# The Latest on Insulin Pumps

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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

- Actual Pump Practices Study Results

- Tuning The Bolus Calculator

- Handling Insulin Stacking

- TDD and Best BC Settings

- Infusion Set Issues

# The Challenge Of Diabetes
Bringing the A1c down smoothly takes effort



Courtesy Tim Bailey, MD, FACE, CPI
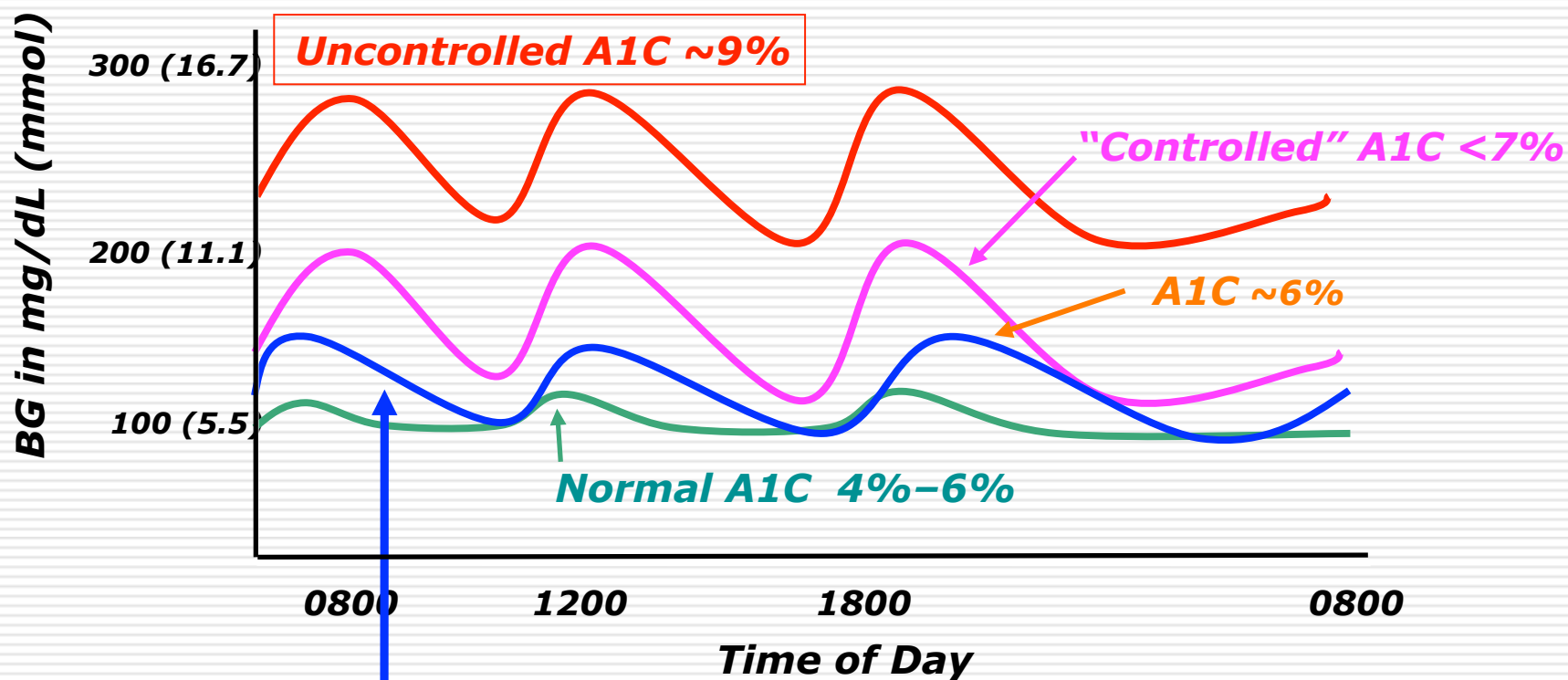
# Select Appropriate Goals

| ADA Age-Appropriate A1c And Meter Goals | | |
|---|---|---|
| Age | A1c | Approx. Avg. Meter Glucose * |
| Less than 6 | 7.5% to 8.5% | 168 to 197 (**10 mmol/L**) |
| 6 to 12 | 8% or less | 183 or less (**9.4 mmol/L**) |
| Over 12 | 7.5% or less | 168 or less (**8.9 mmol/L**) |
| Over 19 | 7% or less | 154 or less (**8.3 mmol/L**) |
| **AACE:** Over 19 | 6.5% or less | 140 or less (**7.8 mmol/L**) |

* With only premeal BGs, meter average would be lower than these values.

Most adults aim for a meter average of 8.6 mmol/L (154 mg/dl) or less

**ISPAD goal is ≤ 7.5% for everyone, with few hypos**

# Ways To Get To Goal
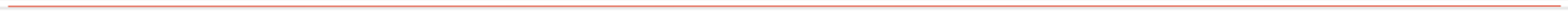
# Pump Advantages



- Reliable, precise insulin action

- Ease of use (fewer missed doses)

- Less insulin and less insulin stacking

- Easier to exercise

- Lower A1c & less severe hypoglycemia*

- Less glucose exposure and variability

- Better atch for variable basal insulin need

- Less social limitation

- Better data access for HCPs and parents

* Pickup JC, Sutton AJ: Severe hypoglycaemia and glycaemic control in Type 1 diabetes: meta-analysis of multiple daily insulin injections compared with continuous subcutaneous insulin infusion. Diabet Med 2008 Jul;25(7):765-74.

# Basals And Boluses



Managing Type 1 Diabetes: Intensive/Physiologic Insulin Replacement
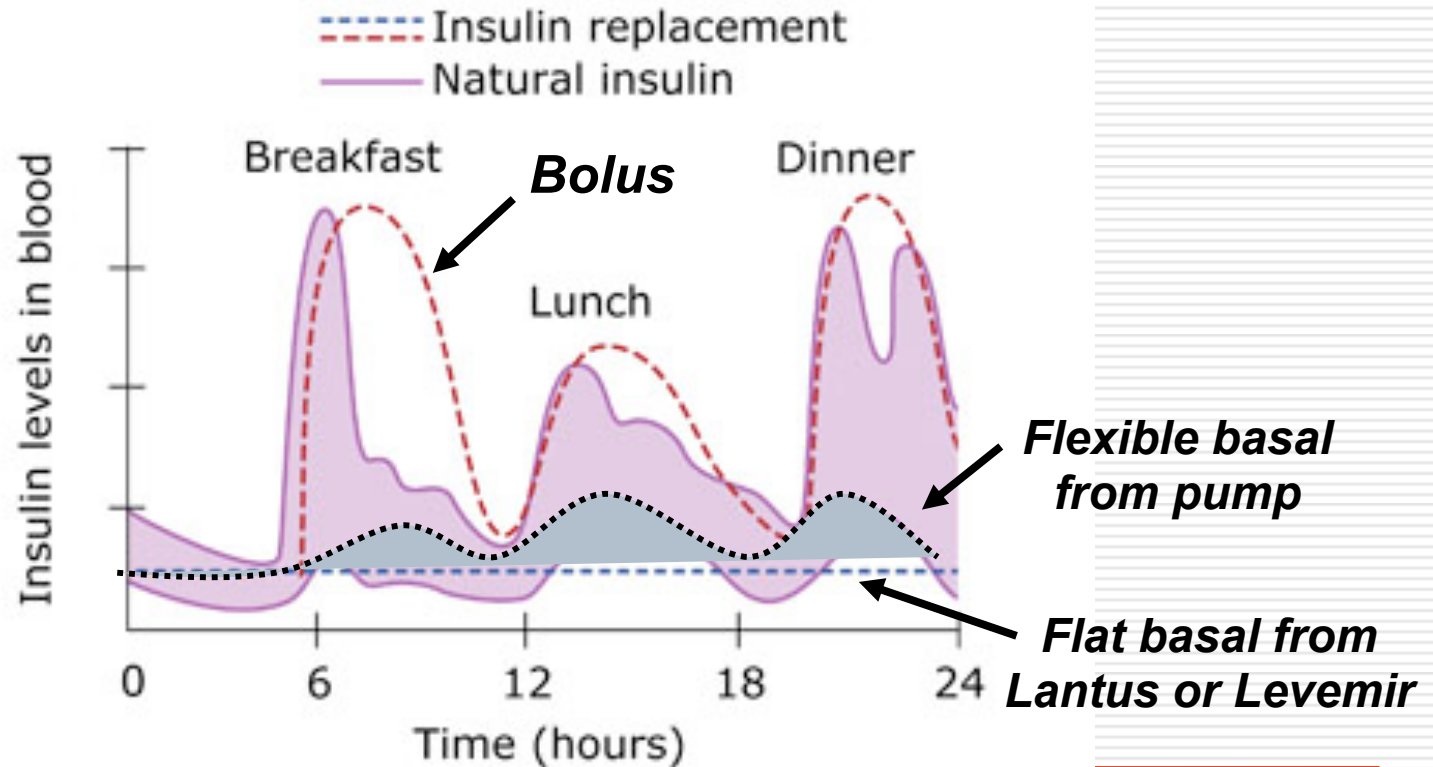
A pump's basals and boluses provide a better match

