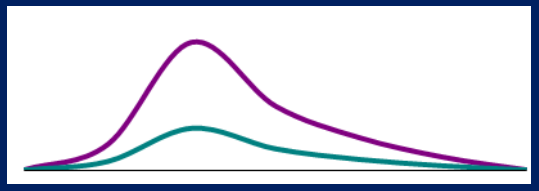

Strike The Spike!

Strategies for Combatting After-Meal Highs

Gary Scheiner MS, CDE
Owner and Clinical Director
Integrated Diabetes Services LLC
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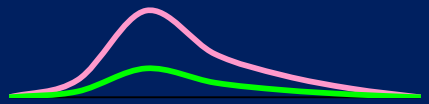
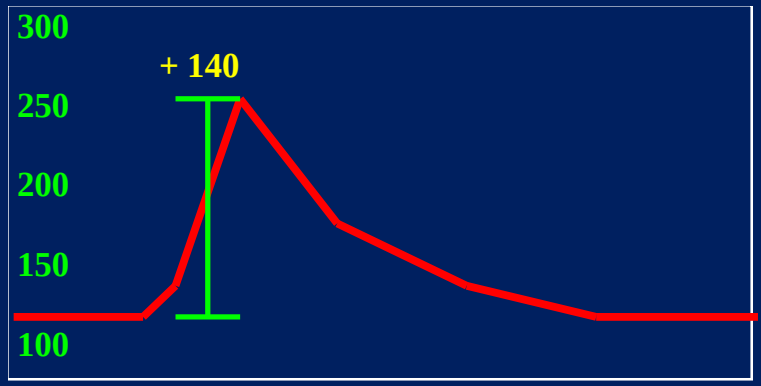


Overview

- Definitions
- Risks
- Detection
- Management

After-Meal Peaks Defined

The net rise that occurs from before eating to the highest point after eating.

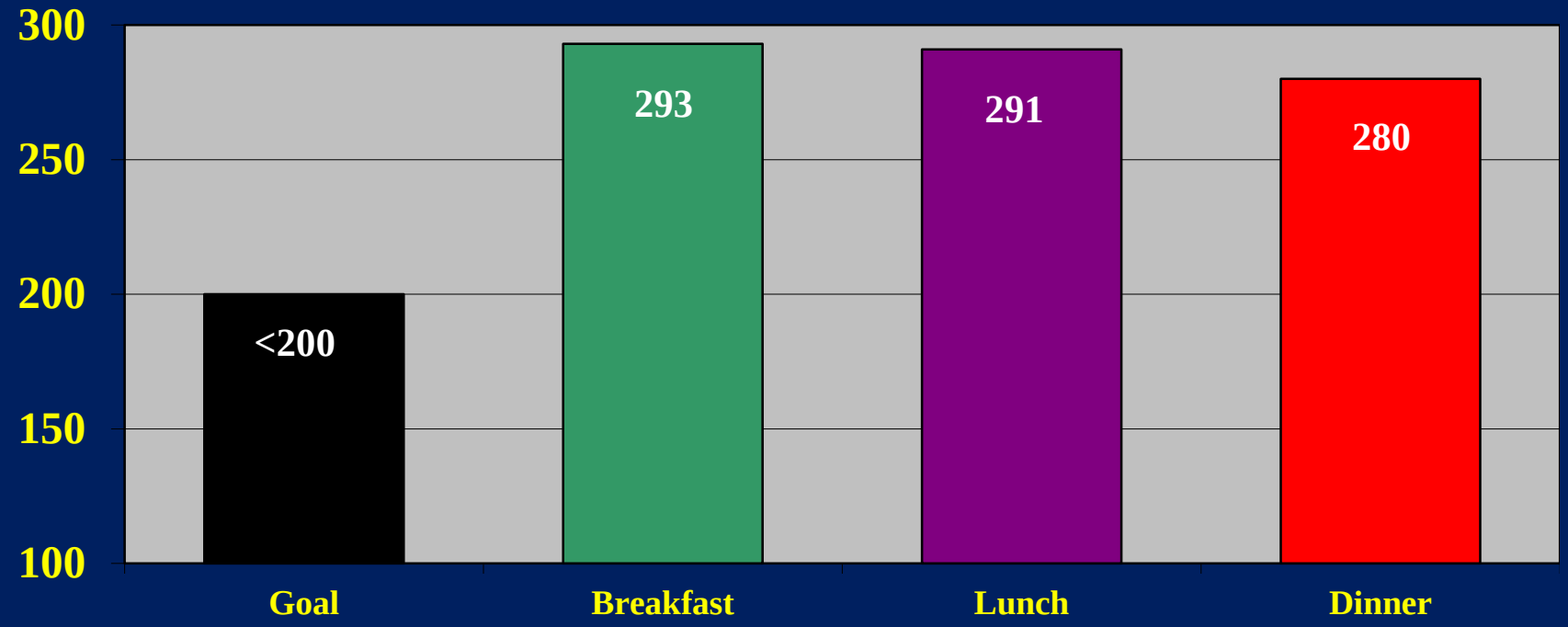


- ADA Goal:
  <180 mg/dl 1-2 hrs after start of meal
- AACE Target:
  <140 mg/dl at “peak”
- European Diabetes Policy Group:
  <165 (to prevent complications)
- International Diabetes Federation:
  < 140 mg/dl 2 hrs after meal

After-Meal Goals

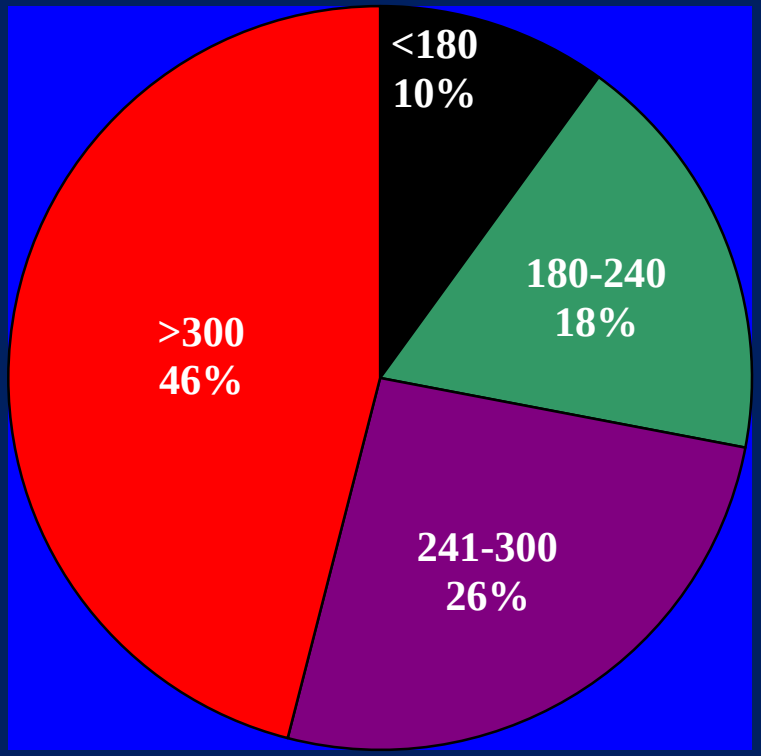
- **Children:**
  < 200-240 @ peak
  (< 100 pt. Rise)
- **Adults:**
  < 180-200 @ peak
  (< 80 pt. Rise)
- **Pregnancy**
  < 140-160 @ peak
  (< 60 pt. Rise)

