

Insulin Pumps Give Different Bolus Recommendations When BOB Is Large

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John Walsh, P.A., C.D.E.
North County Endocrine
700 West El Norte Pkwy
Escondido, CA 92126
(760) 743-1431

[The Diabetes Mall](#)
www.diabetesnet.com
(619) 497-0900
jwalsh@diabetesnet.com

Highlights



Bolus on board* (BOB) is meant to improve bolus accuracy

HOWEVER, different pumps may recommend very different bolus amounts when

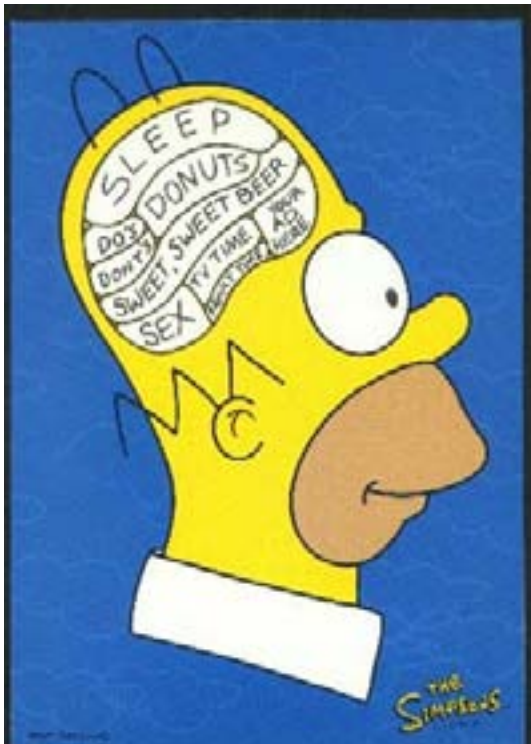
- 1. BOB is present and the glucose is below target,*
- 2. Or BOB is larger than the correction bolus need and additional carbs will be eaten*
- 3. Or the BOB calculation is inaccurate due to an inaccurate duration of insulin action (DIA)*

This presentation explores why pump bolus differences arise.

* aka: insulin on board (IOB), active insulin, unused insulin

Let's Repeat That

Recommended boluses from different pumps differ when:



BOB is present and the glucose is below target,

Or BOB is larger than the correction bolus need and additional carbs will be eaten

Or the BOB calculation is inaccurate due to a duration of insulin action (DIA) that is either too short or too long.

Bolus On Board*

BOB* shows how much glucose-lowering activity remains from recent boluses to:

- Avoid insulin stacking
- Improve bolus accuracy
- Reveal the current carb deficit or insulin deficit

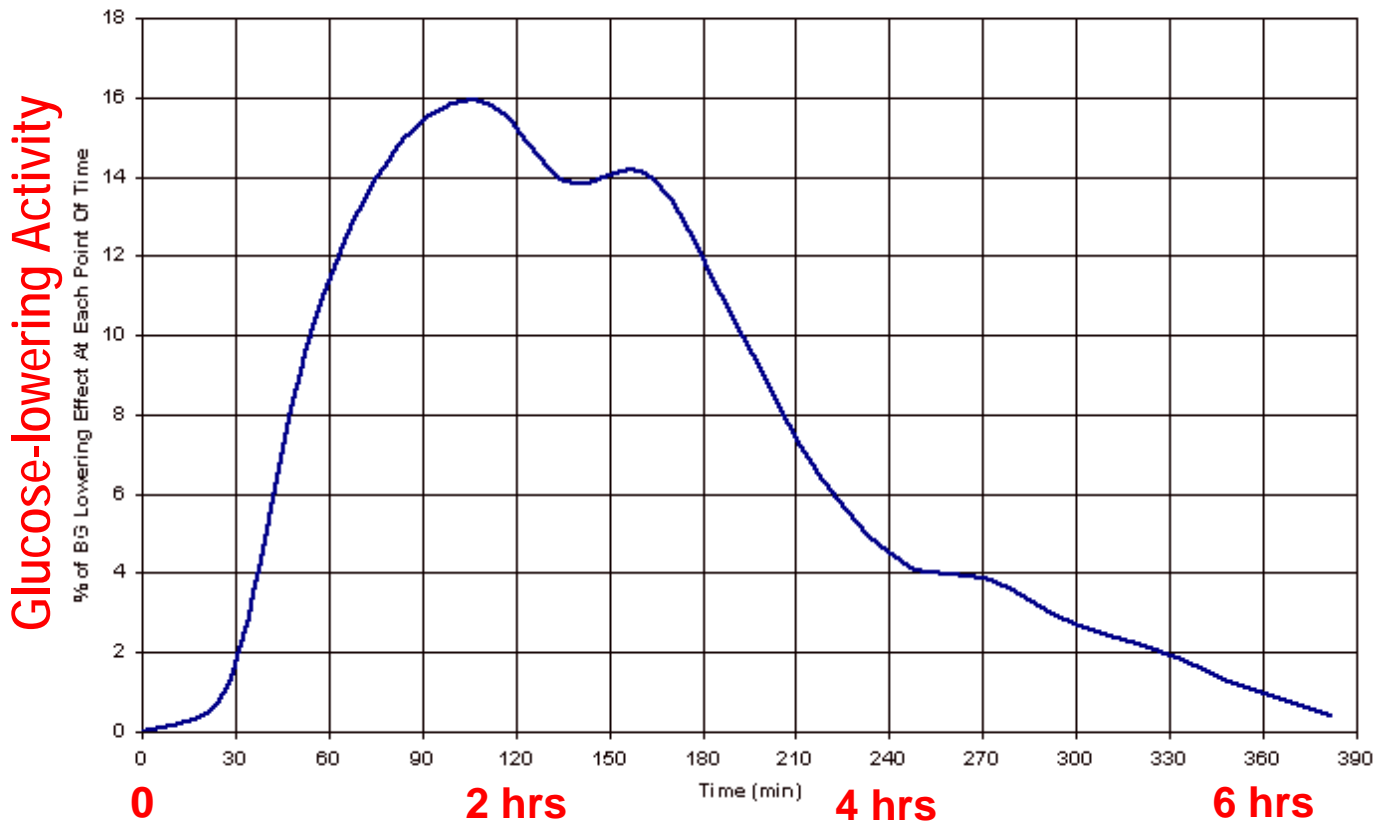
BOB does not measure any basal insulin activity
A pump requires an accurate DIA to accurately calculate the BOB

* BOB – a more precise term than IOB or active insulin

Duration Of Insulin Action

An accurate duration of insulin action is needed for BOB to work.