# The Actual Pump Practices Study

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

- 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 that had BG values directly entered from an attached CozMonitor Freestyle meter were chosen

- An average of 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 396 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

# APP Study – BGs and Basal Rates

## Glucose, Insulin and Carb Data

| Group: | All 396 Pumps | Low Third | Mid Third | High Third |
|---|---|---|---|---|
| Avg. Meter BG | 144 mg/dL 8.0 mmol/L | 181 mg/dL 10.0 mmol/L | 227mg/dL 12.6 mmol/L | 144 mg/dL 8.0 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

## 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 10.1 mmol/L | 227mg/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 –
# 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 Conclusion

- Find an accurate TDD

- Then get pump settings from it
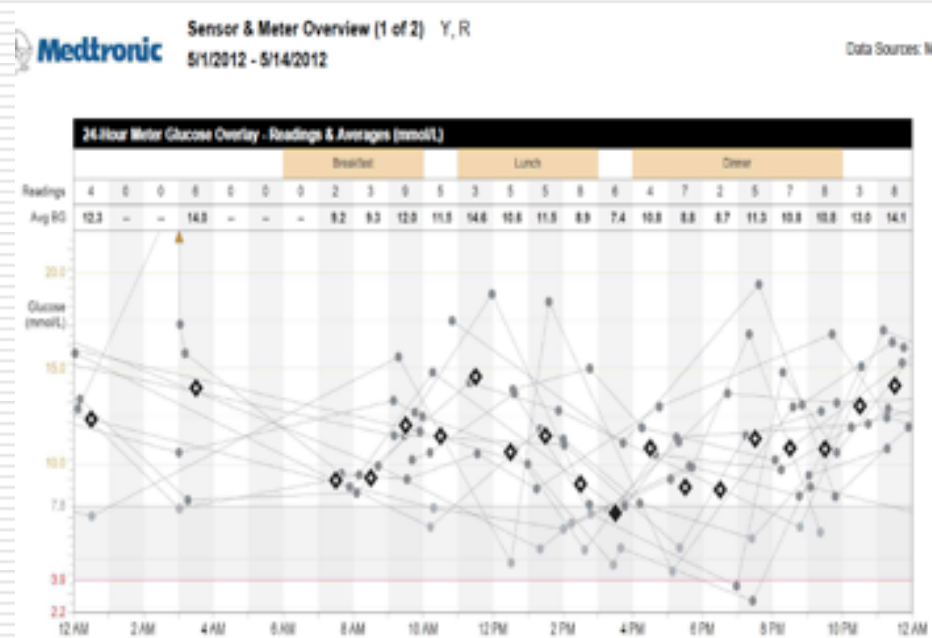


Pattern management starts once TDD is accurate.

# 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, add fiber
                                                         Symlin, GLP-1 agonist, 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!*

# Tips –
# The Other Things You Need

- 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

- Don't over-treat lows with carbs

- Don't over-treat highs with insulin

- Don't give blind boluses

# Tuning the Bolus Calculator

# 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                    Grams of carb



*Photo courtesy www.sixuntilme.com*



*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, 6.1 mmol/L or 110 mg/dl), OR a narrow correction range (ie, 5.6-6.7 mmol/L or 100-120 mg/dl).
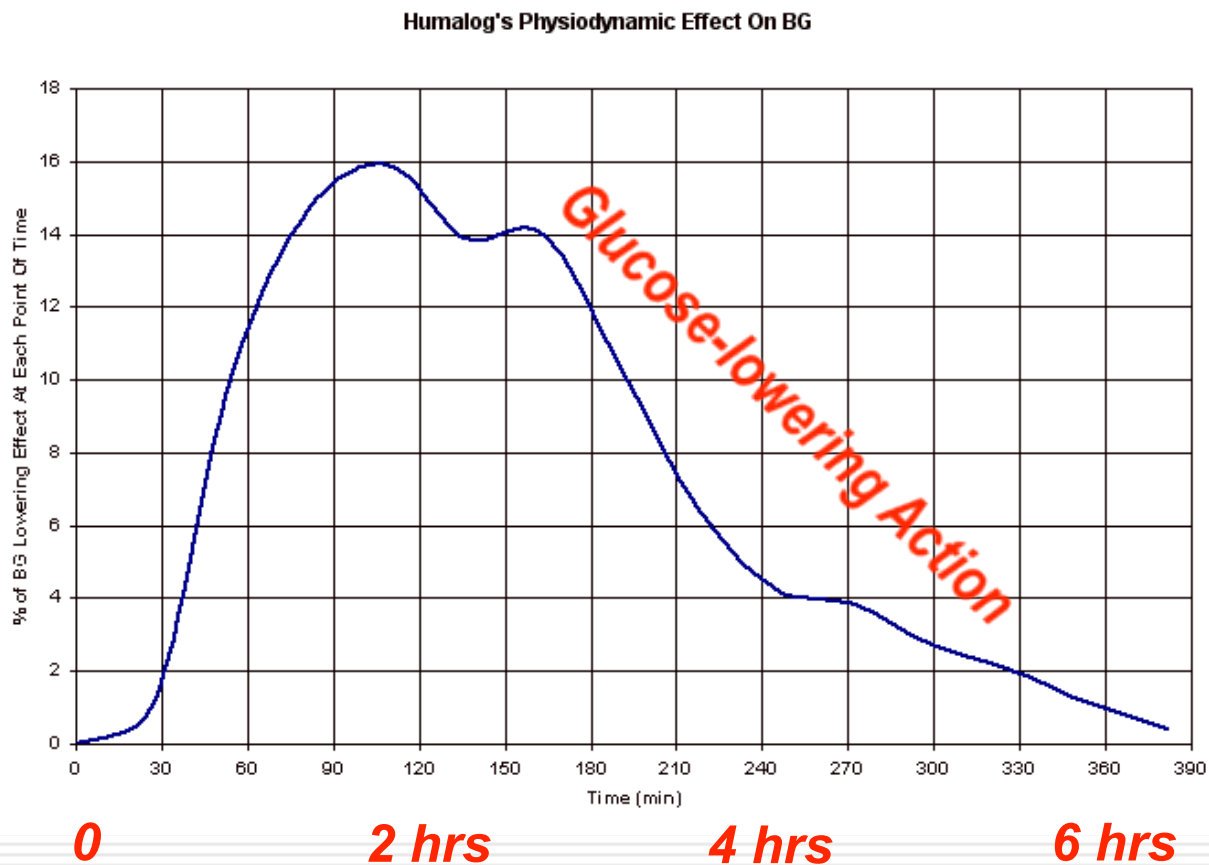
*

