolus Balance Differs by Age		
Prior to puberty	30-45%	High carbs, lower counter-regulatory hormones, honeymoon phase
Puberty	40-55%	High carbs, mid to high counter-regulatory hormones
Adult	45-60%	Mid carbs, mid counter-regulatory hormones
Thin elderly	40-50%	Mid carbs, lower counter-regulatory hormones

Most adults do best at 50 to 60% of TDD as basal

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Temp Basal Rates

- Great for physical activity, illness, fever, menses, testing new basals
- Never suspend. Instead, use a temp basal reduction – pump restarts on time with fewer followup highs
- Don't stop a pump for lows – provides no benefit until 60-90 min. later

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Carb Boluses

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Carb Bolus Types

Regular
- Taken immediately – 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 (bean burrito, steak, etc.) Test 1-2 hrs after meal. typeonenation

Get Accurate Carb Boluses

- Use carb counting resources
  - CalorieKing, MyFitnessPal
- Know portion sizes
  - Measure portions or use a gram scale at home
- Base CarbF on TDD
  - CarbF = (2.6 x weight) / TDD
- Keep a record of bolus doses that work!

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Stop Post Meal Spiking

- Count carbs carefully
- Bolus 15 to 30 min pre-meal
- Use combo bolus with picky eaters
- Delay eating until below 140 mg/dL
- Eat more low GI foods, complex carbs, fewer carbs
- Exercise after meals
- Use a Super Bolus
- Add fiber/psyllium/acarbose/Symlin/GLP-1 agonist

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Clever Pump Trick – Bolus Early To Stop Meal Spikes

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

Normal glucose profile shown in shaded area

Best glucose occurred with 60 minute bolus – **but too risky to recommend!!!**

Bolus 15-30 min early – 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.

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Clever Pump Trick – Super Bolus to Stop Meal Spikes

A Super Bolus uses temp basal reduction to shift part of the next 2 to 3.5 hrs of basal insulin into a bolus – less spiking, less risk of a low later.[1,2]

Helps for foods greater than ¼ of your weight(lbs) in grams, ie, more than 40 gr for someone weighing 160 lbs. Max carbs/meal = Wt(lb) X 0.36 to stay in control[2]

[1] J. Walsh: http://www.diabetesnet.com/diabetes_presentations/*uper-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. JDST, 3(1), 89-97, 2008

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Bolus to Cover Protein and Maybe Fat

Protein –

- Half the grams of protein in food are converted to glucose over the next 6-8 hours
- Most meals don't have enough protein to matter
- But when the grams of protein in a meal or snack are greater than 1/6th of your weight(lbs), cover half of these grams with an extended or square wave bolus given over a 4-5 hr period

Fat –

- Individual varieties of fats in foods differ tremendously in whether and how much they will affect the glucose
- Are hard to cover: some fats have little impact, some delay carb digestion, and some raise the BG from insulin resistance

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Correction Boluses

- In the APP Study, 396 pumpers averaged 2.1 correction boluses and 5.6 correction units per day (11.6% of the TDD)[1]

- Makes up for deficits in basal rates or carb boluses

- The better your control, the larger your CorrF becomes (to give smaller correction doses)

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

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Use TDD to Stop Highs and Lows

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Insulin Adjustments for Glucose Control

- If it ain't broke, don't fix it!

- **Mild** – tweak pump settings or lifestyle

- **Moderate** – For patterns, use pattern management. Otherwise calculate new TDD and retune pump settings

- **Severe** – Reset TDD to an improved TDD (iTDD) and select new settings from this iTDD to correct the problem

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Improve Insulin Doses In Sequence

1. Stop frequent lows first
2. Then correct high A1c/avg BG

   This lets you find an ideal TDD (iTDD)

3. Set & test basals from iTDD
4. Set & test CarbF from iTDD
5. Lower post meal BG's
6. Set & test CorrF from iTDD
7. Enjoy good control or return to #1

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

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Stop Frequent Lows First

- **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.
  - Divide weight(lbs) by 4 to see what TDD a person needs if they have an average sensitivity to insulin[1,2]