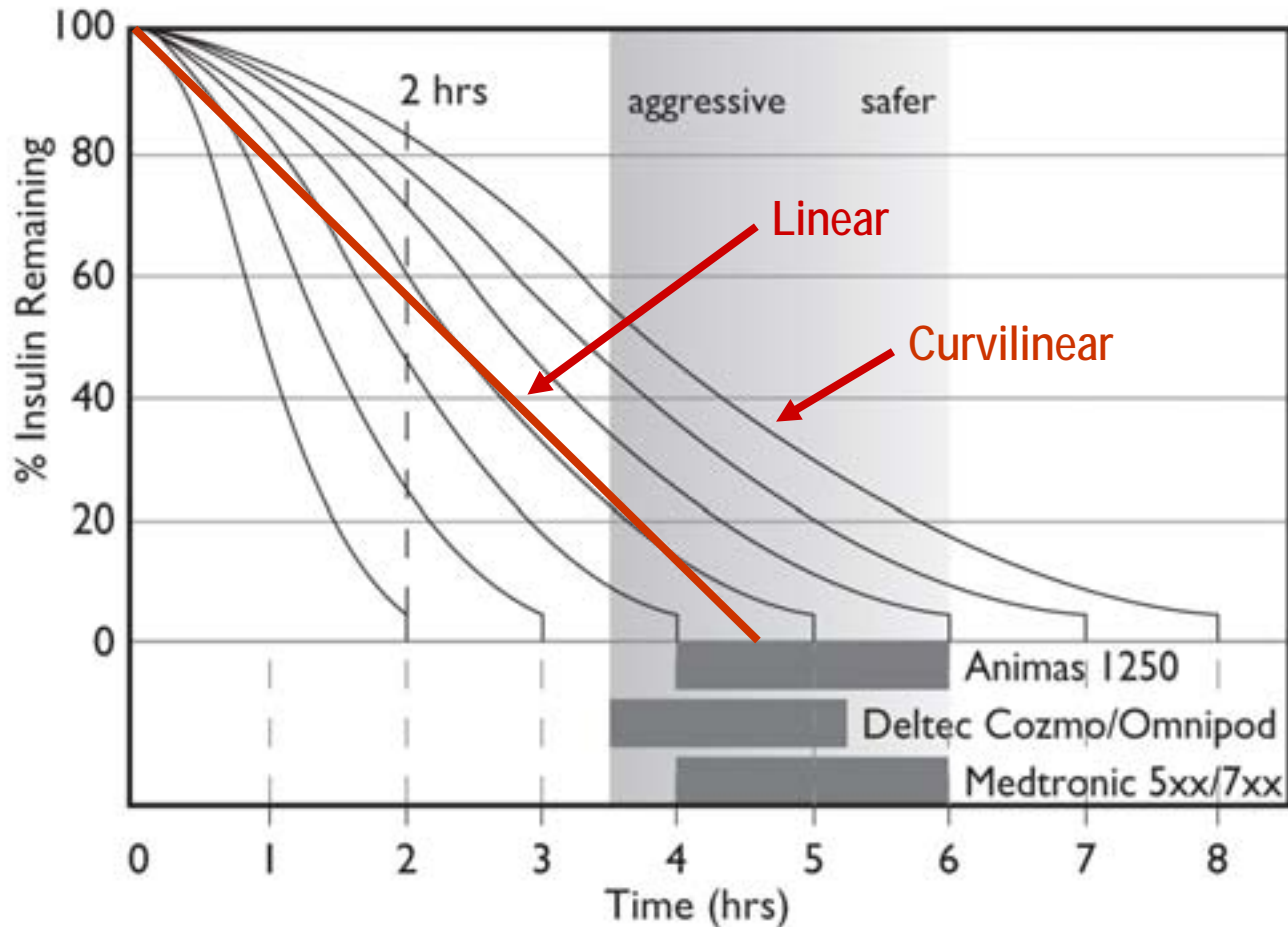
Humalog's Physiodynamic Effect On BG



Many pump users set their DIA too short!!!

A DIA shorter than 4-7 hrs hides BOB and its glucose lowering activity.

Recommended DIA Times



From Pumping Insulin, 4th Edition

An accurate DIA significantly improves control
Allows accurate bolus calculations when BOB is present

We recommend that almost all DIAs be set between 4 and 6 hrs in order to get accurate bolus calculations.

DIA Adjustments

How Different Pumps Handle DIA				
	DIA Type	% Of DIA Time Measured	Default DIA	Time Increment For Adjustments
Animas 1250	Curvilinear	100%	4 hrs	30 min
Deltec Cozmo	Linear	100%	3 hrs	15 min
Insulet Omnipod	Linear	100%	NA	30 min
Paradigm 522/722	Curvilinear	95%	6 hrs	60 min

This table show how each pump calculates its duration of insulin action. This, in turn, affects how BOB is calculated when a glucose value is entered into the pump.

Why The DIA Gets Set Too Short

MANY pumpers and clinicians set the DIA too short.

Clinicians often mistake the insulin level in the blood (3-4 hr duration) for insulin's glucose-lowering effect that lasts 4-8 hrs.

When a pumper finds that recommended bolus doses do not bring high BGs down (often caused by a low basal rate), shortening the DIA is perceived to be easier or safer than raising basal rates or lowering the carb factor.

A DIA time less than 3.5 to 4 hours almost always indicates that basal rates or carb boluses are too low and is usually indicated by an elevated A1c level.

A short DIA forces insulin delivery toward boluses

Problems Arise With Short/Long DIAs

If DIA is set too short --> hides boluses, tends to increase bolus doses, causing basal rates to be lowered

If DIA is set too long --> exaggerates bolus action, tends to decrease bolus doses, causing basal rates to need to be raised



The Paradigm® 515 Insulin Pump

The typical DIA range of 2 to 8 hrs in pumps is too wide for today's insulins!

Bolus On Board

Let's look at various scenarios to see how BOB is handled differently in different pumps.

Situation:

Let's say a person tests near bedtime and finds their BG is 160 mg/dl. Do they need to:

- bolus to lower this reading,
- eat additional carbs to prevent a low during the night,
- or do nothing and sleep soundly?

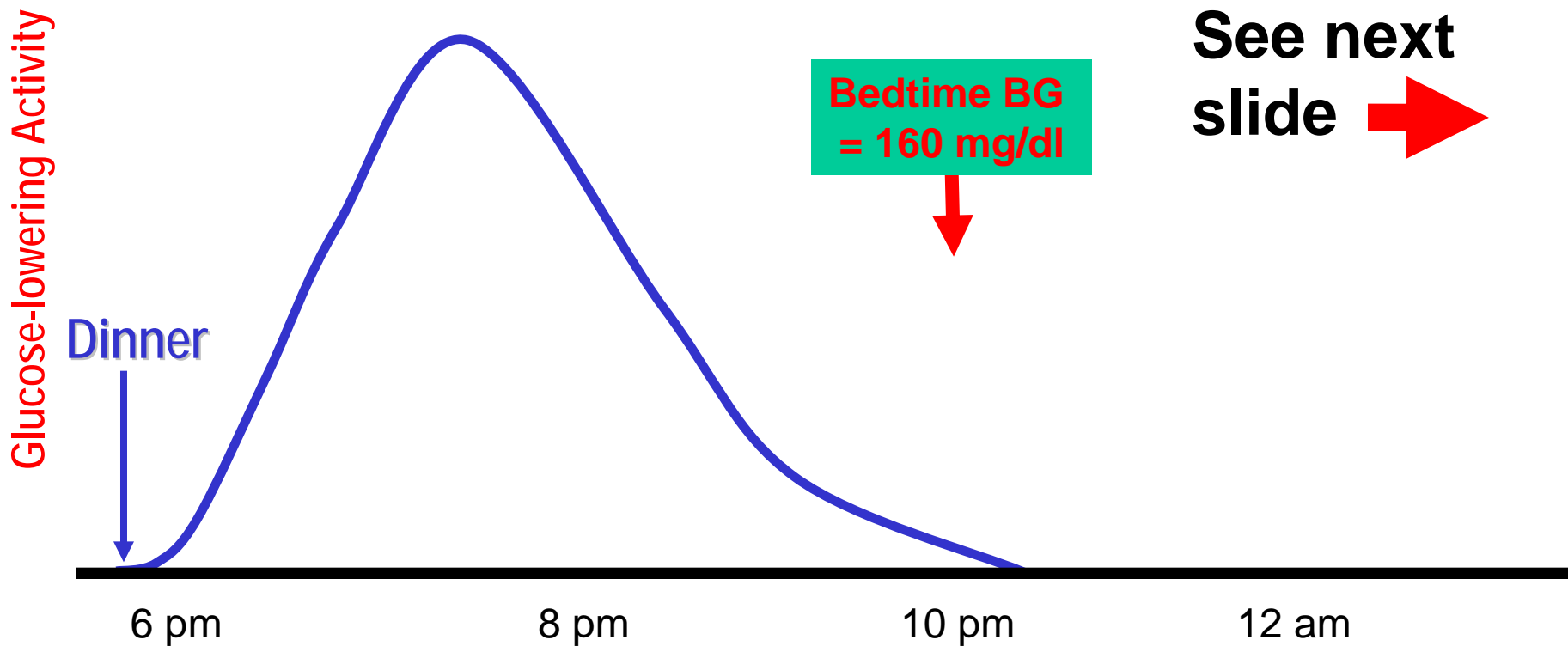
My glucose is 160 ... do I eat or do I bolus?



This person's carb factor = 1 unit for 10 grams, with a correction factor of 1 unit for each 40 mg/dl above 100 mg/dl (their target).