After-Meal Peaks: Reality in Type-1 Diabetes



Source: Boland et al, Diabetes Care 24: 1858, 2001

After-Meal Peaks: Reality in Type-1 Diabetes



Source: Boland et al, Diabetes Care 24: 1858, 2001

After-Meal Highs: Immediate Problems

- Tiredness
- Difficulty Concentrating
- Impaired Athletic Performance
- Decreased desire to move
- Mood Shifts
- Enhanced Hunger

After-Meal Highs: Immediate Problems

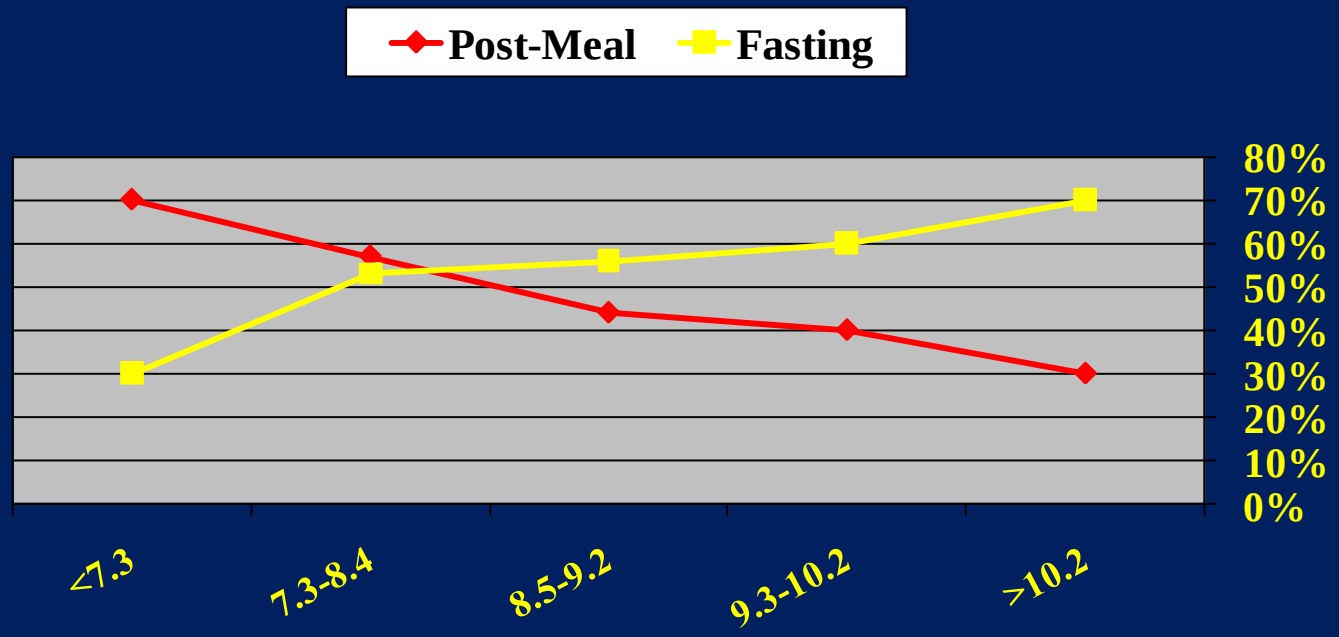
Australian Study of Children w/Type 1. Parents & children reported BG > 270 had negative impact on:

- **Thinking (68%)**
- **Mood/Emotions (75%)**
- **Coordination (53%)**

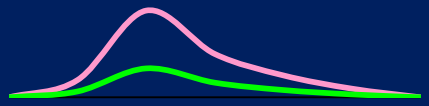
J Pediatr Endocrinol Metab. 2006 Jul;19(7); 927-36

Long-Term Problems

Relative Influence on HbA1c



Source: Monnier et al, Diabetes Care, 26, 3/03, 881-885

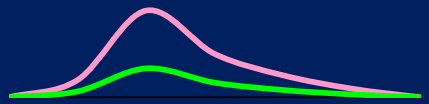


Long-Term Problems (contd)

52 Type 1's, similar BP between groups

Post-prandial glucose	Range	Time to onset of proteinuria
Persistent <200	110-198	**23 yrs**
Intermittent >200	118-228	**19 yrs**
Persistent > 200	201 +	**14 yrs**

Source: Kidney Intl. 1987; 32 (supp 22): S53-S56



Long-Term Problems (contd)

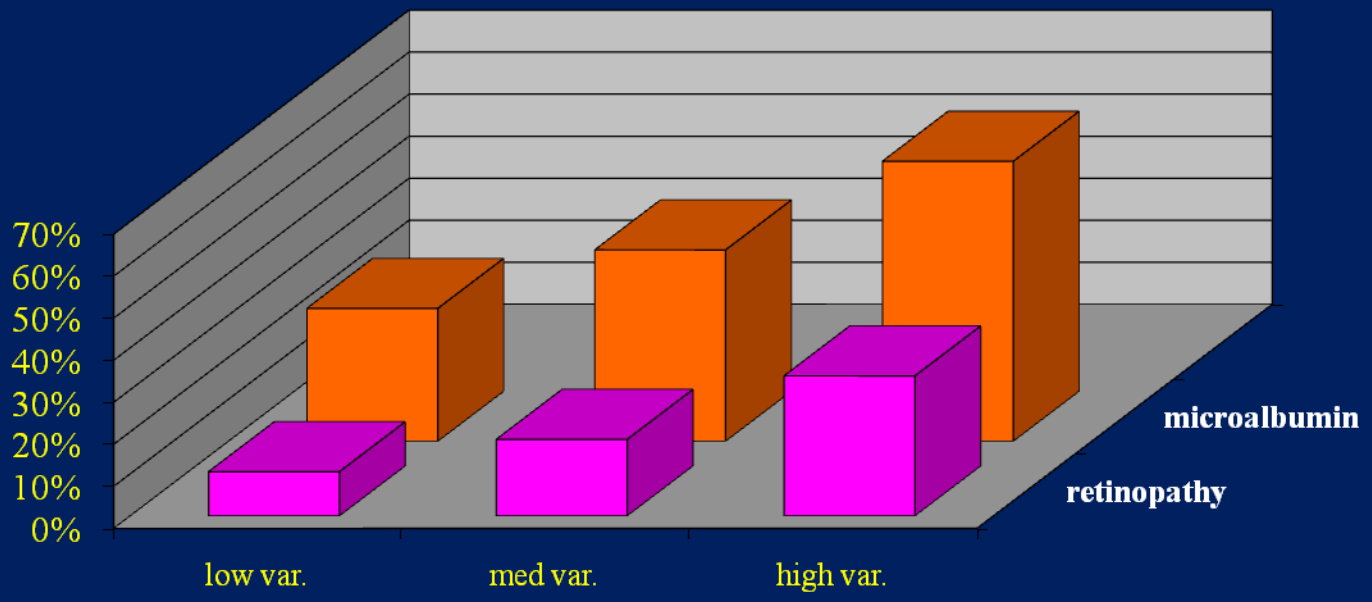
Type-2s Starting on Oral Meds

	Meds to limit post-meal rise	Meds to control pre-meal BGs
HbA1c reduction	Identical	Identical
Fasting BG	Identical	Identical
Cognitive Function	Unchanged	**Declined**

