Dose Guide for Insulin Pumps and CGMs – by John Walsh, PA, CDTC

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Pumps and CGMs improve glucose levels and quality of life as clinicians and users become proficient in their use. At each clinic visit, establish together the things that can be done for great glucose readings: healthy foods, boluses given 15 to 30 min. before meals, regular exercise, glucose monitoring 6 x a day or wearing a CGM at least 6 days a week, and not over-treating lows with carbs nor highs with insulin. Set clear goals, such as an A1c <7.5% or <7.0% with few lows, or 70% of readings in target range.

Steps to Better Control:

The *average total daily insulin dose (TDD)* (14 days or more) controls the A1c, frequency of highs and lows, and is the best guide to appropriate pump settings. As a guide to a person's insulin sensitivity or to check for a possible insulin overdose, *compare the current TDD with a reference TDD for weight. Wt(lbs) / 4* = the expected TDD for a person who has an avg. sensitivity to insulin. The avg. TDD (all basal and bolus doses) is available in a pump or pump download.

A. *Stop frequent lows first. For example, if BGs are less than 60 mg/dl 4 or more times a week in a healthy adult, reduce the average TDD by 5% to 10%.* (Allow less hypoglycemia in ill, elderly, or hypoglycemia unaware individuals.). Reduce again if needed.

B. *Then stop frequent highs.* If the A1c is >7.5% or the average glucose is over 165 mg/dL with few lows, increase the average TDD with **the 5-1-6 Rule**:

1. *Raise the TDD by 5% for every 1% reduction desired in the A1c*, e.g. If the A1c is 10.0% and the target is 7.0%, 10% – 7% = a 3% lower A1c x 5% = a 15% increase in the TDD. For an average TDD of 40 u/day, the new avg. TDD would be 40 u x 1.15 (or 115%) = 46 units a day.

2. *Or raise the TDD by 1% for every 6 mg/dL reduction desired in the average glucose,* e.g. if the average meter glucose is 200 mg/dL and the target is 140 mg/dL, (200 – 140) = 60 / 6 = a 10% increase in the TDD. For an average TDD of 40 u/day, 40 u x 1.1 (or 110%) = 44 units as the new TDD. (A CGM's average glucose can be trusted; a meter average can mislead if user treats but doesn't test when low, tests on other meters, etc.)

3. A pump wearer can also check glucoses 6-8 times a day and cover all highs with correction boluses. After 7 days, this new 7-day average TDD can be used to select better pump settings. Repeat if needed.

Use the Pump Settings Tool at www.opensourcediabetes.org to optimize TDDs and pump settings.

C. For *basal and bolus testing*, a clear-out period is needed before the test – no boluses for 5 hrs and no carbs for 3 hrs.

1. *Set and test basal rates* – Basal insulin makes up 45% to 60% of TDD for most adults. 50% basal is a good place to start. (Use Table 1 to find an average hourly basal.) A successful basal test keeps the glucose within +/- 30 mg/dL of the starting glucose over 6 to 8 hrs.

2. *Set and test the CarbF (I:C ratio)* –
CarbF = 2.6 x weight(lbs)/TDD (e.g. for 154 lbs and 40u TDD, 2.6 x 154 / 40 = 10.0 grams/unit as the CarbF). See Table 2 for adjustment increments. A successful CarbF test brings the premeal glucose to within +/- 20 mg/dL of the starting glucose after 5 hrs with no lows. In pre-teen children who generally need smaller boluses, use CarbF = 3.0 x weight(lbs)/TDD.

3. *Set and test the CorrF (ISF)* –
CorrF = 2000/TDD; so for a TDD of 40u, 2000/40 = a 50 mg/dL drop per unit. With larger basal and carb bolus deficits (ie, a high A1c), correction boluses become larger (or a smaller CorrF number shown in Table 3). As basal & carb bolus deficits shrink, smaller correction boluses and a larger CorrF are needed. A successful CorrF test brings a high glucose down to within +/- 30 mg/dL of target glucose after 5 hrs.

1. Avg. Basal Rate for Basal %s of TDD	
For a basal % of:	**Avg. Basal Rate per Hour will be:**
40%	TDD x 0.017
45%	TDD x 0.019
50%	TDD x 0.021
55%	TDD x 0.023
60%	TDD x 0.025
Example: if TDD = 50 u and 50% basal is desired, 50u x 0.021 = 1.05 u/hr	