Scenario 1: No Insulin Stacking

Here, only one bolus is active and the bedtime BG is 160 mg/dl with no BOB. The amount of correction bolus insulin to give is easy to determine.



Scenario 1: No Insulin Stacking

Correction bolus to lower the BG from 160 to 100 = 1.5 u

BOB = 0 u

$$1.5 \text{ u} - 0 \text{ u} = 1.5$$

Recommended bolus = 1.5 u

All pumps agree here...

1. No Insulin Stacking

No Difference In How Pumps Cover A High BG

MiniMed
ENTER FOOD

0 grams

MiniMed
Meter BG

160 mg/dL

ESTIMATE DETAILS

Est total: **1.5U**

Food Intake: 30 gr

(Meter) BG: 160

Food: 0U

Correction: 1.5U

Active Ins: **0U**

ACT to Proceed

ESC to back up

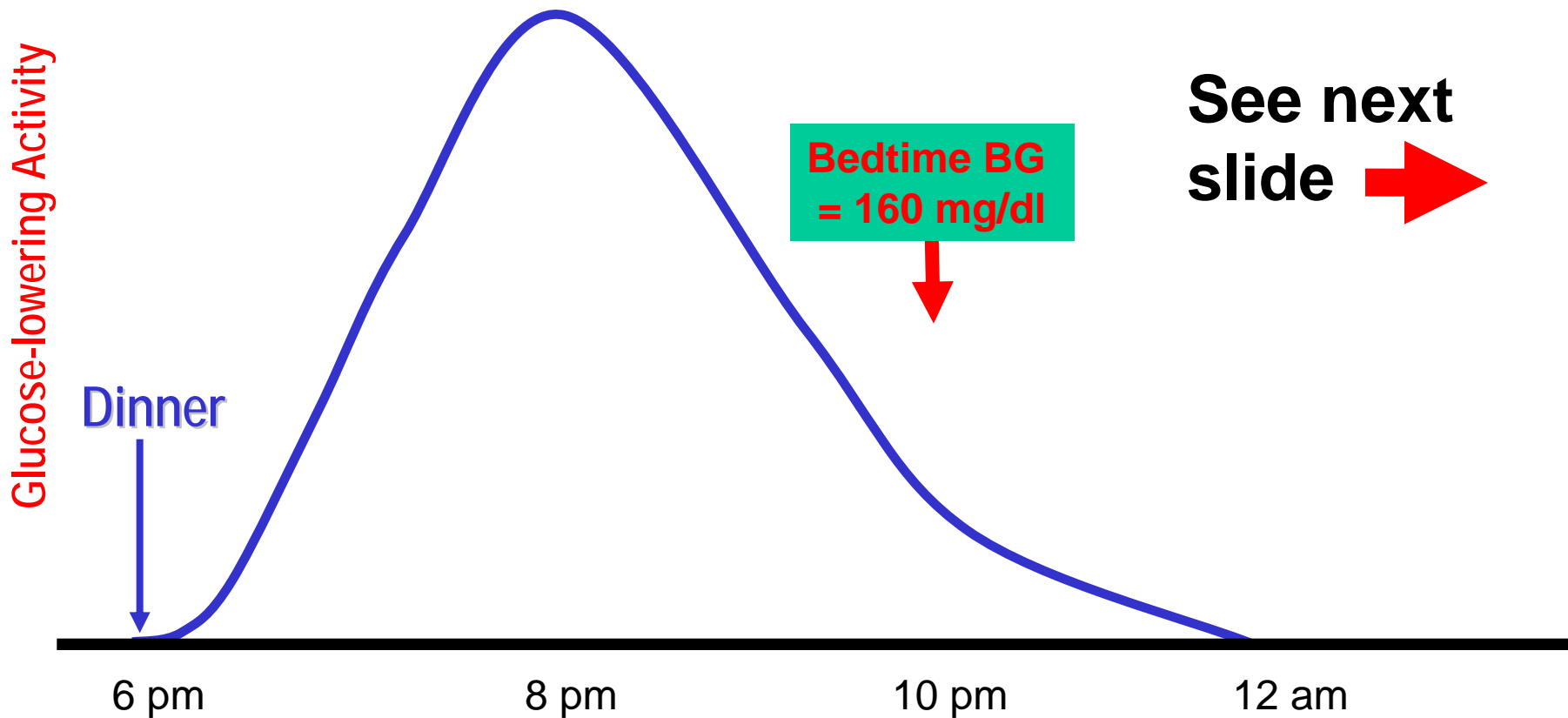
No BOB is present
to subtract from
correction bolus

	0
	+ 1.5
-	- 0
	<hr style="border: 1px solid black;"/>
- =	<u>1.5 u bolus</u>

When no BOB or active insulin present, the correction bolus need is the same in all pumps.

Scenario 2: Some Insulin Stacking

Here, only one bolus is active, the bedtime BG is 160 mg/dl, and some BOB is present. The amount of correction bolus insulin to give is easy to determine.



Scenario 2: Some Insulin Stacking

Correction bolus needed to lower the BG from 160 to 100 = 1.5 u

BOB = 1.0 u

$$1.5 \text{ u} - 1.0 \text{ u} = 0.5 \text{ u}$$

Bolus required = 0.5 u

Again, all pumps agree...

2. Some Insulin Stacking

No Difference In How Pumps Cover A High BG

MiniMed
ENTER FOOD
0 grams

MiniMed
Meter BG
160 mg/dL

ESTIMATE DETAILS

Est total: **0.5U**

Food Intake: 30 gr

(Meter) BG: 160

Food: 0U

Correction: 1.5U

Active Ins: **1.0U**

ACT to Proceed

ESC to back up

Excess BOB is subtracted from correction bolus

$$\begin{array}{r}
 0 \\
 + 1.5 \\
 - 1.0 \\
 \hline
 = -0.5 \text{ u bolus}
 \end{array}$$

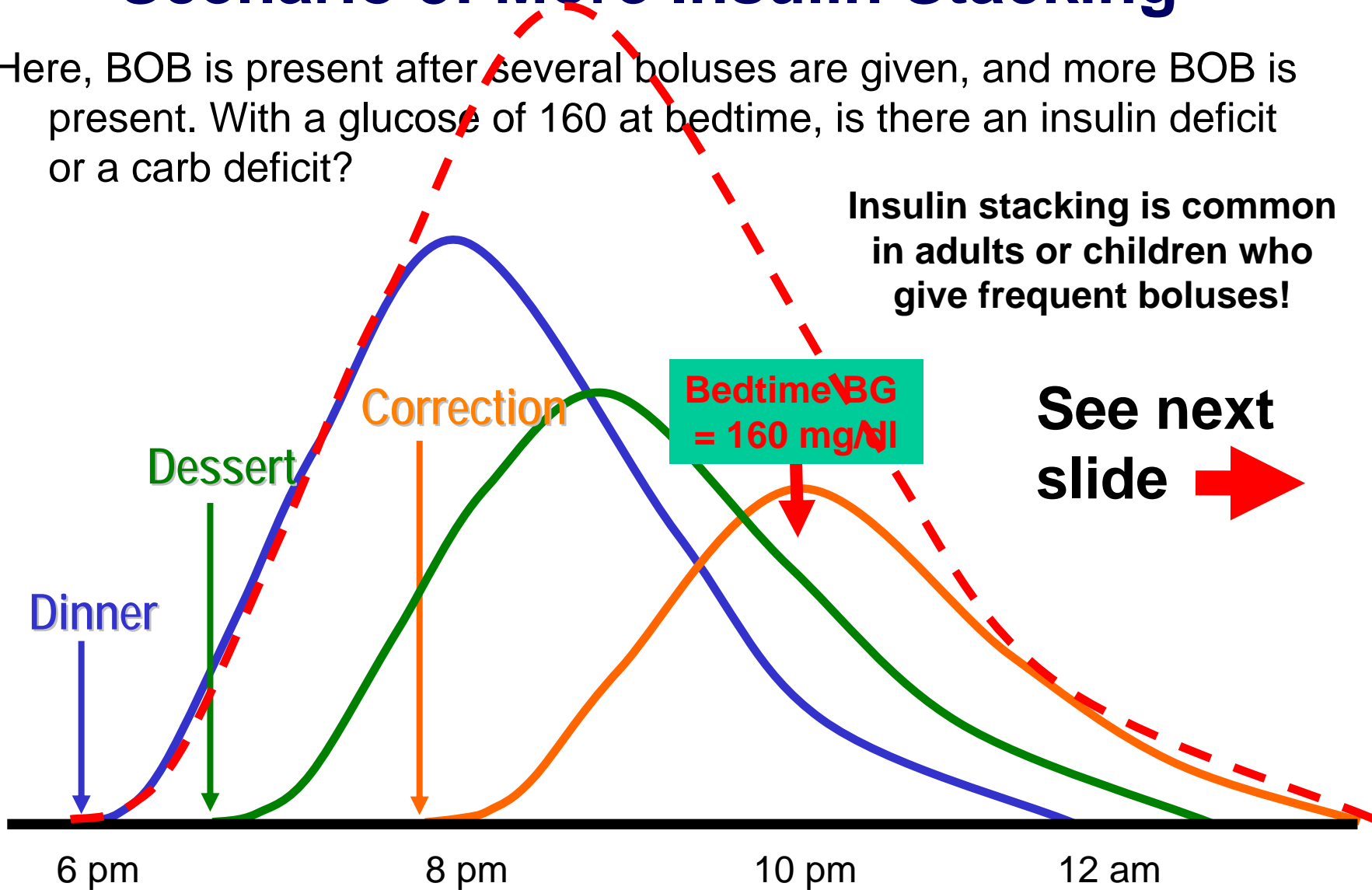
When BOB or active insulin is less than that needed for the correction bolus, all pumps recommend the same bolus.