Example: Someone who weighs 160 lbs would be expected to have a TDD of 40 units (160/4 = 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.
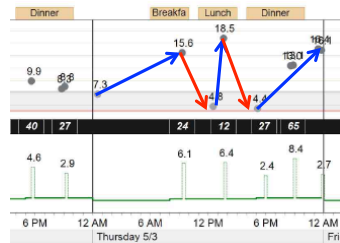

Incidence Rate* of SH at various ages
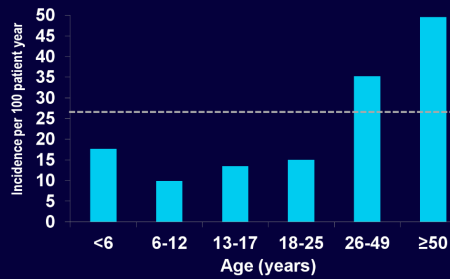
* the rate of seizure/coma in the DCCT was 26.7 /100 patient year

T1D Exchange

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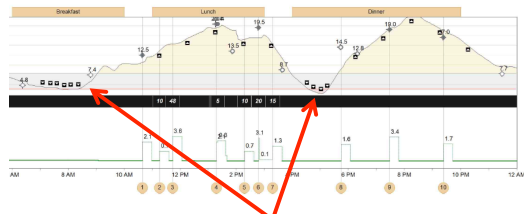## Example 1 – Frequent Lows on Meter

41 yo female with A1c = 6.9%
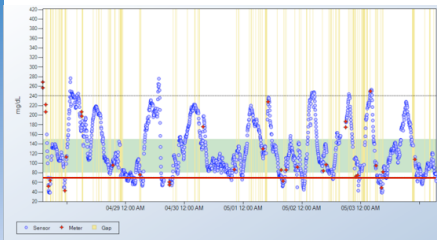
TDD = 50.5 u/d

152 lb/4 = 38.0 u/d

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Hidden Hypoglycemia

Person eats when low but does not test with a meter.
Only a CGM will give a record of this!
Always tell your doctor about any hidden lows you may be having.

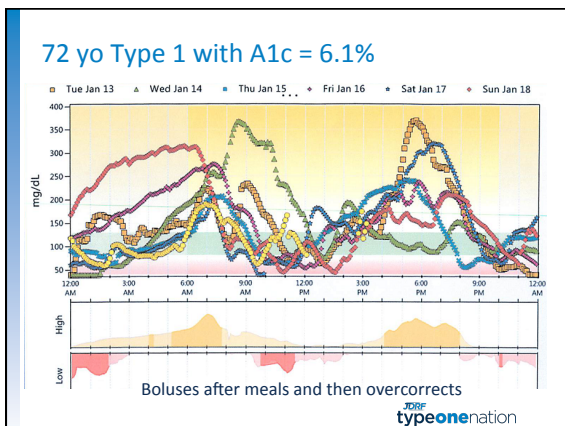typeonenation

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Example 2 – Frequent Lows on CGM

~ 2 Lows-to-Highs per day

70 mg/dl

28 yo female – Wt: 120 lbs

Current TDD = 43.6 u/day

Wt/4 (120/4) = 30.0 u/day

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72 yo Type 1 with A1c = 6.1%

■ Tue Jan 13   ▲ Wed Jan 14   ■ Thu Jan 15   ◆ Fri Jan 16   ● Sat Jan 17   ● Sun Jan 18

Boluses after meals and then overcorrects

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Clever Pump Trick –
How Many Carbs for a Low?

1. **No BOB:** 1 gram for each 10 lbs of weight (minimum 10 gr)
2. **With BOB:** Add grams = BOB* x CarbF

Example: Amy's BG = 52 mg/dL with 2u of BOB (CarbF = 8 g/u)

- At 140 lbs, she needs 14 grams of carb for the low glucose
- *Plus* 2u BOB x 8 gram/u = 16 grams to offset BOB
- Amy needs 14 g + 16 g = 30 grams for this low

* DIA time must be accurate

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Next Stop Frequent Highs

Raise the TDD with the 5 and 6 Rules:

Raise the TDD by 5% to lower an A1c by 1%

Or by 1% to lower average BG by 6 mg/dL

$$\frac{\text{Current BG – Target BG}}{6} = \text{% rise in TDD}$$

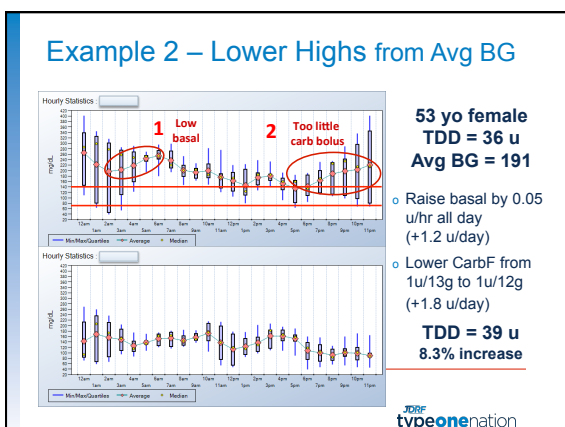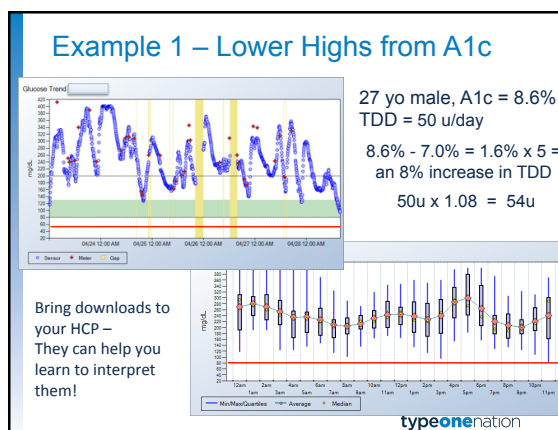**Example:** Amy's avg TDD is 40 u/day, avg BG 200 mg/dL (few lows), and BG goal 140 mg/dL:

200 mg/dL – 140 mg/dL = 60 mg/dL

60 mg/dL ÷ 6 = 10% rise in TDD

40 units x 1.10 = 44 units a day

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Example 1 – Lower Highs from 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

Bring downloads to your HCP – They can help you learn to interpret them!

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Example 2 – Lower Highs from Avg BG

1 Low basal   2 Too little carb bolus

**53 yo female
TDD = 36 u
Avg BG = 191**

○ 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
8.3% increase**

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Jackson Pollack's CGM

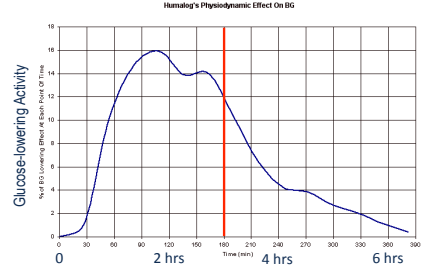Price: $3,000,000

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How Long Does a Bolus Lower the Glucose?

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Duration Of Insulin Action in the Body
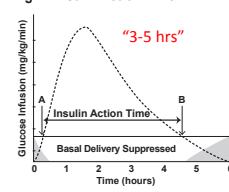### Accurate boluses require an accurate DIA

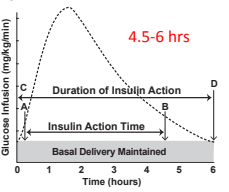Humalog's Physiodynamic Effect On BG

Glucose-lowering Activity (% of BG Lowering Effect At Each Point Of Time)

| 0 | 2 hrs | 4 hrs | 6 hrs |

Time (min)

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Insulin Action Time ≠ Duration of Action

Fig. 1 Insulin Action Time

"3-5 hrs"

Glucose Infusion (mg/kg/min)

A ← Insulin Action Time → B

Basal Delivery Suppressed

0 1 2 3 4 5 6
Time (hours)

IAT is measured between points A and B, and involves suppression of basal delivery.