# DIA, BOB, and Insulin Stacking

## Duration Of Insulin Action (DIA)
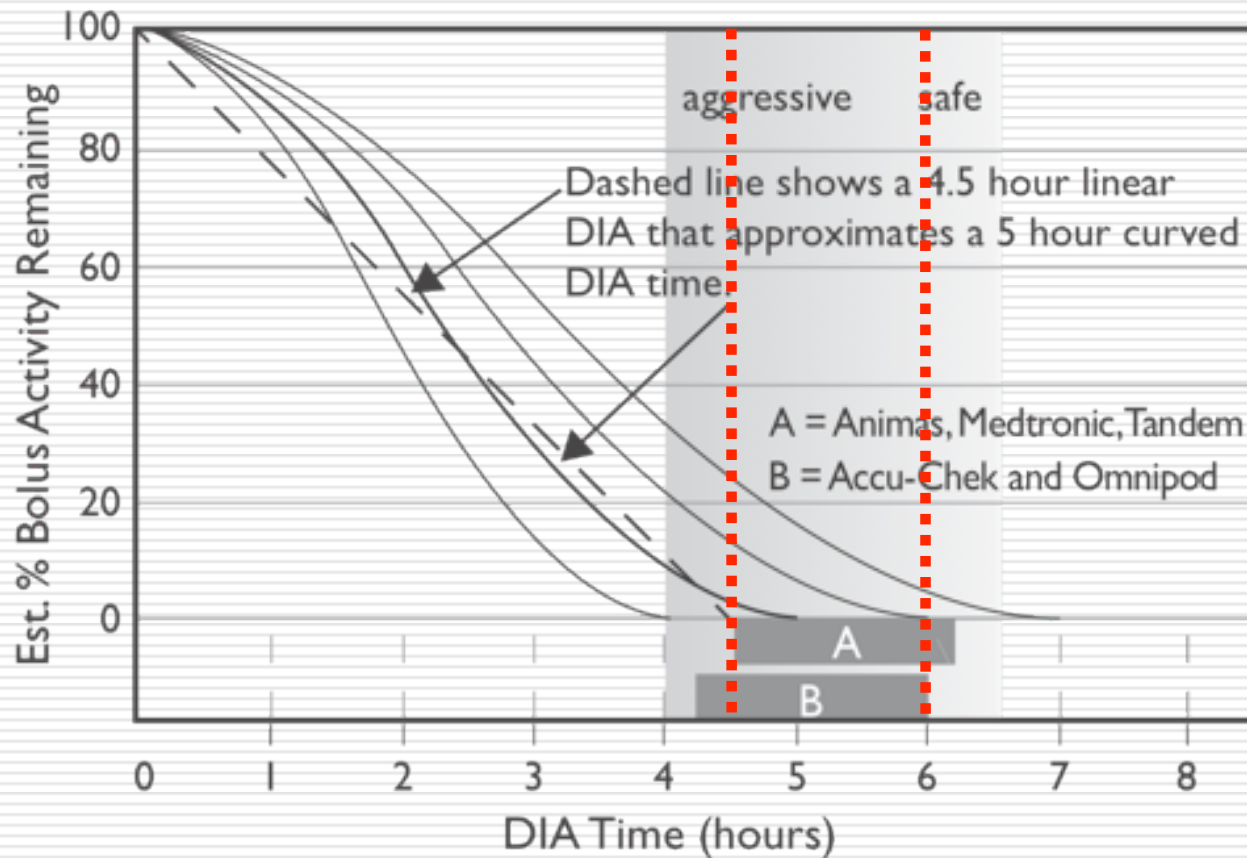How long a bolus lower the glucose

## Bolus On Board (BOB)
Bolus insulin still active from recent boluses

# Duration Of Insulin Action (DIA)



Humalog's Physiodynamic Effect On BG

*0*          *2 hrs*          *4 hrs*          *6 hrs*

*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!*

# Recommended DIA Times



Set DIA to 4.5 to 6 hrs for accurate calculation of BOB and bolus doses

*Graphic adapted from Mudaliar et al: Diabetes Care, 22: 1501, 1999*

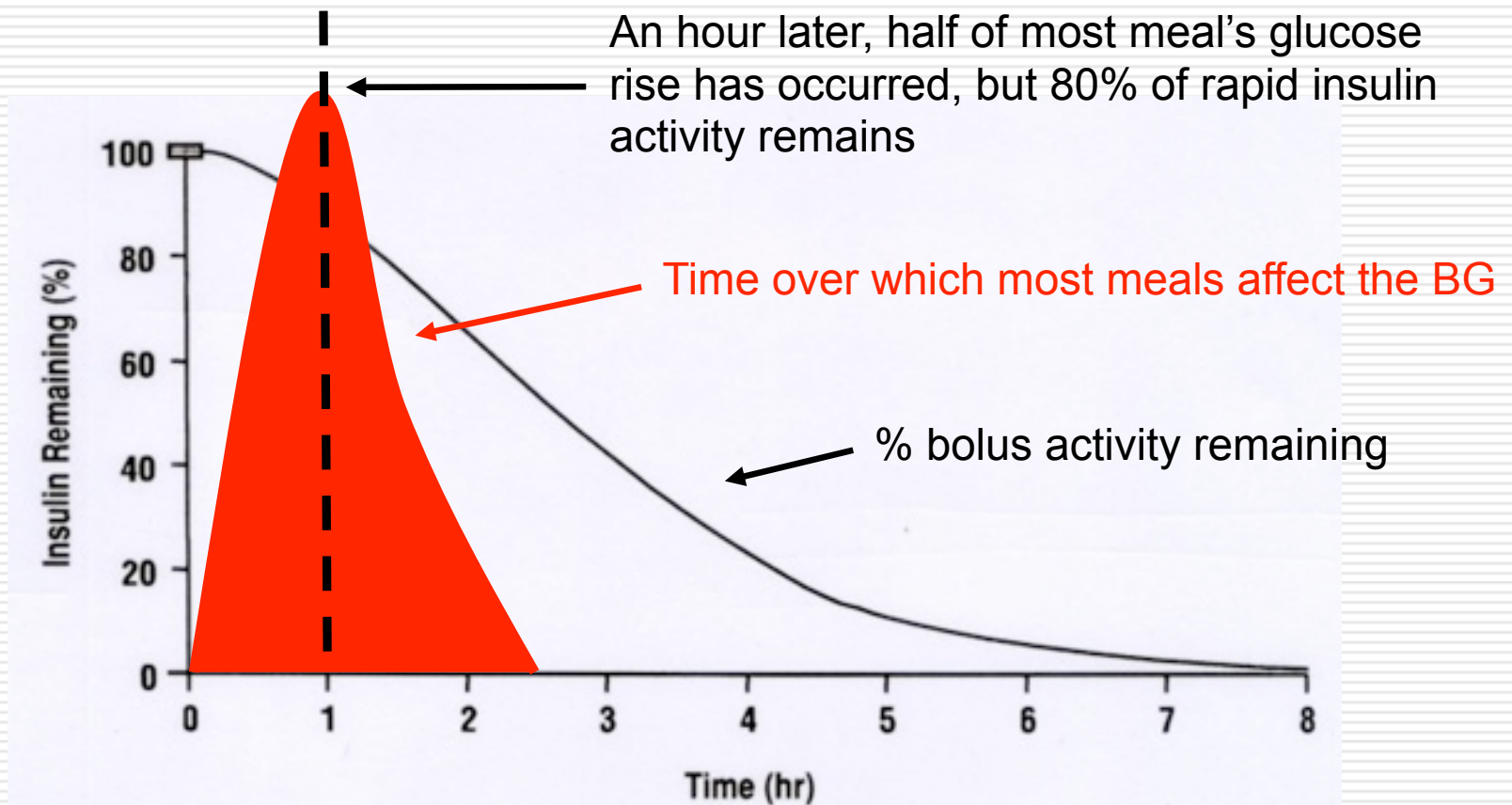# Typical Carb Digestion Times

| 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

# Most Carbs are Faster than "Rapid" Insulin

An hour later, half of most meal's glucose rise has occurred, but 80% of rapid insulin activity remains

Time over which most meals affect the BG

% bolus activity remaining

Insulin Remaining (%)

Time (hr)

**Take Home:** Bolus 15 to 30 minutes before meals

Use extended and combo boluses sparingly

From *Pumping Insulin*
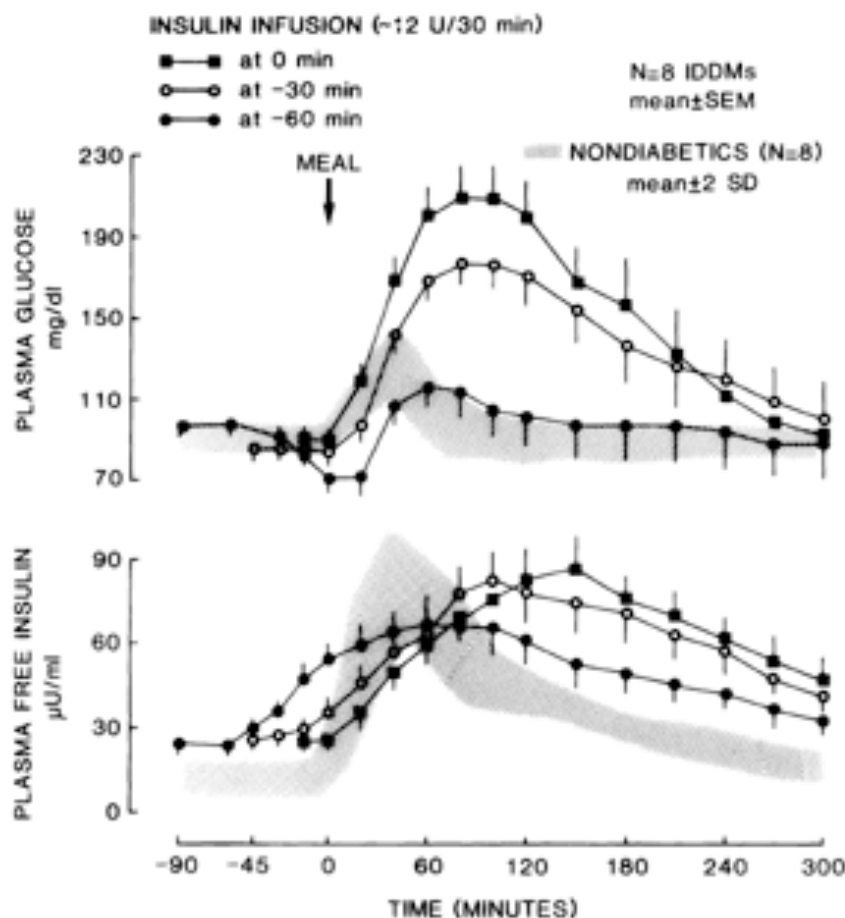
# Clever Pump Trick – Bolus Early To Stop Meal Spiking