Scenario 3: More Insulin Stacking

Here, BOB is present after several boluses are given, and more BOB is present. With a glucose of 160 at bedtime, is there an insulin deficit or a carb deficit?

Insulin stacking is common in adults or children who give frequent boluses!

See next slide 



Scenario 3: More Insulin Stacking

Correction bolus needed to lower the BG from 160 to 100 = 1.5 u

BOB = 4.5 u

$$4.5 \text{ u} - 1.5 \text{ u} = 3.0 \text{ u}$$

$$\text{Excess BOB} = 3.0 \text{ u}$$

Here, there is a carb deficit = 3.0 u x 10 grams per unit, so 30 grams of free carbs should be needed

Most pumps* only recommend that no bolus be given.

* The latest Deltec Cozmo pump has a Low BG Manager that suggests how many carbs are needed to prevent a low BG later.

3. More Insulin Stacking

Pump Bolus Recommendations Begin To Differ

MiniMed
ENTER FOOD
0 grams

MiniMed
Meter BG
160 mg/dL

ESTIMATE DETAILS

Est total:
Food Intake: 30 gr
(Meter) BG: 160
Food: 0U
Correction: 1.5U
Active Ins: **4.5U**
ACT to Proceed
ESC to back up

BOB is subtracted from correction bolus but presence of excess BOB is not addressed

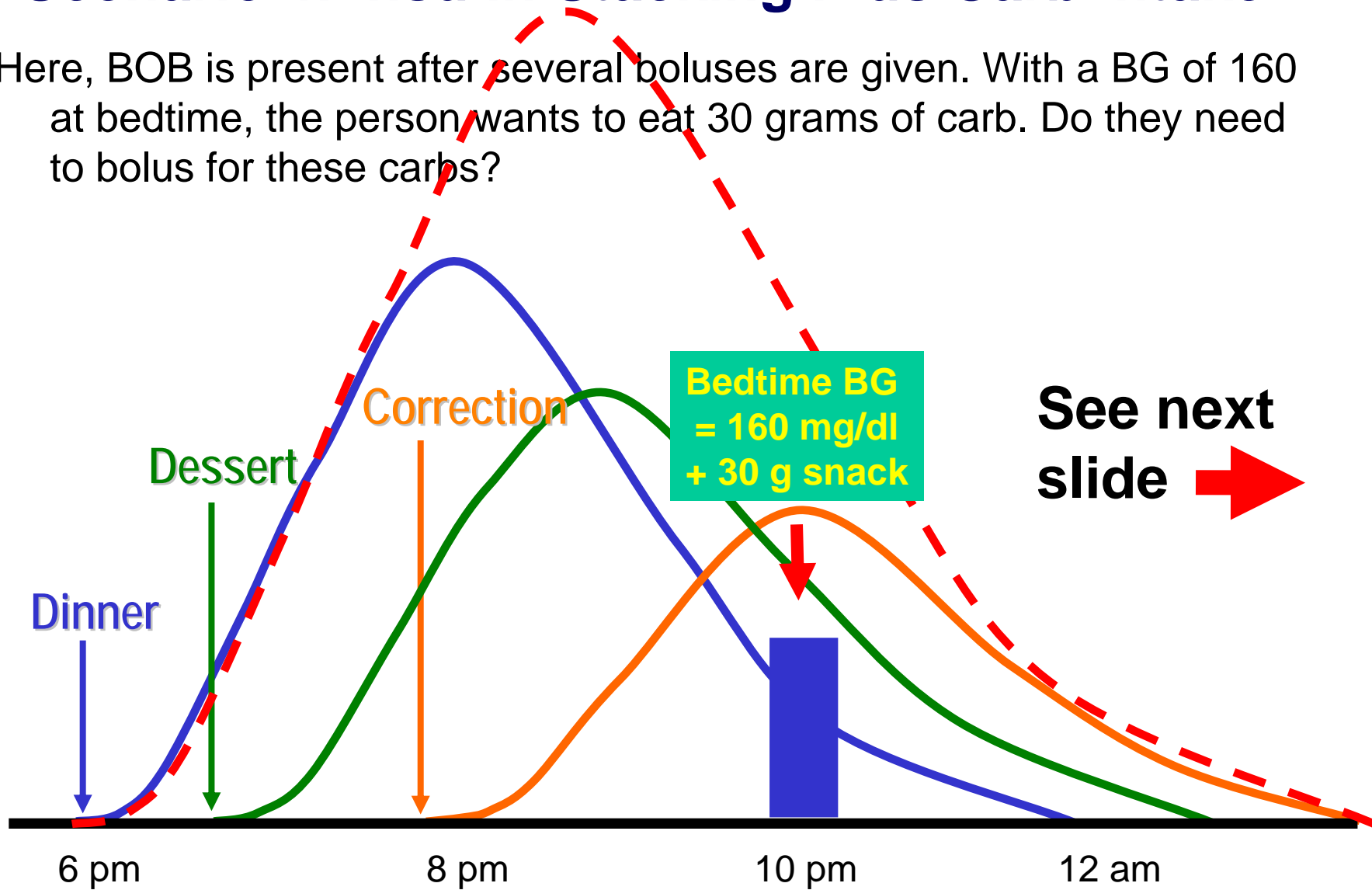
0U		
30 gr		
160		
0U		0
1.5U		+ 1.5
4.5U	-	- 4.5
	=	<u>- 3.0 u bolus</u>

Here, BOB or active insulin is greater than correction bolus need, so free carbs should be eaten (a negative 3u bolus = 30 g of carb in this case). The Cozmo recommends carb intake, other pumps suggest no bolus.



Scenario 4: Insulin Stacking Plus Carb Intake

Here, BOB is present after several boluses are given. With a BG of 160 at bedtime, the person wants to eat 30 grams of carb. Do they need to bolus for these carbs?



Scenario 4: Insulin Stacking Plus Carbs

Correction bolus needed to lower the BG from 160 to 100
= 1.5 u

BOB = 4.5 u

Carb bolus needed for 30 grams = 3.0 units

$$\text{BOB insulin} = 4.5 - (1.5 + 3.0) = 0 \text{ units}$$

Here, there is no reason to give a bolus because the BOB balances the correction and carb boluses. One pump recommends no bolus, other pumps recommend that a 3 unit bolus be given. *

* This difference arises only when BOB is larger than the correction bolus

Scenario 4: Insulin Stacking Plus Carbs Pump Bolus Recommendations Again Differ

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

Excess BOB is subtracted from correction but not from the carb bolus

3	
+ 1.5	
- 4.5	
- =	0 u bolus

With BOB or active insulin greater than correction bolus need, bolus recommendations differ more. The Cozmo pump recommends no bolus, other pumps recommend 3 units.