Fig. 2 Duration of Insulin Action

4.5-6 hrs

Glucose Infusion (mg/kg/min)

C ← Duration of Insulin Action → D

A ← Insulin Action Time → B

Basal Delivery Maintained
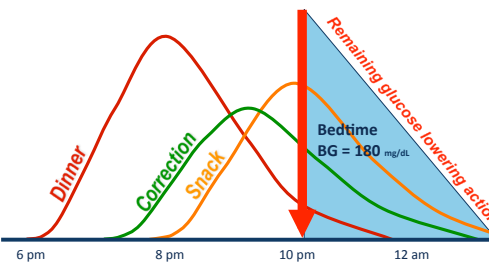
0 1 2 3 4 5 6
Time (hours)

DIA is measured between points C and D. Once basal delivery is maintained, the PD of a bolus insulin can be directly measured.

J Walsh, R Roberts, L Heinemann. Confusion Regarding Duration of Insulin Action A Potential Source for Major Insulin Dose Errors by Bolus Calculators. *J Diabetes Sci Technol January 2014 vol. 8 no. 1 170-178.*

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Bolus on Board / Insulin Stacking

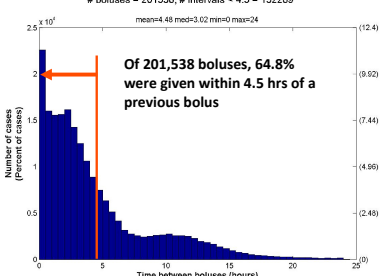**Bedtime BG = 180 mg/dL – is there an insulin or a carb deficit?**

Remaining glucose lowering action

Dinner   Correction   Snack

Bedtime BG = 180 mg/dL

6 pm   8 pm   10 pm   12 am

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Insulin Stacking Is Common

boluses = 201538, # intervals < 4.5 = 132289

mean=4.48 med=3.02 min=0 max=24

Number of cases (Percent of cases)

Of 201,538 boluses, 64.8% were given within 4.5 hrs of a previous bolus

Time between boluses (hours)

J Walsh, D Wroblewski, T Bailey. Disparate Bolus on Board Recommendations in Insulin Pump Therapy. Poster 2007 AACE Meeting
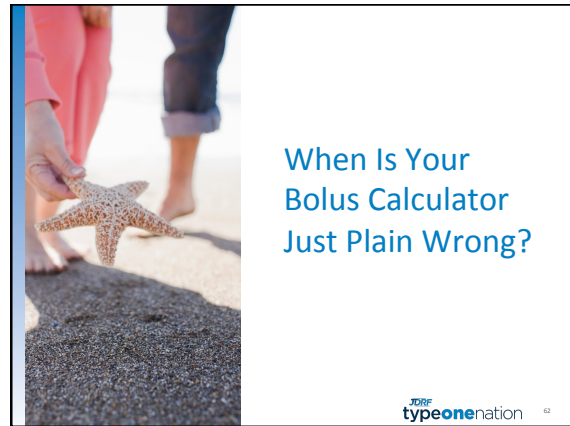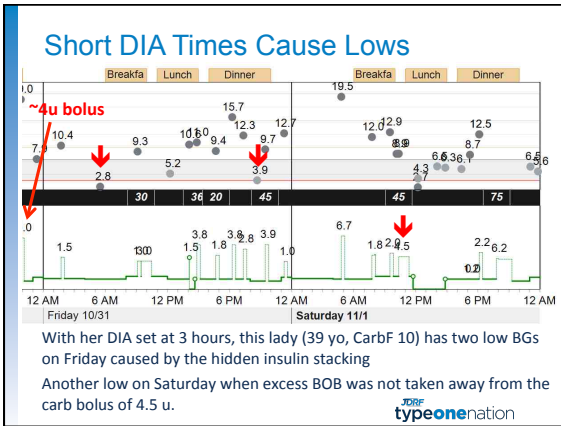
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Short DIA Times Hide BOB & Cause Lows

This is how much BOB a pump thinks is left 3 hrs after a 10-unit bolus using these DIA times:			
	Pump's estimate of Insulin On Board		
When DIA is set to:	3 hr	4.5 hr	5.0 hr	5.5 hr
Estimated BOB is:	0 u	2.5 u	3.4 u	4.0 u

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Short DIA Times Cause Lows

With her DIA set at 3 hours, this lady (39 yo, CarbF 10) has two low BGs on Friday caused by the hidden insulin stacking

Another low on Saturday when excess BOB was not taken away from the carb bolus of 4.5 u.