Source: Neurology 2006; 67: 235-240

Long-Term Problems (contd)

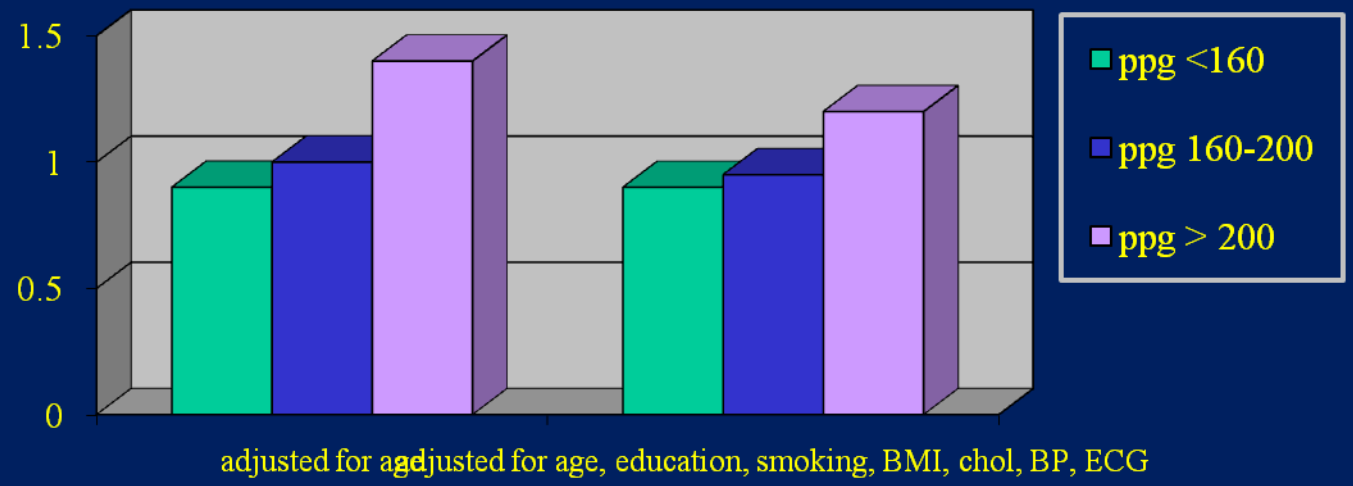
Rates of eye and kidney disease based on glucose variability (using CGM) in Type-2 Diabetes



Source: Liu et al, American Diabetes Association 71st Scientific Sessions 2011, Abstract 2205-PO.

Long-Term Problems (contd)

22-yr CVD Mortality Risk by Baseline post-challenge glucose



Source: Chicago Heart Study, Lowe et al, Diabetes Care, 1997; 20: 163-170.

Long-Term Problems (contd)

Glycemic Variability A Better Predictor of Major Cardiac Events than Admission BG or A1c for Acute MI (Su et al, Diabetes Care online, 1/24/2013)

1 & 2-Hr. BG levels predicted CHD better than fasting BG (Pyorala et al, J Chronic Dis. 1979; 32, 729-745)

2-Hr. BG predicted CHD better than A1c (Jackson et al, Diabetes Res Clin Pract 1992; 17: 111-123. Meigs et al, Diabetes Care 2002; 25; 1845-1850)

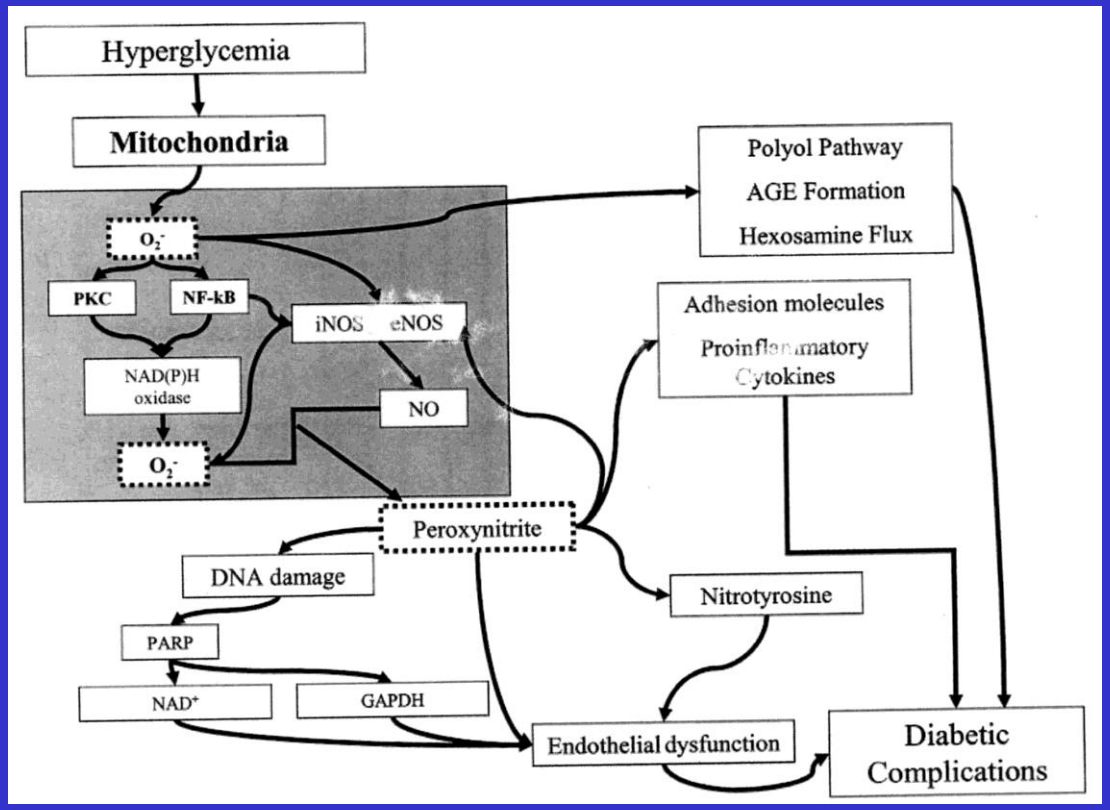
Long-Term Problems (contd)

Post-Lunch BG Linked Strongly to Hazard Ratio for First CV Event (Ceriello, Intl. Diab. Mon. 2007; 19:2; 33-36)