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 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?**
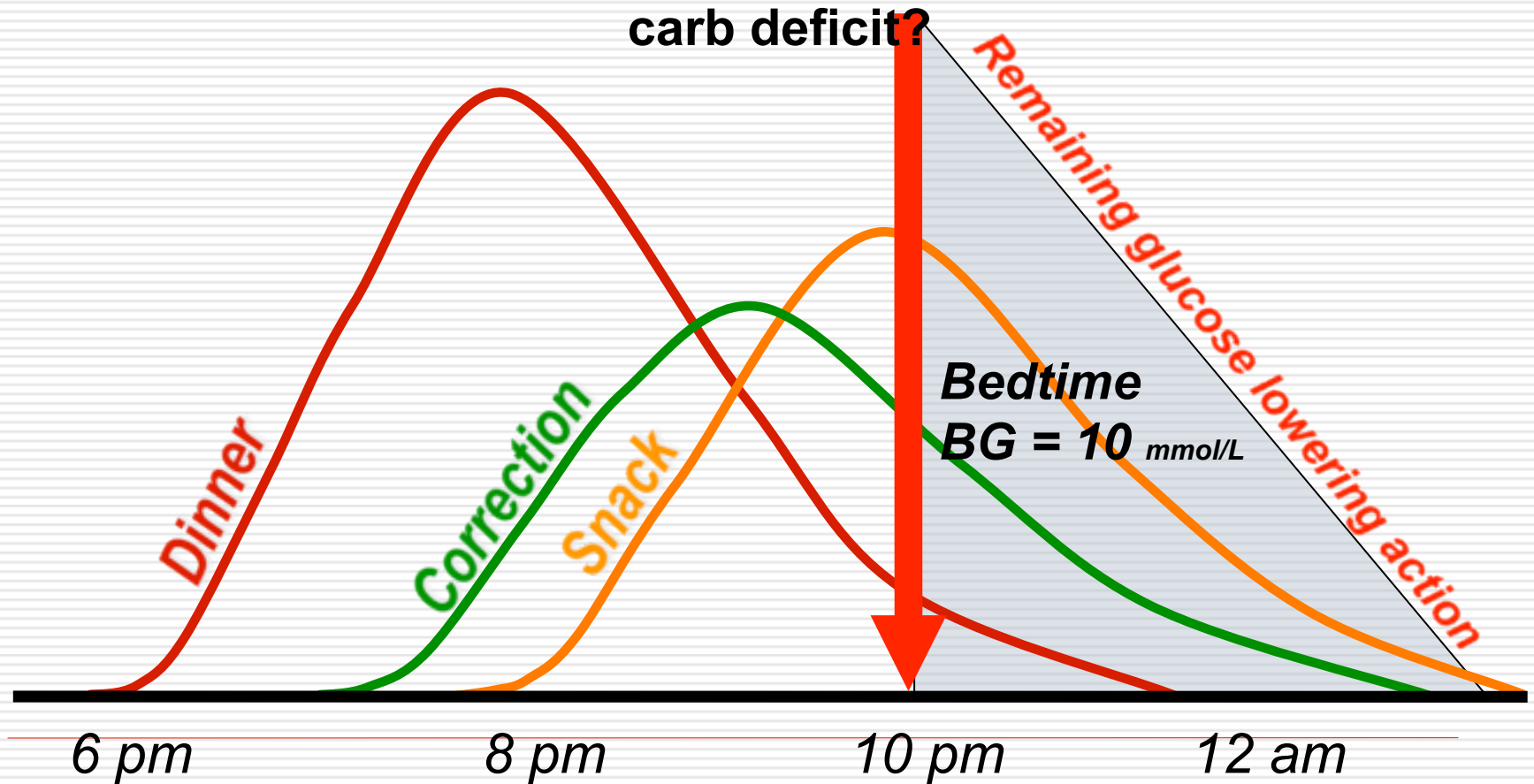
# A Short DIA Hides Insulin Stacking

**3 hours after a 10 unit bolus, this shows how much BOB a pump will think is left with each DIA time:**

| | 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 when she has 5 u of BOB left, a pump user eats a 50 gram dessert on 4 consecutive nights. Her glucose and the bolus recommendations from different pumps 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 6.8 mmol/L (122 mg/dl) at bedtime and she wants a 40 gram snack with 4.0 units of BOB.

CarbF = 10   CorrF = 3.0   Target = 6.7   DIA = 5

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?

# 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, <u>subtract BOB from the combined carb plus correction bolus</u>

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

# Example –
# Recommended Bolus May Be Changed

**MiniMed**
**ENTER FOOD**
## 30 grams

**MiniMed**
**Meter BG**
## 160 mg/dL

**ESTIMATE DETAILS**
Est total:        3.0U
Food Intake:      30 gr
(Meter) BG:       160
Food:             3U
Correction:       1.5U
Active Ins:       4.5U
ACT to Proceed
ESC to back up

**Find IOB or active insulin, then adjust dose:**

3
+ 1.5
- 4.5
= 0 u bolus

# The TDD and Best BC Settings

- The TDD controls the average glucose

- An accurate TDD makes it easy to find accurate basal rates, CarbF, and CorrF

- More accurate BC settings allow BGs to be lower and more stable

# APP Study –
# Doses Used By Successful Pumpers

## 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*

# APP Study – Pump Setting Formulas[1]

**Basal** = ~ 48% of TDD

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

**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

# Size Up the Glucose Problem

- **Severe** – An improved TDD (iTDD) will correct most major glucose problems

  - ☐ Select new pump settings from the iTDD

- **Moderate** – use pattern management to fine tune doses and pump settings

- **Mild** – tweak pump settings

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

# Tips – Steps To Control

- ☐ Stop lows first

- ☐ Take a bolus for every bite
  - ◼ Except for carbs used to treat a low BG
  - ◼ Or for carbs used to compensate for exercise
  - ◼ Check BG before every bolus – Don't blind bolus

- ☐ Bolus 15 to 30 min before meals if possible

- ☐ Periodically check basal/carb bolus balance

- ☐ Look for and correct unwanted patterns

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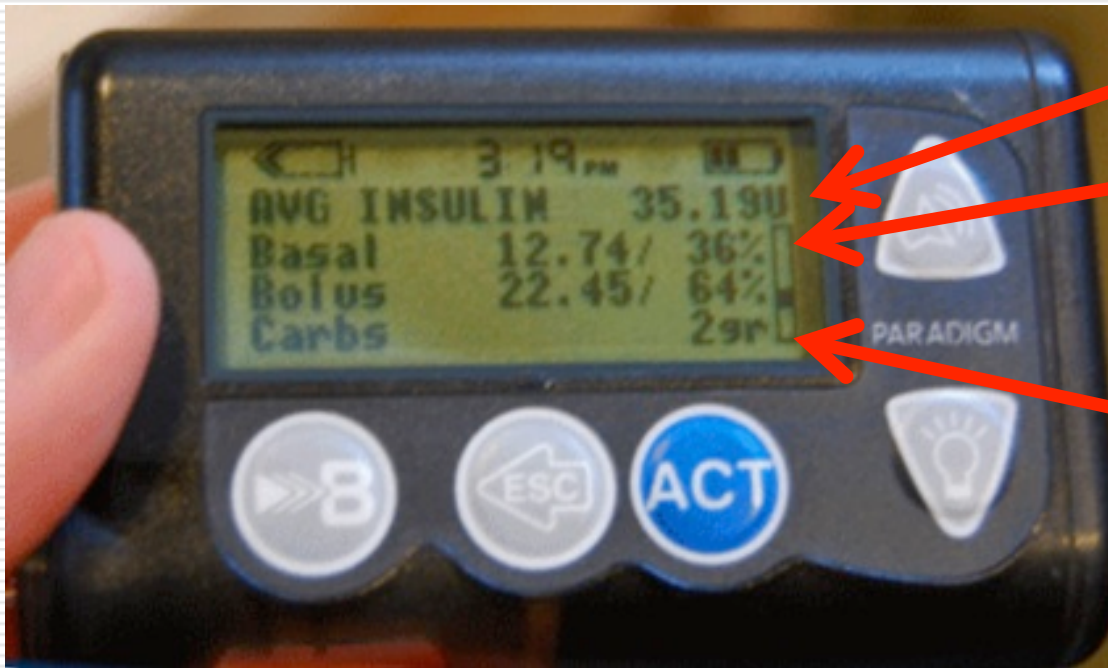


**TDD** = 35.19 u

**Basal %** is low at 36%

2 grams of carb/day means Bolus Wizard is not being used

# Verify the TDD

- Compare TDD to weight(kgs)/1.8

- Contrast TDD with A1c & avg. BG on meter, and check frequency and severity of lows