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When Is Your Bolus Calculator Just Plain Wrong?

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Tuning and Taming the Bolus Calculator

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

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Pump Bolus Calculators Often Recommend Excessive Boluses

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

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Extent of Insulin Overdose from a BC

					Carb + Corr Bolus	
Time	BG mg/dL	Carbs Eaten	Carb Bolus	Total IOB	Cozmo Pump	Other Pumps
6:54 am	111	16	0	0	No bolus given	
9:52 am	174	0	3.0 u	0	4.3 u	4.3 u
10:35 am	140	50	5.0 u	3.3 u	2.2 u	5.0 u
11:58 am	117	40	4.0 u	3.6 u	0.5 u	4.0 u
1:12 pm	137	0	0	2.3 u	Eat 19 g	No action

Bolus Recommendations Differ between Pumps

6.35 excess units recommended by other pumps in just 6 hours!

TDD = 38 u, carb factor = 10 g/u, corr factor = 65 mg/dl, 65 mg/dL x 6.35 u = 413 mg/dl fall in BG if Other Pump's advice is followed
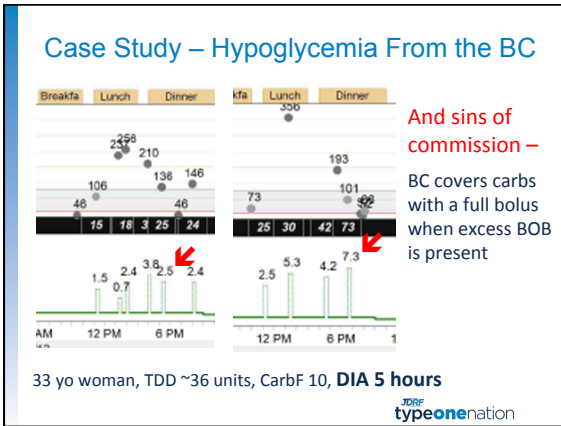
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Case Study – Hypoglycemia From the BC

BCs commit sins of omission –

BG is 89 mg/dL with excess BOB

BC fails to warn user they need carbs to cover this excess BOB

33 yo woman, TDD ~36 units, CarbF 10, **DIA 5 hours**

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Case Study – Hypoglycemia From the BC

And sins of commission –

BC covers carbs with a full bolus when excess BOB is present

33 yo woman, TDD ~36 units, CarbF 10, **DIA 5 hours**

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Check BC's Recommended Bolus

4.35 u of BOB remain from a bolus given 3 hrs earlier – would you give 2.9 more units for a bedtime snack?

Pumps cover all carbs even when excess BOB is present

Here, 4.35u of BOB is larger than correction bolus (1.23u),

Little or no bolus is needed

Ping and Vibe give correct boluses when the BG goes below target

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Clever Pump Trick –
Get an Accurate Bolus

1. When BOB is smaller than correction bolus, the pump's recommended bolus is CORRECT

2. If BOB is larger than correction bolus, add carb and correction bolus, then subtract BOB

Example: Carb bolus = 2.9 u (Pump's recommendation)

Corr bolus   = 1.2 u
BOB   = 4.3 u   **BOB larger than Corr bolus**

Accurate bolus = 2.9 + 1.2 – 4.3 = –0.1 unit bolus

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Troubleshooting the Infusion Set

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Cannula Options

Straight   Slanted

Teflon   Metal   Teflon

6, 9 mm	4, 5, 6, 9 mm	13, 17 mm
3 days*	2 days*	*recommended use
3.4 days**	3.7 days**	**actual use

J Walsh, R Roberts, D Weber, G Faber-Heinemann, L Heinemann. Insulin Pump and CGM Usage in the US and Germany: Results of a Real-world Survey with 985 Subjects. DJST pending pub.