Scenario 5: Further Comparison With Change In BG

To show how recommendations differ, consider this situation:

An Animas 1250, Deltec Cozmo, and Paradigm 722 are given **identical values**:

Carb factor = 1u / 10 gr

Corr. Factor = 1 u / 40 mg/dl over 100

Glucose target = 100 mg/dl

BOB = 3.0 u (shown as -3 u)

30 grams of carb = 3.0 u carb bolus

Then, 5 different BG levels are entered in each pump: 60, 90, 120, 150, and 240 mg/dl

* The Omnipod manufacturer says their pump calculates boluses in the same way as the Paradigm pump, so their pump was not directly tested.

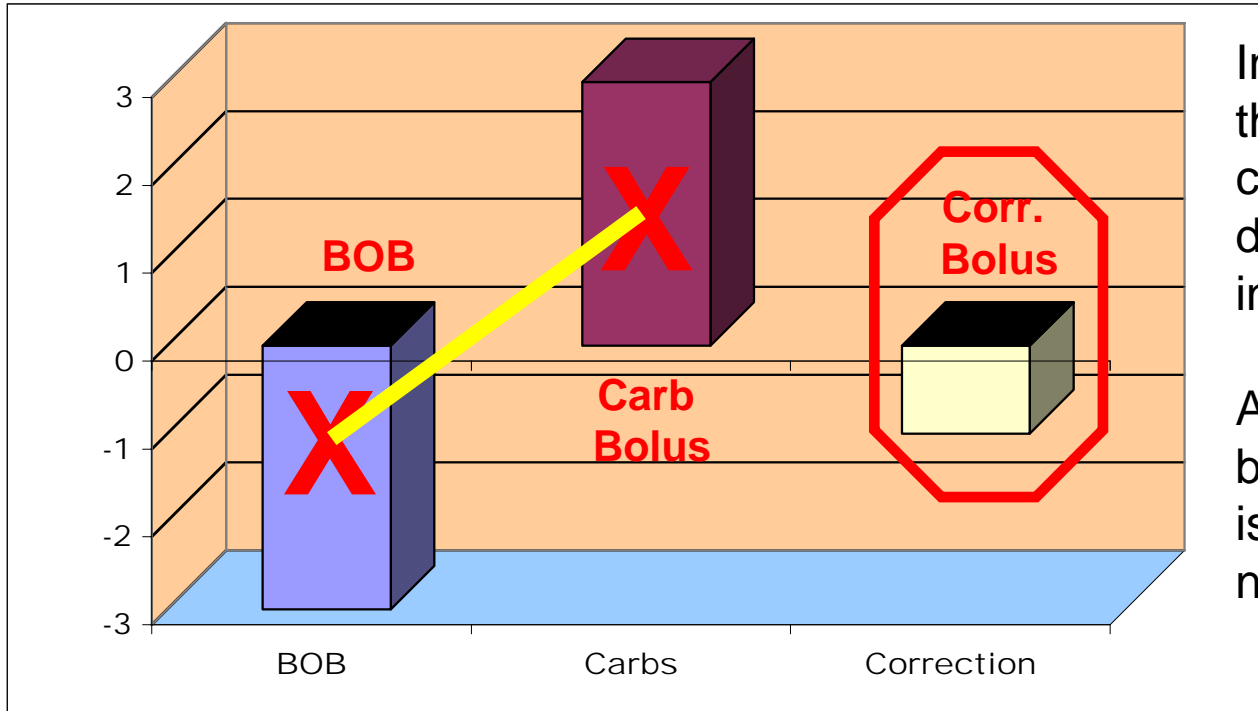
Scenario 5: Effect Of Change In BG

Only the BG changes. The excess BOB cancels out the insulin needed for carbs,

so only the correction bolus should impact the bolus recommended by each pump!

Pump Bolus Recommendations

Here, 3 u of BOB cancels out the 3 units that is needed to cover the 30 grams of carb (carb) that will be eaten. With a BG of 60 mg/dl, a pump would be expected to recommend that free carbs be eaten for the low BG.

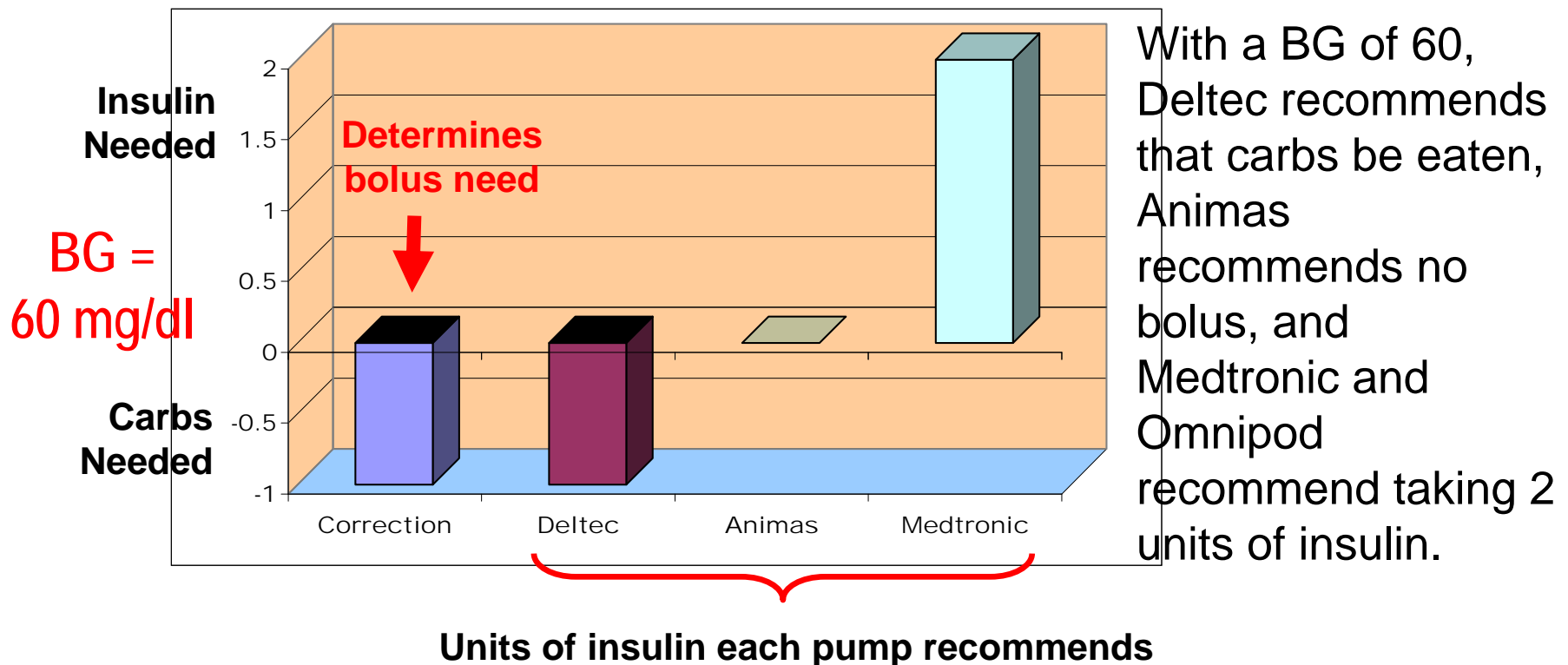


In this and the situations that follow, only the correction bolus should determine how much bolus insulin is needed.

A negative correction bolus means that the BG is low and free carbs are needed.