Post-Brkfst BG predicted mortality better than fasting BG (Hanefeld et al, Diabetologia 1996; 39: 1577-1583)

Long-Term Problems (contd)

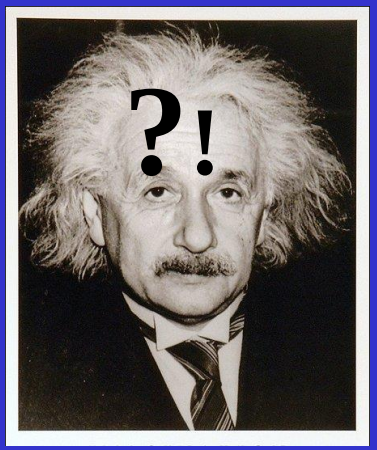
Acute Hyperglycemia: Proposed Mechanism of Damage



Coagulation Abnormality

Oxidative Stress

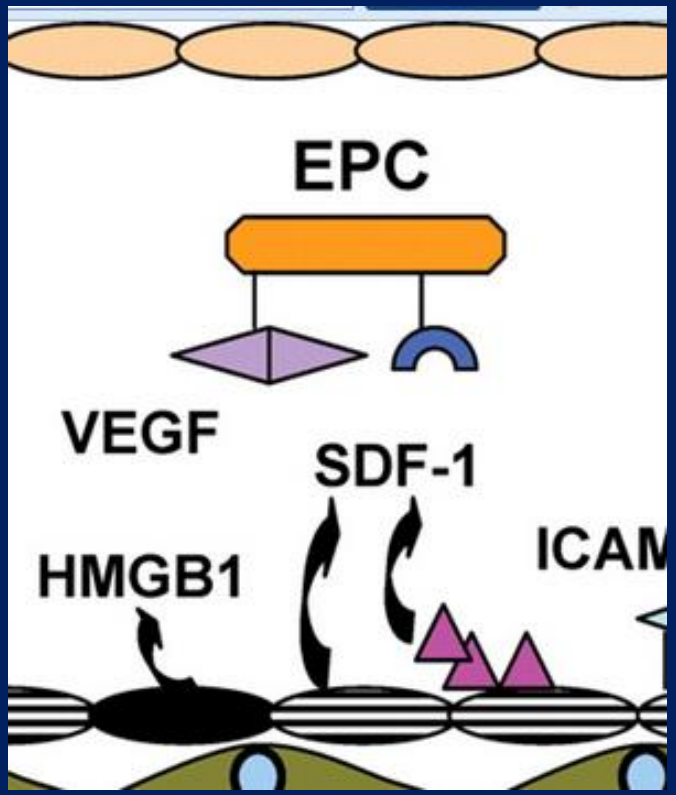
Endothelial Dysfunction



Source: Antonio Ceriello, Univ. of Udine, Italy. *Diabetes* 54: 1-7, 2005

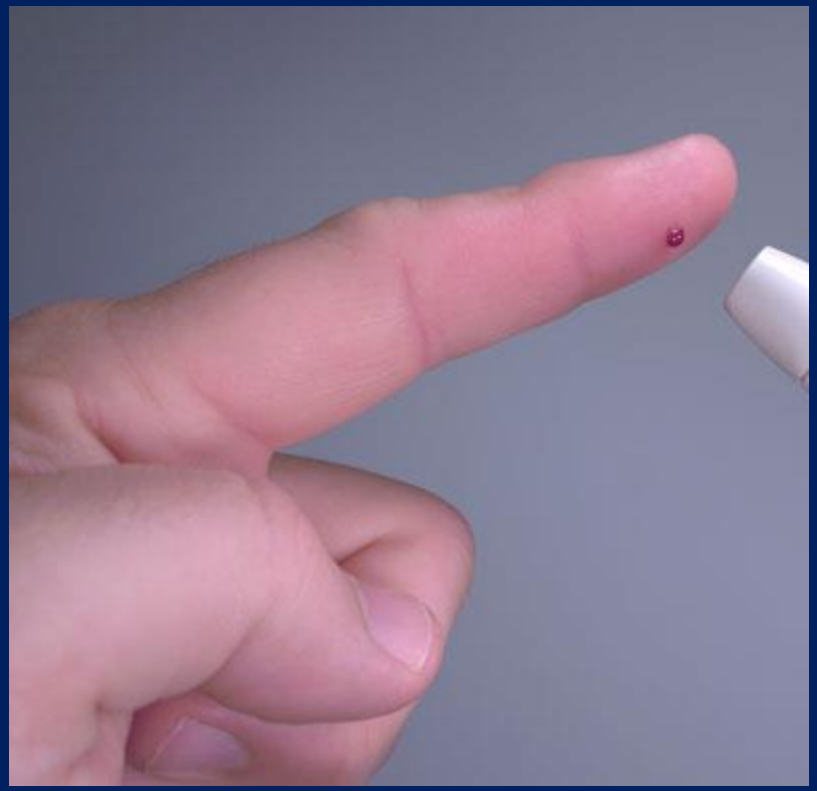
Contribution of endothelial progenitor cells (EPCs)

- Damage to inner lining of blood vessels (endothelium) leads to vascular complications
- EPCs “patch” endothelial injuries
- EPC count increases with reduction in glycemic excursions

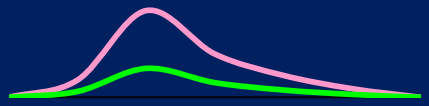


Maiorino et al. *Endocrine*. July 17 2015.

Measurement of After-Meal Peaks



- **Fingerstick BG Checks**
  - Capillary (finger) sample
  - Check BG 1 Hr after *completion* of meal
  - (or) every 15, 20 or 30 min until 2 consecutive BG reductions occur (No addl. Food/insulin until test is completed)

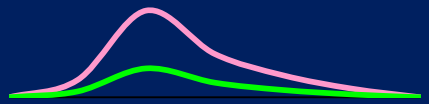


Meter Test Example

Breakfast		Lunch		Dinner	
Pre	***1h Post***	**Pre**	***1h Post***	**Pre**	***1h Post***
117	*281*	157	*166*	191	*204*
90	*302*	58	*247*	89	*147*
151	*264*	77	*152*	235	*222*

Interpretation:

Excessive after-meal peak following breakfast; not after lunch or dinner



Meter Test Example

Time pp	BG Value
Premeal	135
:20	155
:40	168
1:00	214
1:20	222
1:40	175
2:00	141

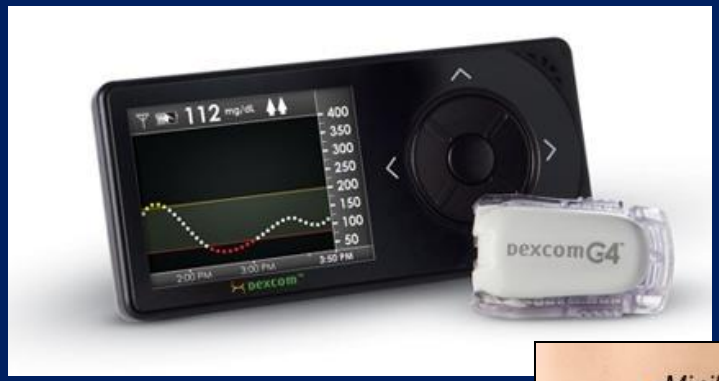
Interpretation:

Peak occurred at 1hr, 20min pp; rise from premeal to peak was approx. 90 mg/dl

Measurement of After-Meal Peaks

- **Blinded CGM**
  - Medtronic iPro (72 hrs) or Blinded Dexcom 7+ (7 days)
  - BG data every 5 minutes
  - Analysis software shows post-meal patterns

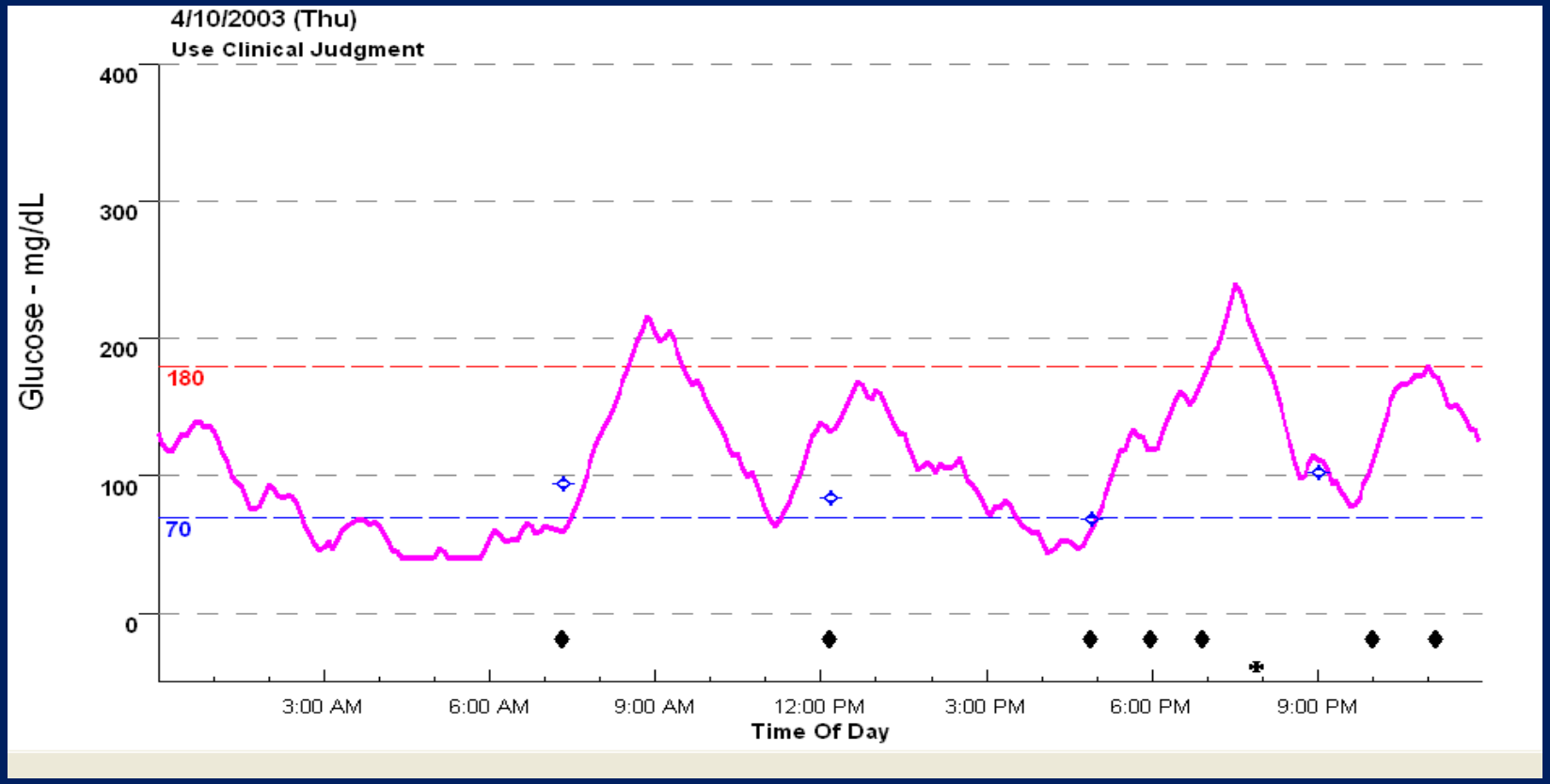
Measurement of After-Meal Peaks



- **Real-Time Continuous Glucose Monitors**
  - Allow tracking of post-meal trends
  - Produce BG estimates every 5 minutes

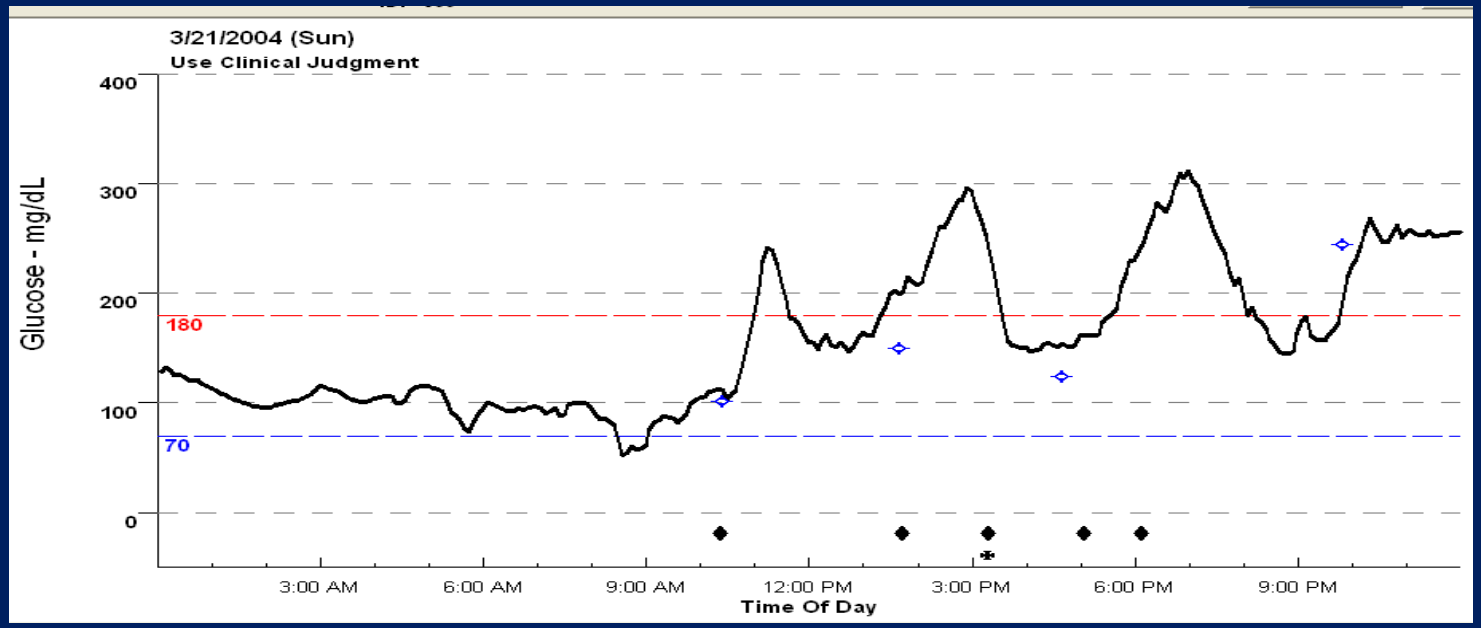
CGMS Case Study

37 year old man (insulin pump)