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Line Disconnect Mechanisms

Motion and degree of manual dexterity required

Twist & pull easiest

Pinch & pull easier

Pinch, twist, & lift hardest

Pinch & lift harder

Tubing lengths: 24", 32", and 43" for most sets

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Auto-Inserters

Inset 30 Accu-Chek Link Assist Inset/Mio

Omnipod

Quick-Serter Cleo

Infusion Set Failure Is Common

- Most of the 16,849 adverse pump events reported to the FDA between 2006-2009[1] involved infusion sets[1]

- A 2006 review of pumps in France likewise found that most serious adverse events involved infusion sets[2]

- Auto-insertion devices have a high failure rate of 8.9%[3]

1 www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/MedicalDevices/
MedicalDevicesAdvisoryCommittee/GeneralHospitalandPersonalUseDevicesPanel/
UCM202779.pdf
[2] Maugendre D. Technical risks with subcutaneous insulin infusion. Diabetes Metab. 2006;32:279-284.
[3] Renard E, et al: Lower rate of initial failures and reduced occurrence of adverse events with a new catheter model for continuous SQ insulin infusion. Diabetes Technol Ther 12:769-773, 2010.

Infusion Sets –
The Achilles Heel Of Pumps

Survey of 1142 pumpers in 40 German diabetes clinics

- 54% reported an increase in glycemia for unknown reasons until their infusion set is changed

- 19% reported kinking, 12% had leakage, 12% air bubbles, and 33% had other issues

- 36% used auto-insertion devices – 72% of them reported that the device failed to work ~10% of the time

Reichert D, et al. Realität der Insulinpumpentherapie in Diabetesschwerpunktpraxen: Daten von 1142. Patienten aus 40 diabetologischen Schwerpunktpraxen. Diabetes, Stoffw. und Herz 22: 367-375, 2013.

Is The Infusion Set The Problem?

- Sites "go bad"?
- "Scarring" or "poor absorption"?
- 2 or more unexplained highs in a row?
- Correction boluses don't work?
- High BGs until set is changed?

Infusion Set Failure On CGM

Infusion Set Failure

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

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How Infusion Sets Fail

- Complete pullout
- Insulin leak along Teflon to skin
- Hematoma under the skin
- Autoinserter
- Occlusion
- Loose hub
- Punctured line

Goal: Less than one failure a year!

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Stop Infusion Set Problems!!!

- Anchor Teflon infusion lines with 1" tape*
  - Stops tugs and pullouts, "unexplained highs" (insulin leaks), skin irritation and "pump bumps"
- Place IV3000 or Tegaderm adhesive over metal sets
- Insert set by hand
- Review site prep and insertion technique with clinician or trainer
- Switch to a reliable set

Always anchor!

* Transpore, Durapore, Hypafix, Micropore

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Take Aways #1

- Pumps and CGMs have made huge strides in options and accuracy
- Think of your TDD as a key ingredient in your control
  - Stop frequent lows first
  - Then lower a high A1c or avg BG with the 5 and 6 rules
  - Use formulas to select optimal settings from the TDD for a pump start and to check current pump settings
- Basal often works best at ~50 to 60% of TDD, stay in basal/bolus balance, avoid too many shifts and large shifts in your basal rates
- Change basal rates 5-8 hrs before highs or lows happen
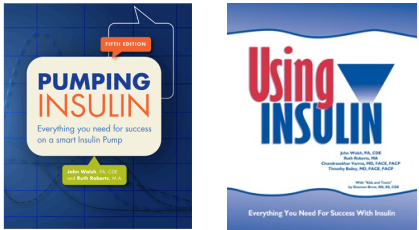- The carb factor and other pump settings are often incorrect

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Take Aways #2

- For safety, subtract excess BOB from the carb dose any time BOB is greater than the correction dose (your pump will not usually do this)
- Some degree of insulin stacking happens in 2/3 of all bolus doses
- Short DIA times hide insulin stacking and cause unexplained hypoglycemia
- Infusion set problems are common but don't have to be
  - Due to their high rate of failure, don't use an auto-inserter unless you never have a problem with it
  - Metal sets are the easiest to use and least likely to fail – great for children, pregnancy, etc.
  - Anchor all Teflon infusion lines with 1" Transpore or other tape to prevent tugging, leaks, and pullouts
  - Apply IV3000 or Tegaderm clear adhesive over metal

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