Bolus Recommendations

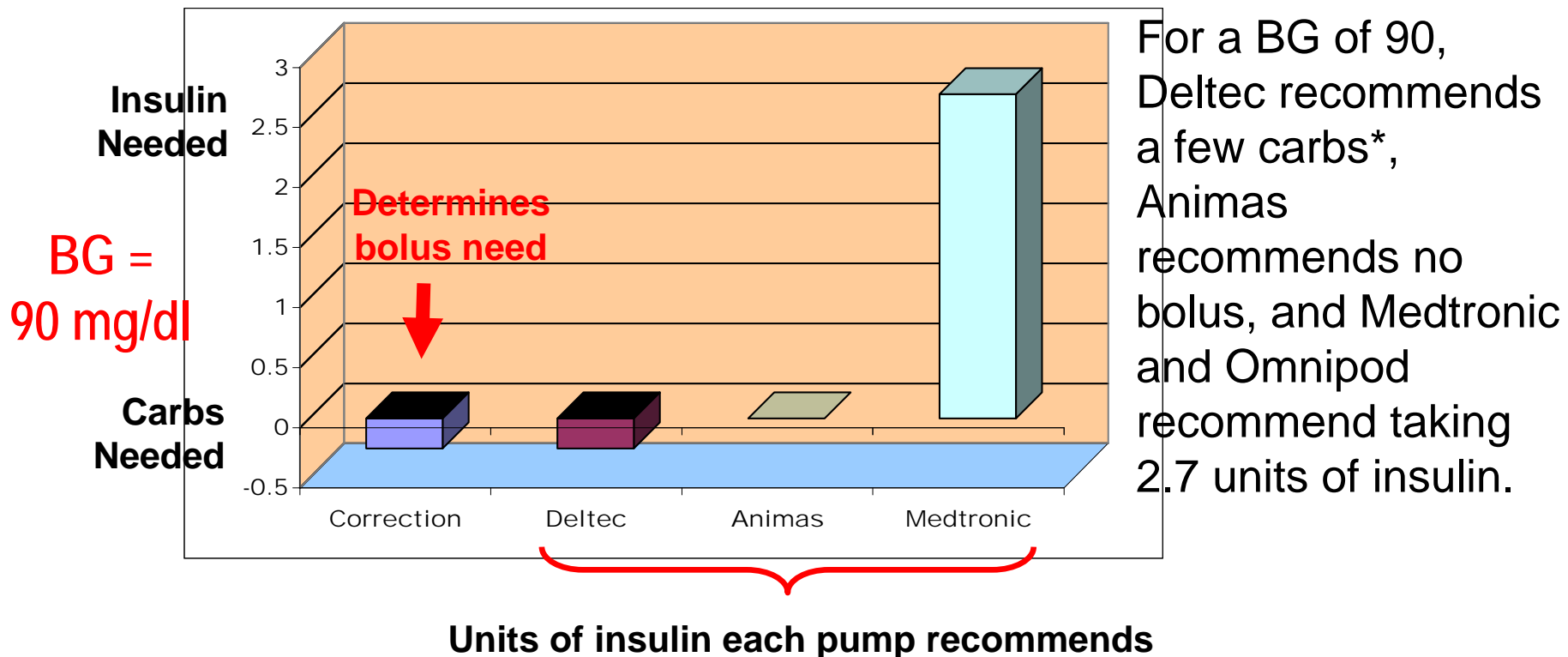
Here (not shown), 3 u of bolus on board (BOB) cancels the 3 units needed to cover 30 grams of carb. With a BG of 60 mg/dl, a recommendation that free carbs be eaten for the low BG is appropriate.



* The Cozmo Low BG Manager recommends how many carbs to eat.

Bolus Recommendations

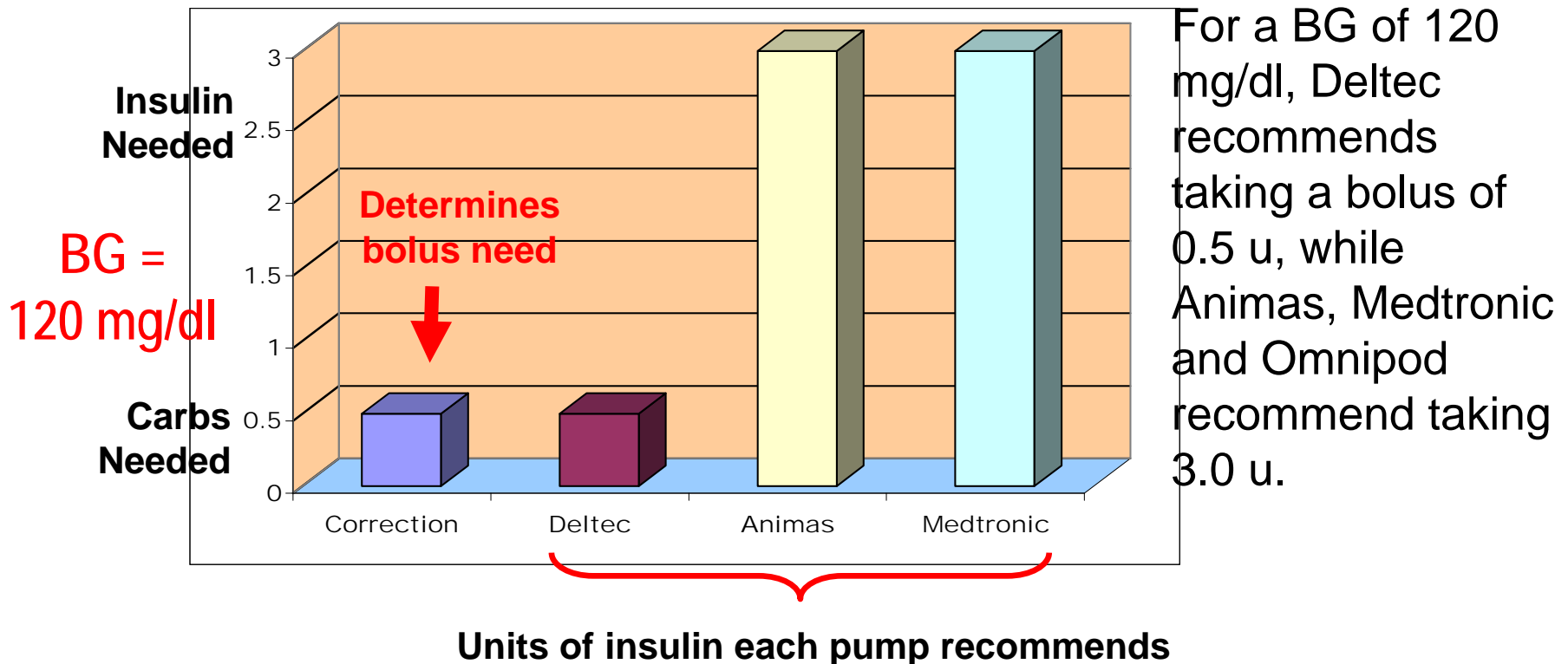
Here (not shown), 3 u BOB cancels 3 units needed for 30 grams of carb. With a BG of 90 mg/dl, a recommendation that a few free carbs be eaten is appropriate.