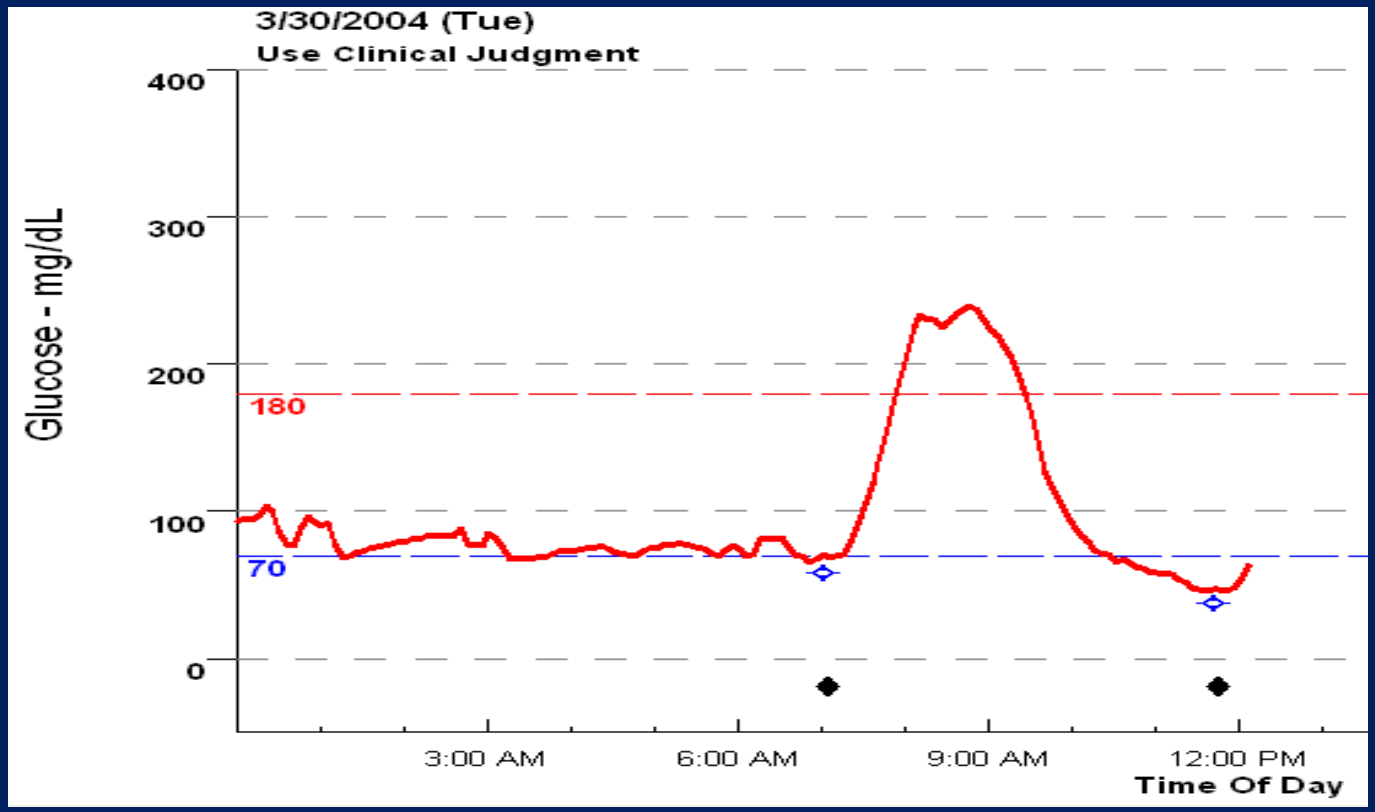
CGMS Case Study

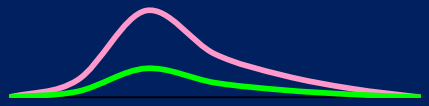
8 year old girl (glargine/MDI)



CGMS Case Studies

60-year old woman (oral meds)

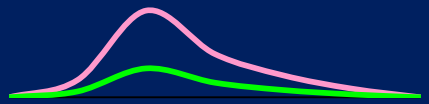




Spike Measurement

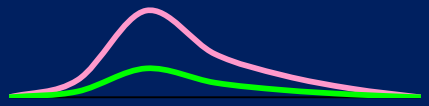
1,5 – anhydroglucitol (AG) "GlycoMark"

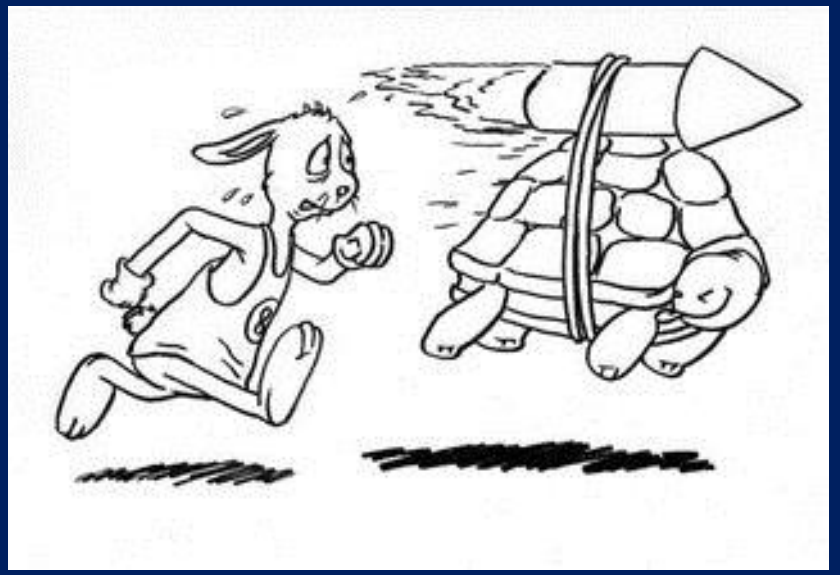
- Laboratory Blood Test
- Measures Duration & Magnitude of High BG Excursions for past 10-14 days
- "Normal" is >14 μg/ml
- >10 is "good"



Why Do We Spike?