- Then decide if TDD should be increased or decreased

# Find an Improved TDD (iTDD)

If current BGs are not great:

- o Lower the current TDD by about 5% for:
    - Frequent lows
    - Or highs AND lows IF lows come first
- o Raise the TDD, using the iTDD Table on next slide to adjust for high A1c or high meter average
    - Increase TDD by 1% for each 0.3 mmol/L drop in avg BG
- o This gives the improved TDD (iTDD)

Keep basal and carb bolus totals balanced

**Avg BG on pumps is 183.9 mg/dl (10.2 mmol) – most need larger TDD.**

# 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
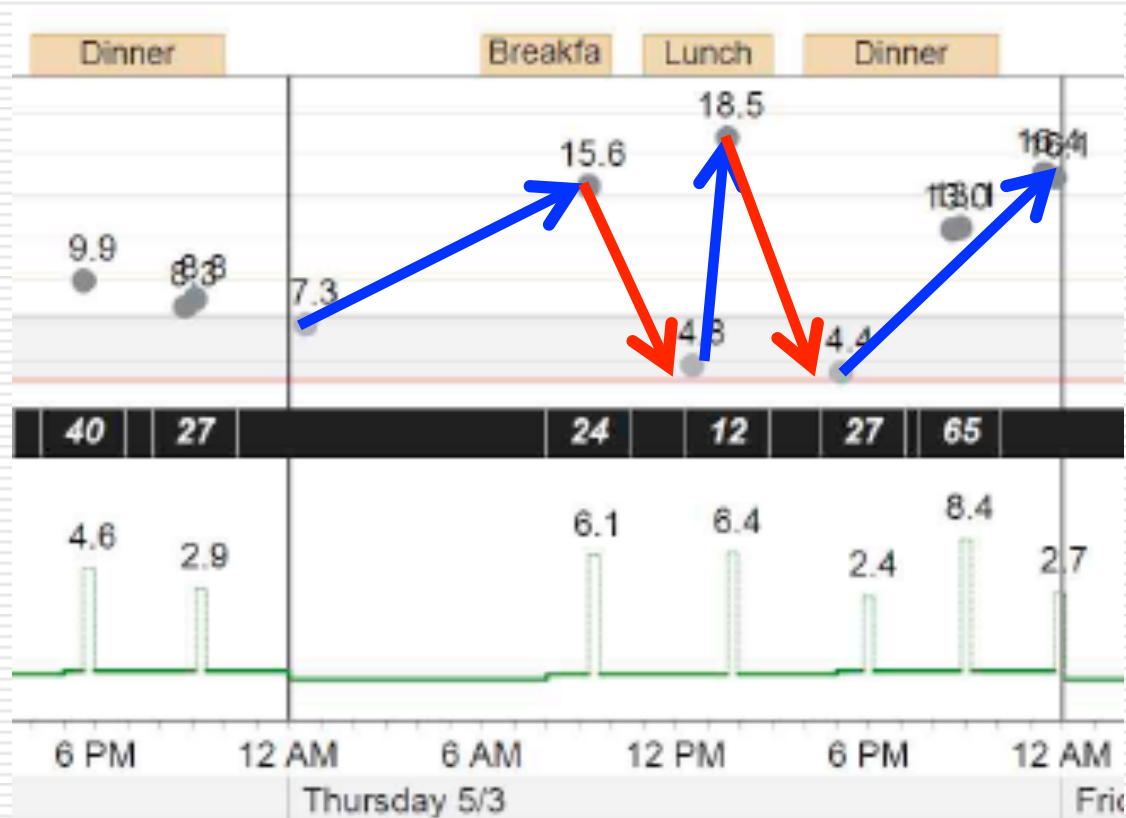


41 yo female with A1c = 6.9%

156lb/4 = 38.0 u/d

Actual TDD = 50.5 u/d

# Stop Frequent Highs

When average BG is high with few lows:

**Raise TDD by 1% for each 0.33 mmol/L (6 mg/dl)
or for each 0.2% in the A1c
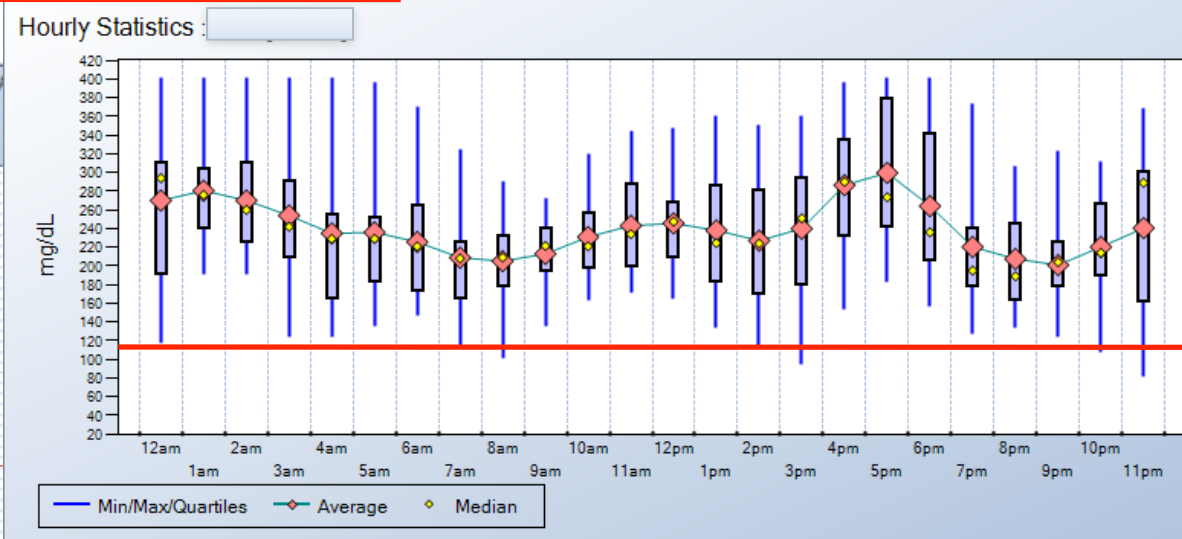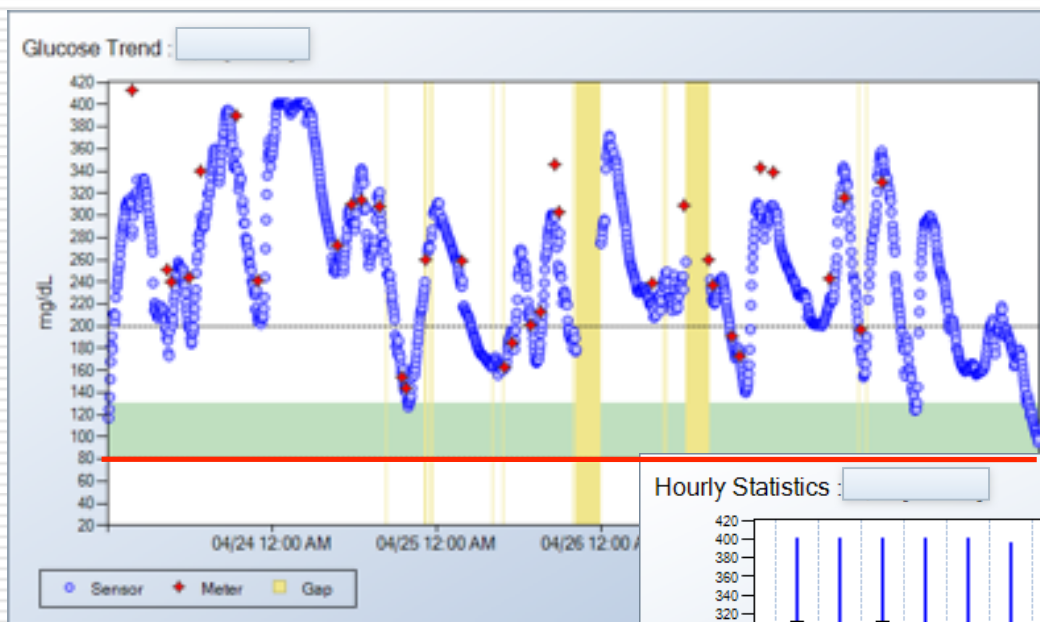you want to lower the average glucose**

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

# Example – Hyperglycemia

# TDD Before & After Adjustment



**Start TDD = 36 u**

o Raised basal by 0.05 u/hr all day (+1.2 u/day)

o Lowered carb factor from 1u/13g to 1u/12g (+1.8 u/day)