* Because the target BG = 100 mg/dl

Bolus Recommendations

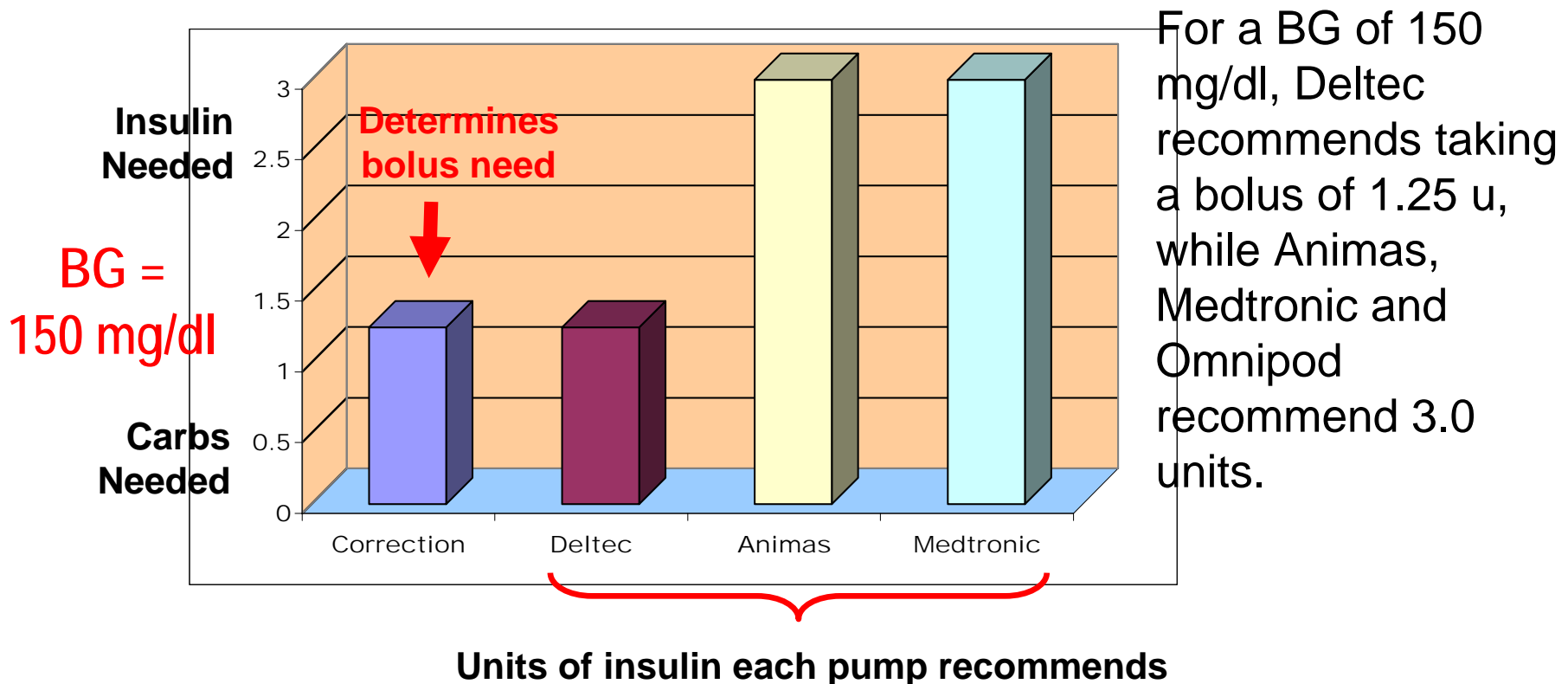
Here (not shown), 3 u BOB cancels 3 units needed for 30 grams of carb. With a BG of 120 mg/dl, a small bolus is appropriate.



Animas starts to cover carbs fully once the BG is above target.

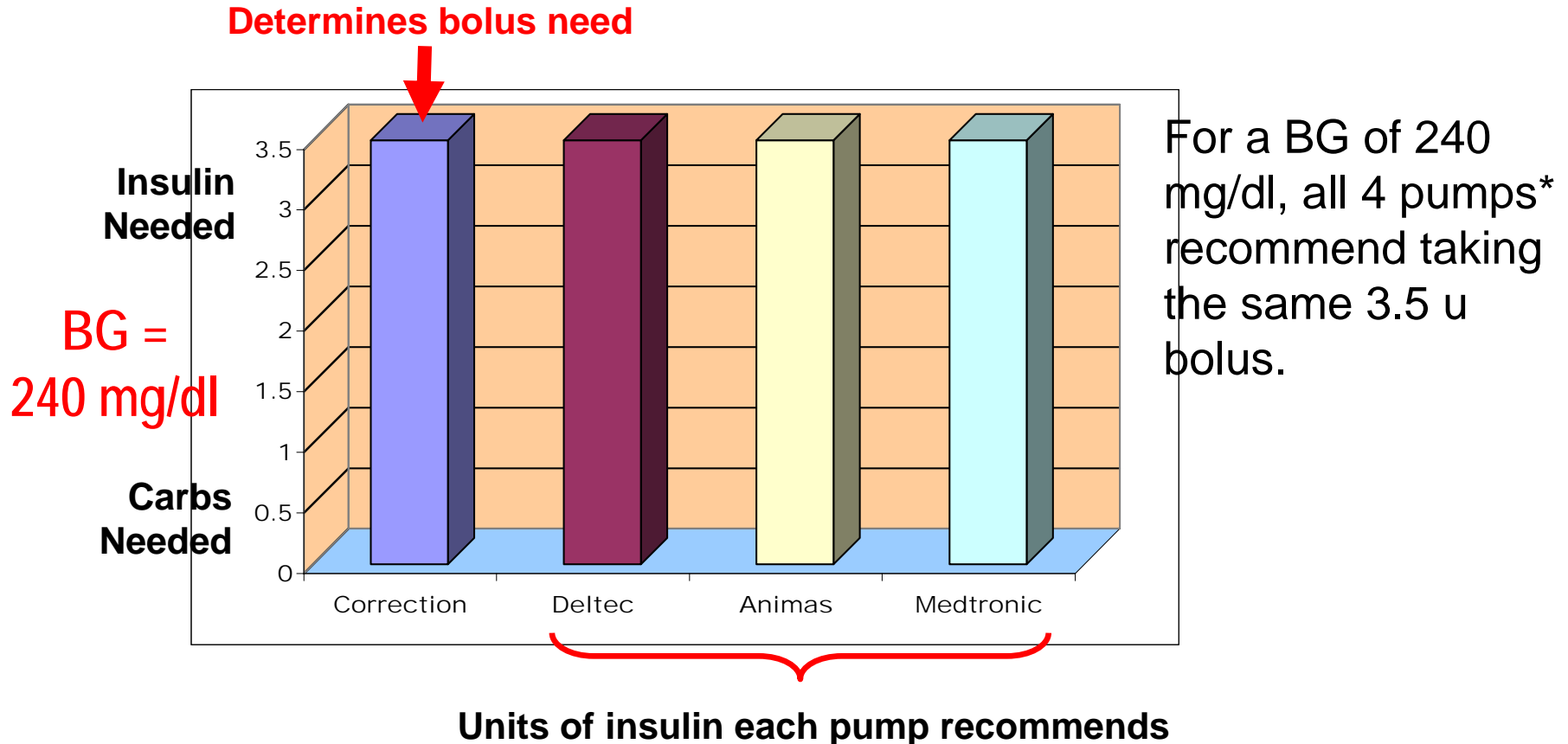
Bolus Recommendations

Here (not shown), 3 u BOB cancels 3 units needed for 30 grams of carb. With a BG of 150 mg/dl, a slightly larger bolus is appropriate.