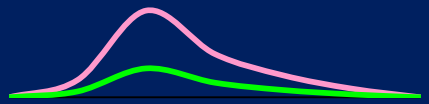
- Insulin/Meds Work Too Slowly
  - Lag far behind pancreatic insulin
  - Glucagon is not properly suppressed
- Food Works Too Quickly
  - Lack of amylin hormone





Spike Control

- ✓ Make Insulin Work Faster
- ✓ Make Food Work Slower



Slowing Food 1:
Use of Glycemic Index

- All carbs (except fiber) convert to blood glucose eventually
- G.I. Reflects the magnitude of blood glucose rise for the first 2 hours following ingestion
- G.I. Number is % or rise relative to pure glucose (100% of glucose is in bloodstream within 2 hours)

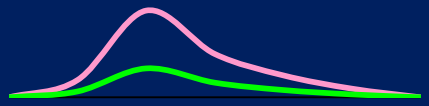
Glycemic Index (contd.)

Example:

Spaghetti

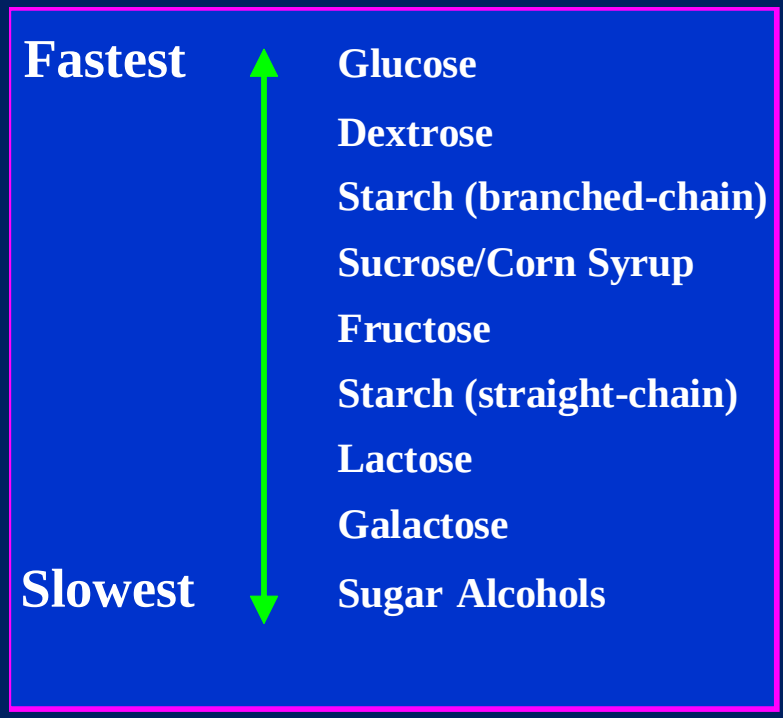
GI = 37

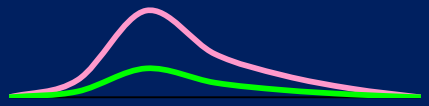
- Only 37% of spaghetti's carbs turn into blood glucose in the first 2 hours.
- The rest will convert to blood glucose over the next several hours.



Glycemic Index (contd.)

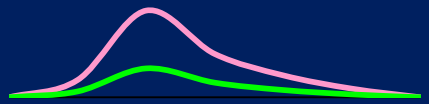
- Lower GI foods digest & convert to glucose more slowly
- High-fiber slower than low
- Hi-fat slower than low
- Solids slower than liquids
- Cold foods slower than hot
- Type of sugar/starch affects GI





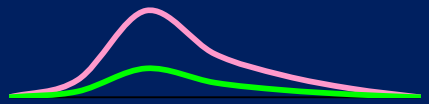
Glycemic Index (contd.)

Slow Stuff	Average Stuff	Fast Stuff
Pasta	Fruit	Breads/Crackers
Legumes	Juice	Salty Snacks
Salad Veggies	Pizza	Potatoes
Dairy	Soup	Rice
Chocolate	Cake	Cereals
		Sugary Candies



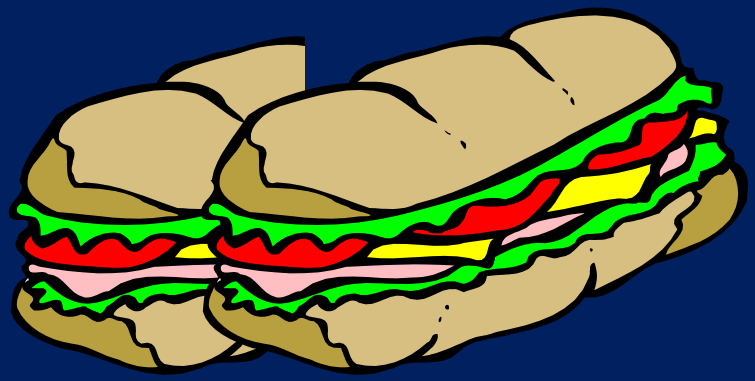
Common Substitutions

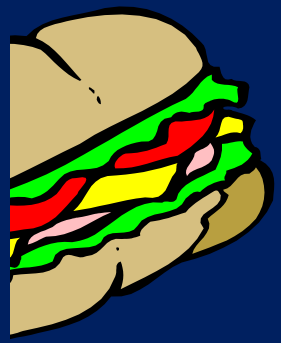
Meal	High-GI Options	Low-GI Options
Breakfast	Cereal, Bagel, Waffle, Pancakes, Muffins	Oatmeal, Milk, Whole Fruit
Lunch	White Bread, Fries, Tortillas, Cupcake	Sourdough/Pumpernickel, Yogurt, Corn, Carrots
Snacks	Pretzels, Chips, Crackers, Doughnuts	Fruit, Popcorn, Nuts, Ice Cream, Chocolate
Dinner	Rice, Mashed or Baked Potatoes, Rolls	Pasta, Peas, Beans, Sweet Potato, Salad Veggies