**End TDD = 39 u**

# Check that Pump Settings Fit the TDD

## 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

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

# TDD and Pump Settings 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

**Do not wait until the next clinic visit!**

# Basal Rates

Keep the glucose flat overnight or when a meal is skipped (with no BOB)
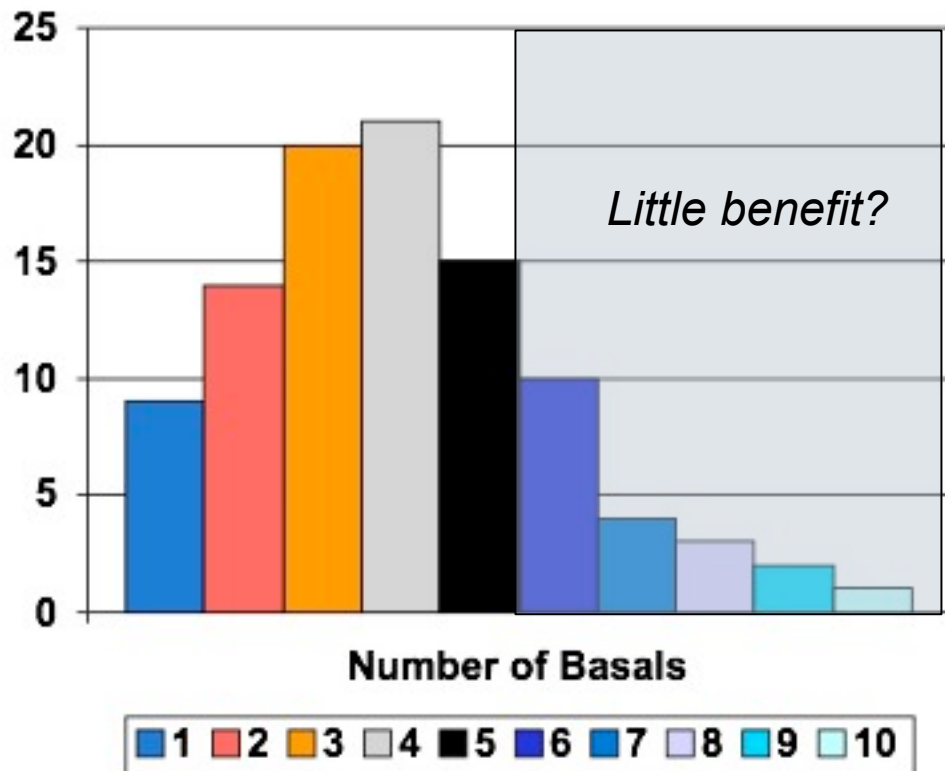
Easy to check – don't eat

Best basals: ~50-55% of TDD usually gives best results

     <50% for young children, some elderly, high carb diet

     >55% for low carb diet, insulin resistant

*See **Pumping Insulin** 5th ed, 2012, for details*

# 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.

# Basal Tips

- 50% Rule: basals usually make up 40 to 65% of an accurate TDD

- Basal rates should be similar, such as between 0.45 to 0.7, or 1.0 to 1.4 u/hr

- Adjust basal rates in small steps – usually 0.05 or 0.1 u/hr

- Change basal rates **3 to 8 hours** before the need arises

- Don't stop (suspend) pump longer than 30 min.

# Carb Counting

☐ Accounts for half the day's control

☐ Use accurate carb counts to match boluses and carbs for post-meal control and lower A1c

☐ Use automatic carb bolus calculations on pump

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

**Carb Factors Found In 405 Pumps**



$R^2 = 0.403$ *Carb settings found in pumps*

*10*  *R2 = 0.40*

34 of 405 pumps (8.4%) had no

*5*  *15*  *20*

Number of Pumps

1  2  3  4  5  6  7  8  9  10  11  12  13  14  15  16  17  18  19  20  21  22
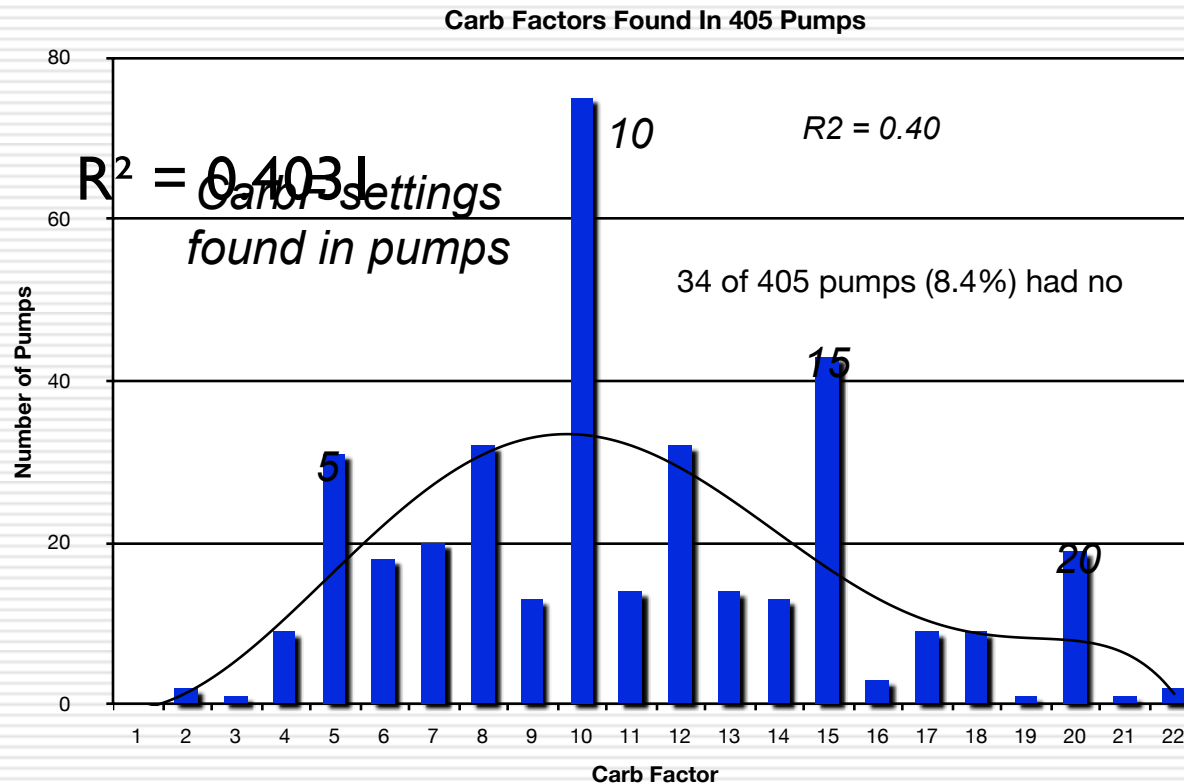
**Carb Factor**

Carb factors are not evenly distributed.

People prefer "Magic" numbers – like 5, 10, 15, and 20 g/u.

Always use formulas to select settings –> much 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*

# Carb Bolus Tips



☐ Make sure the carb factor works for LARGE carb meals: test with carb grams = half the body weight (lbs)

☐ Is carb counting accurate?

☐ Are boluses given 20 min before meals when glucose is normal?

☐ Try not to eat until below 7 mmol/L (140 mg/dl)

*For frequent lows after meals –> raise carb factor #*

*For frequent highs after meals –> lower carb factor #*

# Small CarbF Change = Large BG Change

| If CarbF is lowered from 1u/10g to 1u/9g | |
|---|---|
| TDD = 40 u | Corr F = 49 mg/dl per u |
| **Meal Size** | **BG Change per meal \*** |
| 60 grams | **0.67u x 49** = **– 33 mg/dl** |
| 100 grams | **1.1u x 49** = **– 54 mg/dl** |

\* Calculated as $\left[ \dfrac{\text{carbs in meal}}{\text{new carb factor}} - \dfrac{\text{carbs in meal}}{\text{old carb factor}} \right]$ X $\dfrac{1960}{\text{TDD}}$

# Clever Pump Trick –
## How Many Carbs for a Low?

1. 10 grams for each 35 kg (75 lbs) of weight
2. **+** grams  =  the current BOB*  x  CarbF

**Example:**

n   Amy weighs 70 kg (150 lbs)  =  20 grams of carb

n   And she has 2 units of BOB with a CarbF of 8 grams/unit
    2 u  x  8 g/u  =  16 grams

n   For this low she needs:
    20 g  +  16 g  =  36 grams

Add extra carbs as needed for recent or planned exercise.