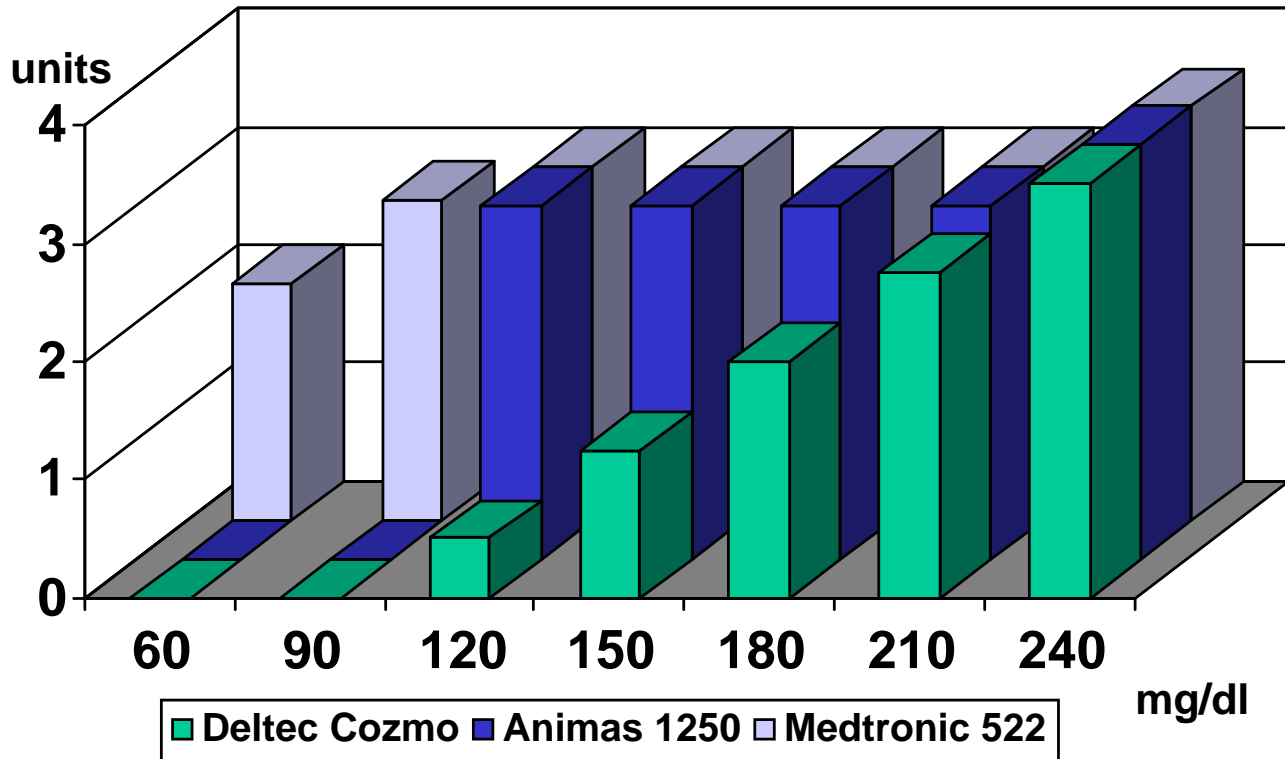
Bolus Recommendations

Here, 3 u BOB cancels 3 units needed for 30 grams of carb. Only at a higher BG of 240 mg/dl do all four pumps recommend the same bolus.



* Omnipod pump gives same recommendations as Paradigm pump

Summary Of Pump Bolus Recommendations



Recommended boluses when:
the BOB = 3.0 u and 30 gr. of carb will be eaten at each glucose level

Carb factor = 1u / 10 gr

Corr. Factor = 1 u / 40 mg/dl over 100

Target BG = 100

TDD = ~50 u

When Do Pumps Differ In Their Boluses?

Bolus recommendation differences between pumps occur:

- When a bolus has been given within the last 4 to 6 hrs
- A BG value is provided to the pump
- And BOB is greater than the current correction bolus requirement

The DIA must be accurately set to obtain accurate BOB values!

Do These Differences Cause Problems?

Bolus errors are often hidden because the average pump wearer is in poor control (avg. A1c is close to 9%).

Poor control suggests that basal and bolus doses are too small – this hides occasional excessive boluses.

Those in good control (and anyone in certain situations) are likely to receive excess boluses from some pumps when bolus recommendations are followed.

When recommended boluses are taken as directed, unexplained hypoglycemia can result.

How To Monitor Your Pump

Most pumps provide sufficient information to override possible errors in recommended boluses:

- The Animas 1250 pump screen conveniently displays the units required for carb and BG, as well as BOB, for user adjustments.
- Although exact calculations are not shown, the Deltec Cozmo gives accurate recommendations*. BOB is easily accessible on the home screen
- If the down arrow on a Paradigm pump is hit 3 times when the recommended bolus is shown, the units for food, correction, and active insulin are available for any user adjustments.
- The Omnipod pump does not show bolus details on the controller screen so information is unavailable to adjust the recommended bolus.

* See next slide

Scenario 4 Repeated: How To Adjust The Bolus Recommendation

MiniMed
ENTER FOOD
30 grams

MiniMed
Meter BG
160 mg/dL

ESTIMATE DETAILS

Est total:
Food Intake:
(Meter) BG:
Food:
Correction:
Active Ins:
ACT to Proceed
ESC to back up

3.0U	
30 gr	
160	
3U	3
1.5U	+ 1.5
4.5U	- 4.5
-	<u>- 4.5</u>
- =	<u>0 u bolus</u>

A Paradigm user can scroll down 3 times to see active insulin for user adjustments:

With the BOB or active insulin equal to both the carb and correction bolus need as shown above, the recommended bolus might be lowered or ignored.

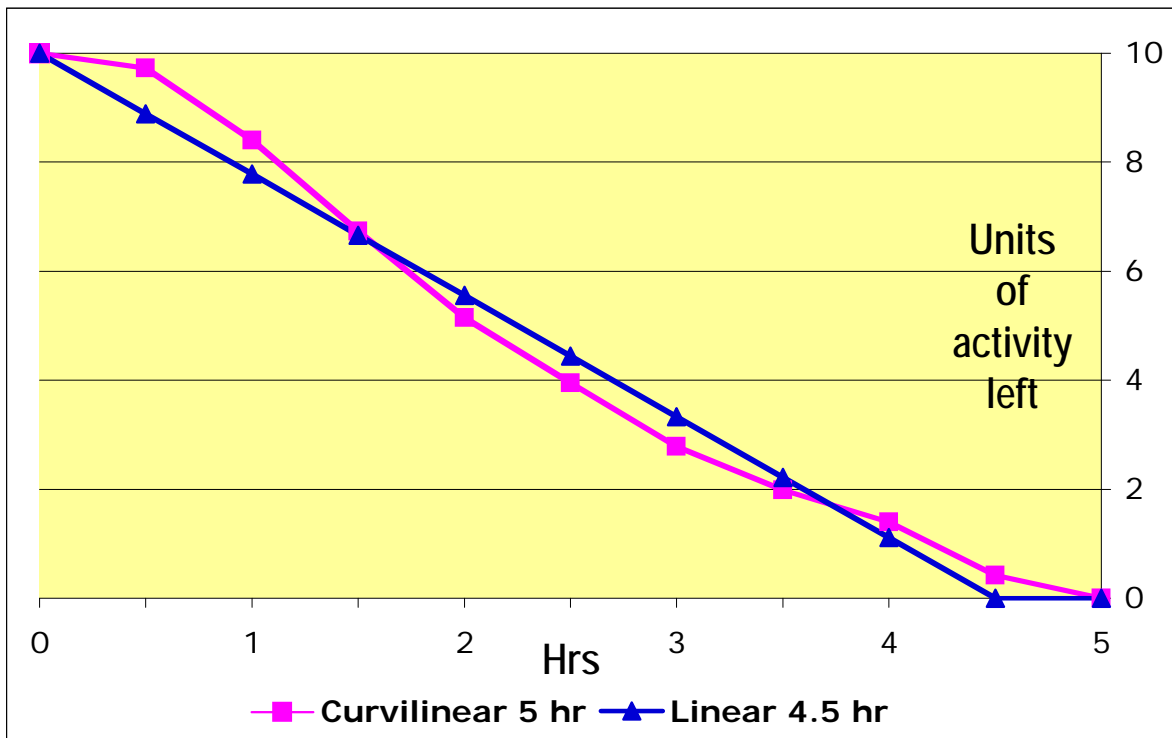
Important Points On Bolus Accuracy

For tracking BOB, the Deltec Cozmo tends to give the best advice, followed by the Animas 1250, then the Medtronic Paradigm 522/722 and Insulet Omnipod

HOWEVER, the Cozmo pump has a default DIA of only 3 hours. This must be reset to at least 4 to 5 hours to obtain accurate BOB calculations

Cozmo and Omnipod use a linear rather than a curvilinear method to calculate BOB. This may introduce small errors in BOB calculations.

Linear Versus Curvilinear DIAs



There are slight time differences when BOB is calculated in a linear versus a curvilinear fashion. This graph shows how the action of a 10 unit bolus disappears over 5 hrs using an Animas (100% curvilinear) pump set at 5 hrs in pink versus a Deltec or Omnipod pump (linear) set at 4.5 hrs in blue.

In general, the DIA in a linear pump would be set 30 minutes shorter to get a similar result as a curvilinear pump. A Deltec or Omnipod pump set at 4.5 hrs is equivalent to a Medtronic or Animas pump set at 5 hrs.

For Answers To Your Questions, Get