2. Change CarbF (ICR) in Small Steps	
If current CarbF is:	**Adjust up or down by:**
Less than 5.0 gr/u	+/- 0.2 to 0.3 grams/u
5-10 grams/u	+/- 0.3 to 0.5 grams/u
10-15 grams/u	+/- 1.0 grams/u
16-24 grams/u	+/- 1 to 2 grams/u
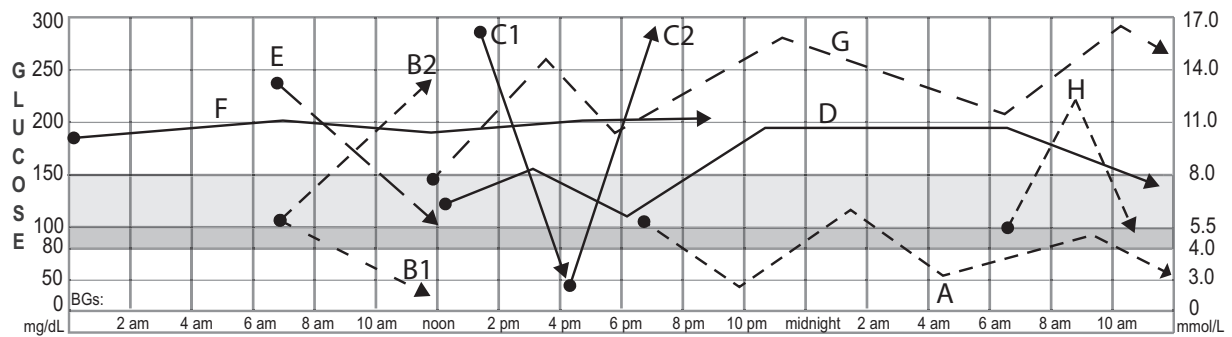
D. *Use pattern management* – Common problematic patterns are shown above with solutions below. Address breakfast lows or highs first, then correct the next time of day when the glucose is lowest or highest. Several patterns often coexist. Choose one at a time and adjust the basal rate or bolus most responsible for that pattern. **Get rid of excess lows first,** then the highs.

   A) *frequent lows* (lower TDD by 5-10% & find new settings from it), B1) *lows at a particular time of the day* (lower basal rate 5-8 hrs earlier or raise CarbF before previous meal), B2) *highs at a particular time of the day* (raise basal rate 5-8 hrs earlier or lower CarbF before previous meal), C1) *over-correction of highs* (do not increase recommended bolus, raise the CorrF/ISF, set DIA to 4.5 hrs or longer), C2) *over-treatment of lows* (stop lows, don't overtreat: carbs = wt(lbs)/10 in grams + BOB x CarbF) D) *most common pattern* (high after dinner and into night – raise afternoon and evening basal, lower supper CarbF), E) *pre-breakfast highs* (stop bedtime highs, raise night basal) F) *frequent highs and relatively flat all day* (raise basal rates), G) *frequent highs with post-meal spiking* (raise basal rates and lower CarbF (I:C ratio), H) *post-meal spiking* (bolus earlier).

E. *Use a CGM to improve readings*

   1. ***In Real Time*** – Spend more time between the lines: Increase boluses or basal rates with less carb intake to stay below upper glucose target. Increase carb intake or decrease basal rates or carb boluses to stay above lower target. When you bolus, consider BOB (bolus on board that remains active), your current glucose, and the rate and direction of change on CGM.

   2. ***From CGM download*** – get a clear view of improvements needed in basal rates, boluses, or lifestyle.

3. Use Larger CorrF with Lower A1c	
Recent A1c	**Corr Factor Formula**
>10%	CorrF = 1400/TDD
8% to 10%	CorrF = 1600/TDD
7% to 8%	CorrF = 1800/TDD
6.6% to 7%	CorrF = 2000/TDD
< 6.6%	CorrF = 2200/TDD

F. *Monitor basal/carb bolus balance.* Most adults and adolescents do best with about 55% (45-60%) of the TDD as basal insulin. Basal % can be lower in children prior to puberty and in lean older adults. For frequent lows, lower the basal rates if basal insulin makes up over 55-60% of avg. TDD or raise the CarbF if carb boluses are more than 45-50% of TDD. For frequent highs, raise the basal rates if basal insulin is less than 45-50% of avg. TDD or lower the CarbF and ensure accurate carb counts if carb boluses are less than 40-45% of TDD.

Pump Tips

- The bolus calculator (BC) improves control. Select settings carefully and enter carbs and BG before each meal. A bolus lowers the glucose for 4-6 hours. Set the DIA at 4 to 6 hours to avoid hidden insulin stacking.
- To treat lows, give 1 gram of fast carb for each 10 lbs of weight (6 grams minimum) plus BOB x CarbF.
- Check for infusion set failure first when 2 unexplained highs occur in a row. Give an injection and change the set.
- To estimate average daily calorie intake, multiply the average daily grams of carb in pump history by 10. If calories or grams appear low, the BC is not being used or carbs are being undercounted.
- Change basal rates 2-3 hrs before a rise or fall begins or 5-8 hrs before the high or low glucose happens.
- Use a single glucose for the correction target. For example, use 80 or 90 mg/dL for pregnancy, 100 or 110 for most adults and teens, or 140 mg/dL for hypo unawareness, high risk profession, or living alone.
- Override BC's recommended bolus when BOB is greater than correction units, after recent exercise, etc.
- Avoid self-induced lows due to exercise, excessive boluses, missed carbs, alcohol intake, or starting a diet. Avoid self-induced highs from late bolusing, inadequate basal rates, high GI food choices, or inaccurate carb counts.
- When clarification is needed for highs or lows, make a record of carb grams, foods eaten, activity, bolus doses, etc that occurred in the 5-6 hr period before each low and high glucose reading .