**\* DIA time setting must be accurate to get an accurate BOB.**

# Types of Carb Boluses

**Regular**

- Taken immediately – for most meals
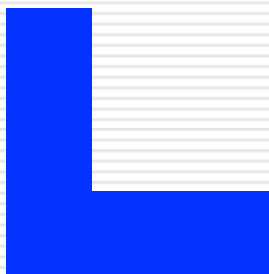
**Combo / dual wave**

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

**Extended / square wave**

- Extended over time – gastroparesis, Symlin, GLP-1 agonist

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

# Clever Pump Trick –
# Stop Post Meal Spikes

- Count carbs carefully

- Bolus 15 to 30 min before meals if 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

# Clever Pump Trick –
# Super Bolus – Shift Basal To Bolus
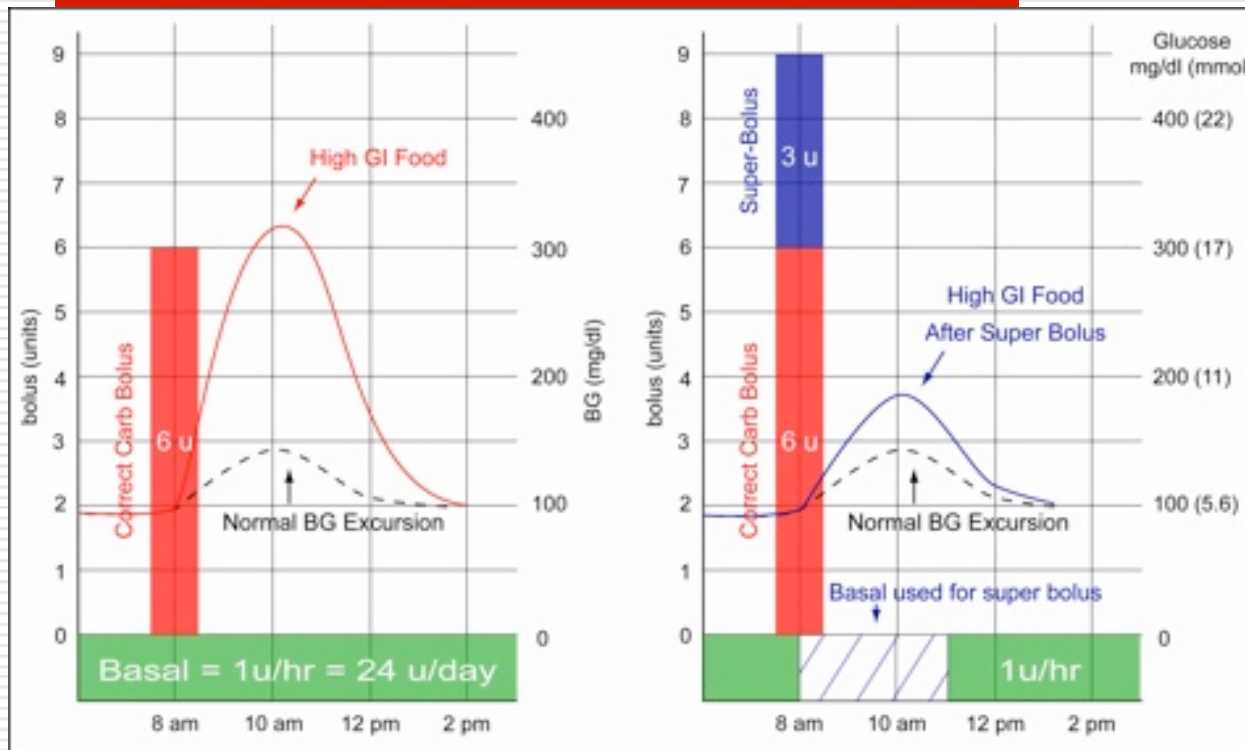


Helps when eating over 30 to 40 grams of carb

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

# Infusion Sets

The Achilles Heel of Pumps

# Infusion Set Failure

**Infusion sets fail from:**

- Partial/complete pullouts

- Leaking around Teflon to skin (common)

- Loose hub

- Use of auto-inserter

- Pets & punctures

- Occlusions
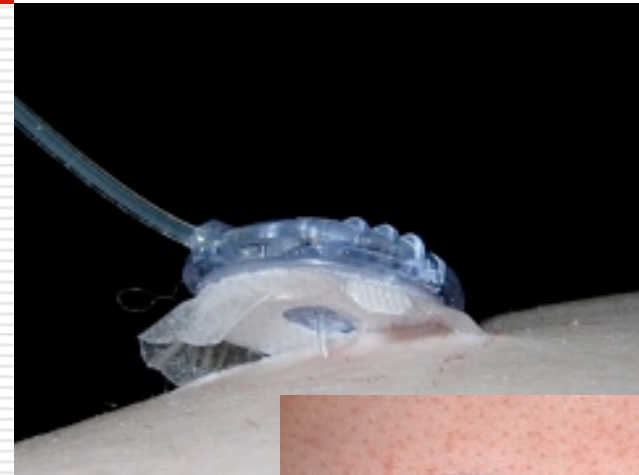
# Average BGs Before & After Set Change
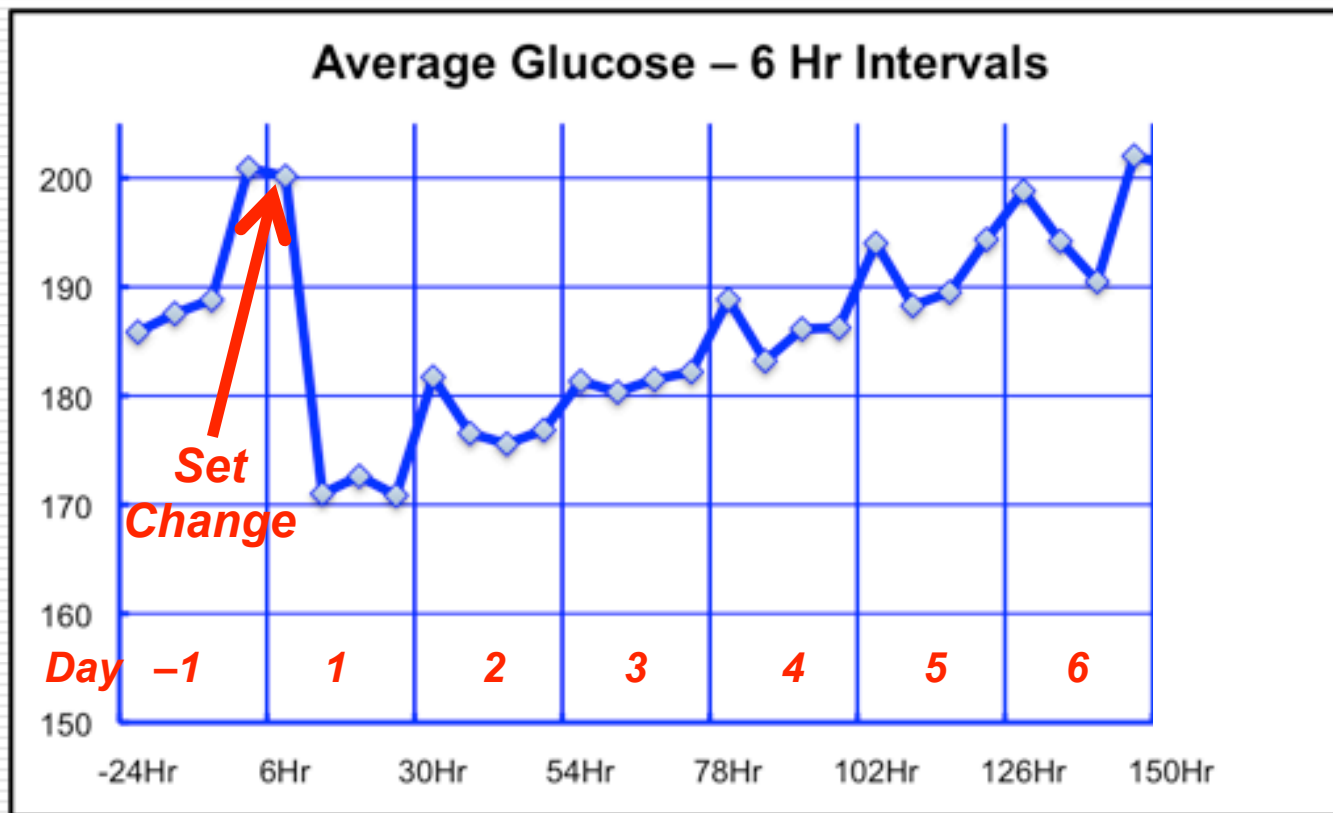


Average BG levels during 6 hr intervals before and after infusion set change in 396 pumps with ~20 infusion set changes/pump.

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

# 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
- Review site prep technique
- Switch to a different brand of infusion set

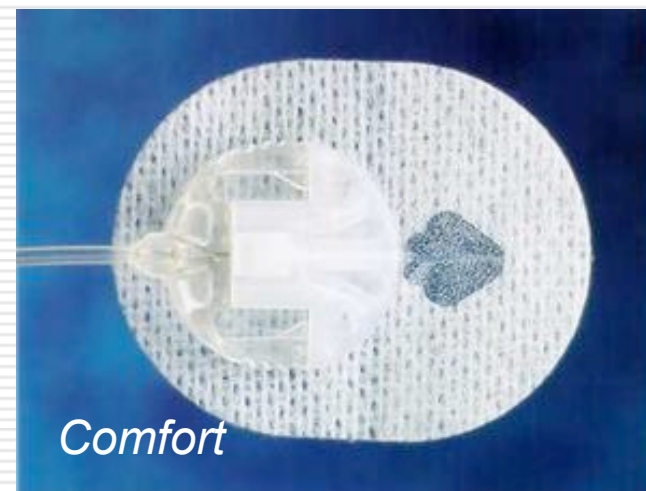# Infusion Set Failure Shown On CGM
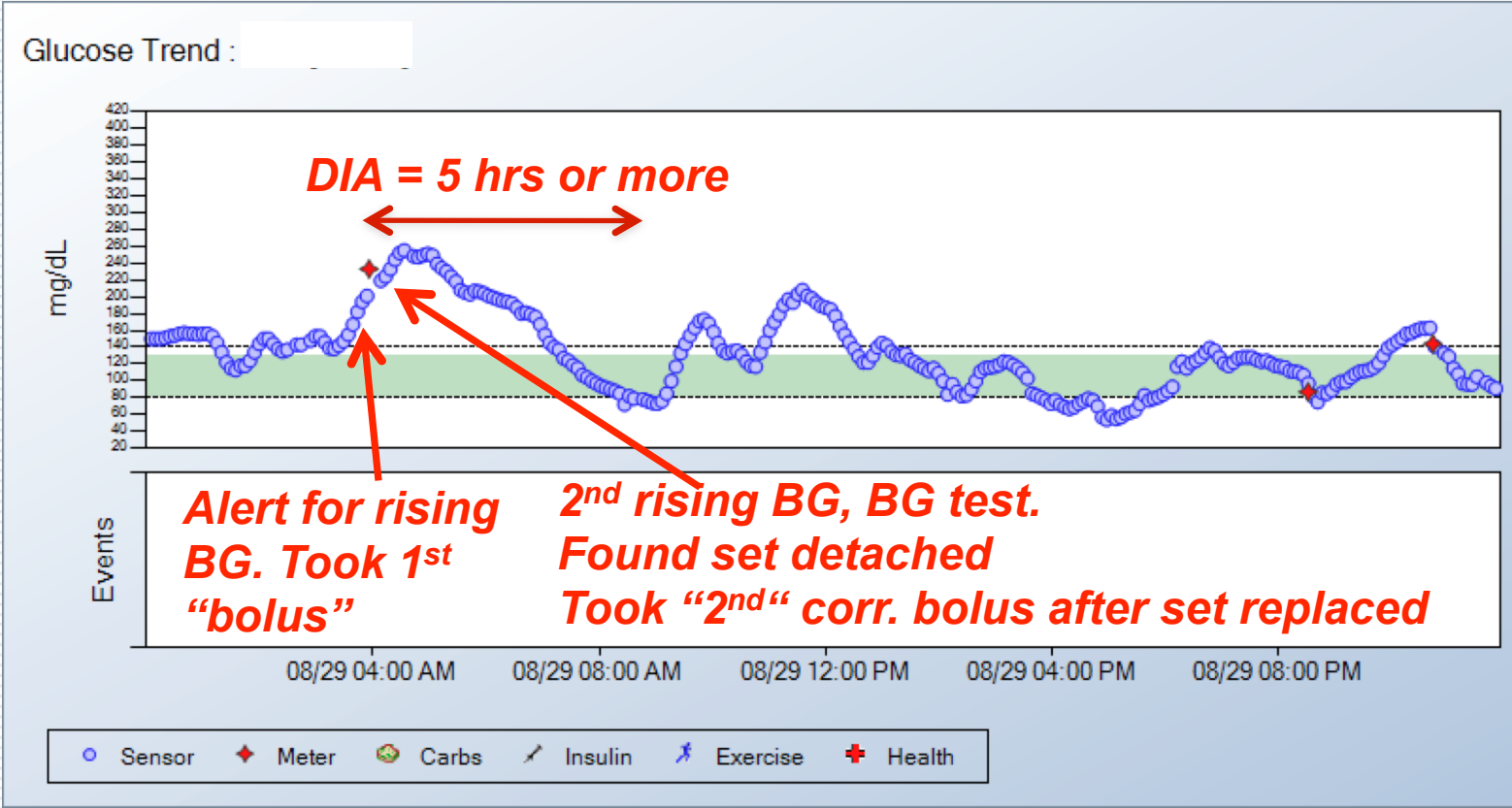
# APP – Occlusions Worsen Control

| BG Tertile | Low | Middle | High |
|---|---|---|---|
| **Avg BG** | 144 mg/dl<br>8.0 mmol/L | 181 mg/dl<br>10.1 mmol/L | 227mg/dl<br>12.6 mmol/L |
| **BGs/day** | 4.73 | 4.41 | 4.01 |
| **Blocks/month** | 1.36 | 3.04 | 3.57 |

# Use Reliable Infusion Sets



*Contact Detach*



*Comfort*

ALWAYS anchor the Comfort infusion line with 1" tape to minimize site irritation and reduce tugging that can cause leaks.
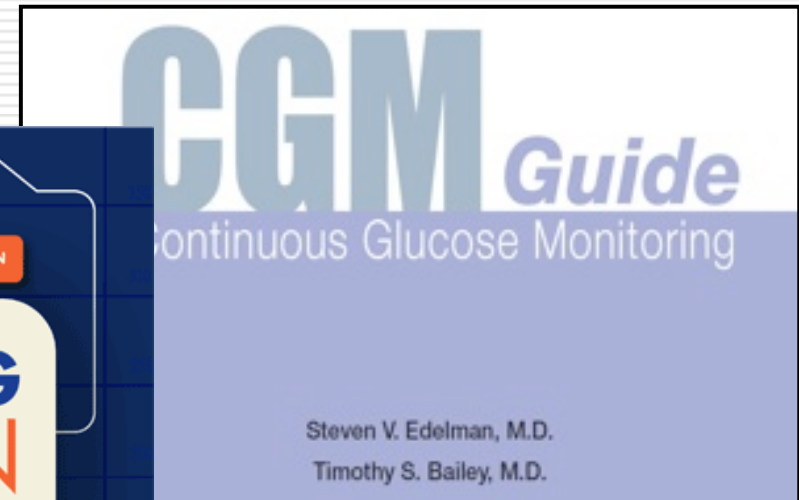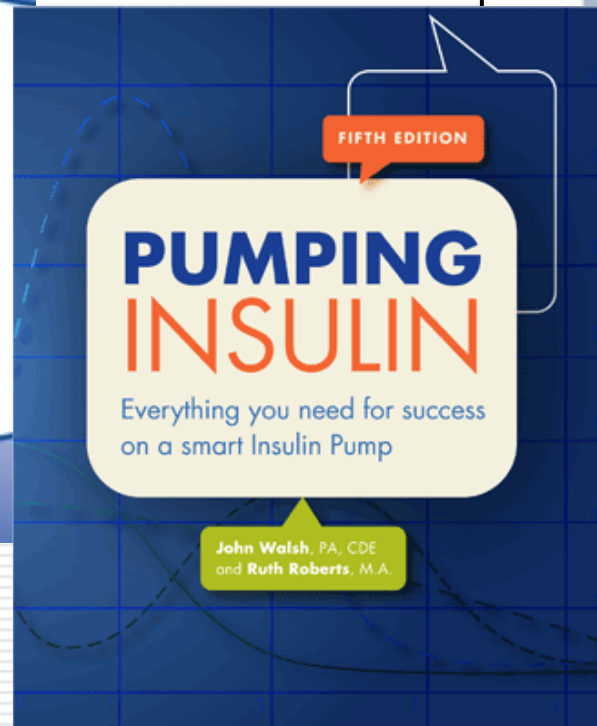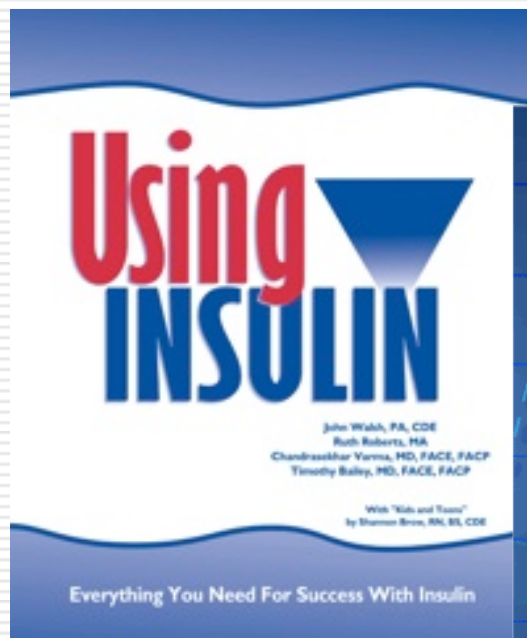
# Anchors – Not Just For Boats!!!

## 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

*No anchor!*

Lose tape not insulin

# Questions & Discussion



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