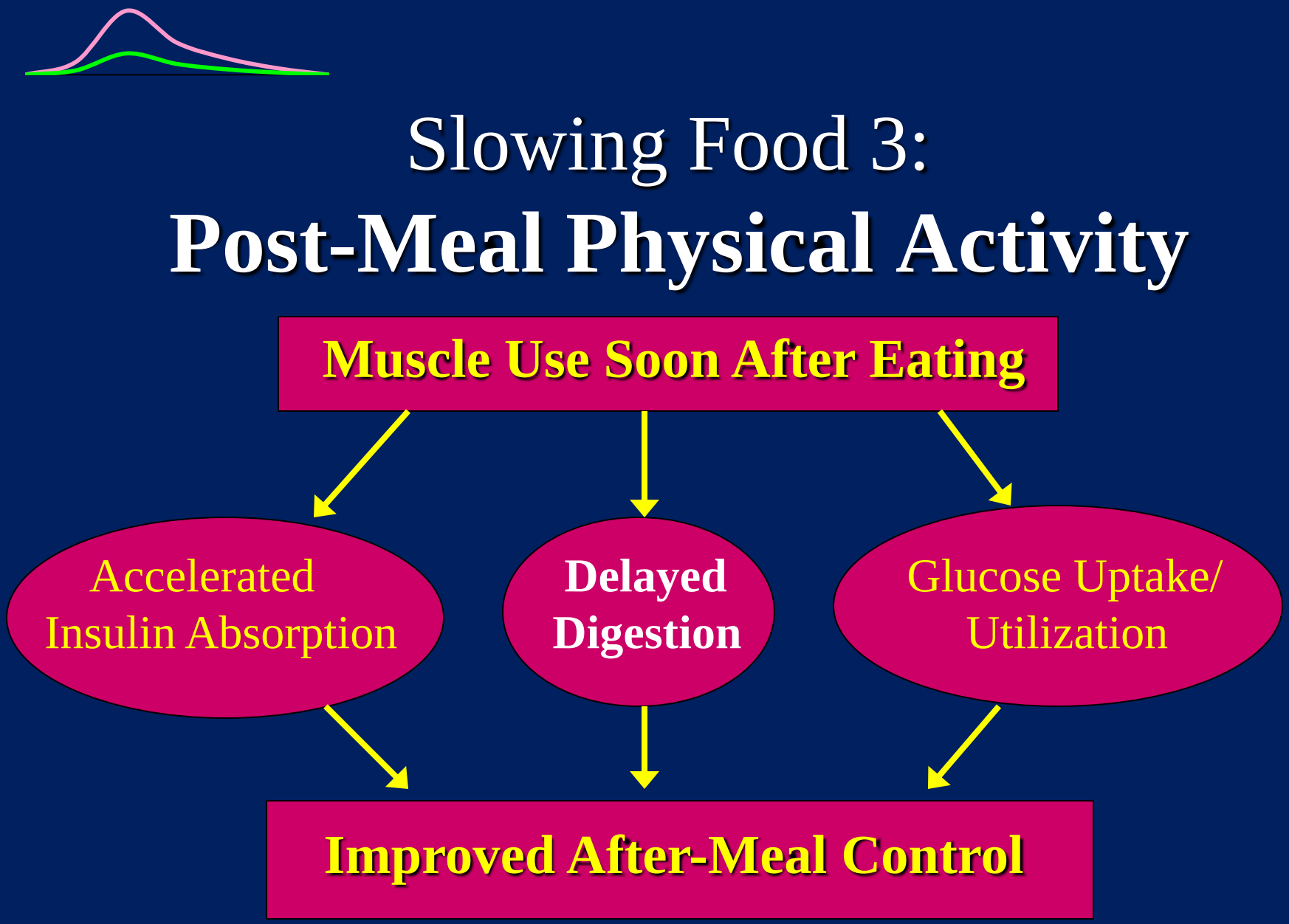
Slowing Food 2:
Splitting The Meal

- ✓ Part at the usual mealtime
- ✓ Part 60-90 minutes later
- ✓ Full insulin/meds given prior to meal





Slowing Food 3:
Post-Meal Physical Activity



Slowing Food 4:

Add Some Acidity

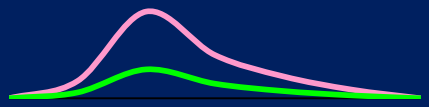
⬇60-min glucose response 55%*

✓Tomatoes

✓Sourdough

✓Vinegar (Salad Dressing/Condiments)

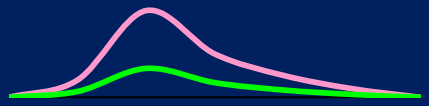
*Journal of the American Dietetic Association, 2005: v7 no12.



Slowing Food 5: **Meal Sequencing**

- ✓ **Eat veggies before starch when having mixed meals**
- ✓ **Make lunch the “higher carb” meal (less at breakast & dinner)**

Presented at the American Diabetes Associaion Scientific Sessions, 2012, symposium on minimizing glucose variability.



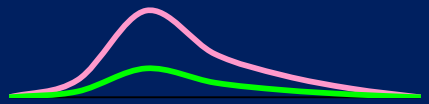
Slowing Food 6:
Medicinal Approaches

α-Glucosidase Inhibitors
(acarbose, miglitol)

+ **Slows carb absorption** in the small intestine

+ Gradual glycemic rise post-meal

- Often causes GI upset/flatulence



Medicinal Approaches

DPP-IV Inhibitors:
(sitagliptin, vildagliptin)

+ facilitate glucose-dependent insulin secretion

+ suppress glucose-dependent glucagon secretion

+ **slow gastric emptying**

Medicinal Approaches

GLP-1s
(exenatide, liraglutide)

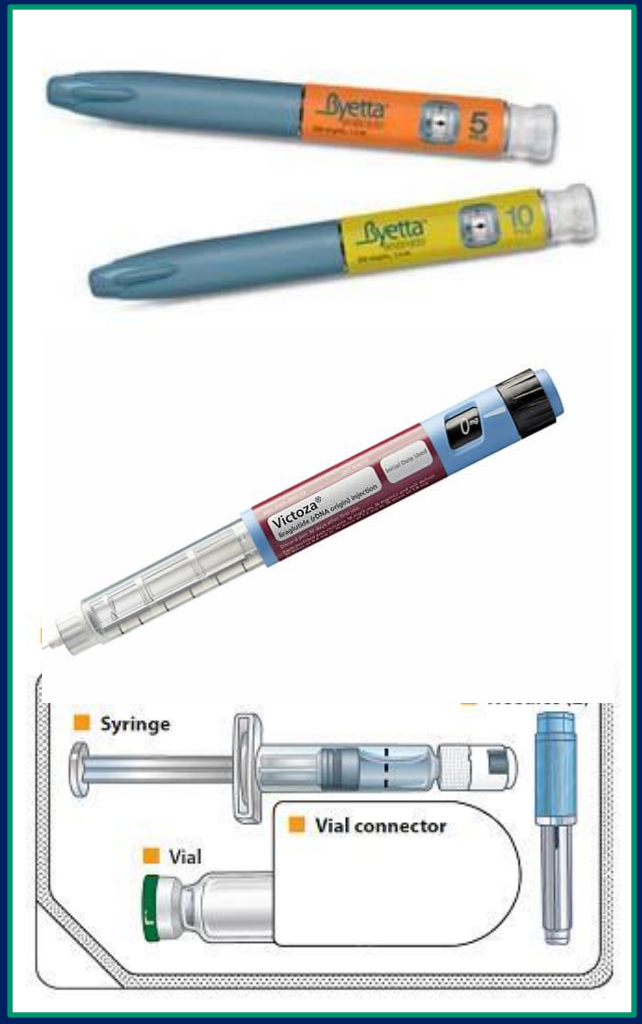
- subcutaneous injectible hormone

+ enhances 1st & 2nd phase insulin secretion

+ **slow gastric emptying**

+ suppresses appetite

- may cause nausea



Medicinal Approaches

Amylin Analog:
(pramlintide)

- subcutaneous injectible hormone

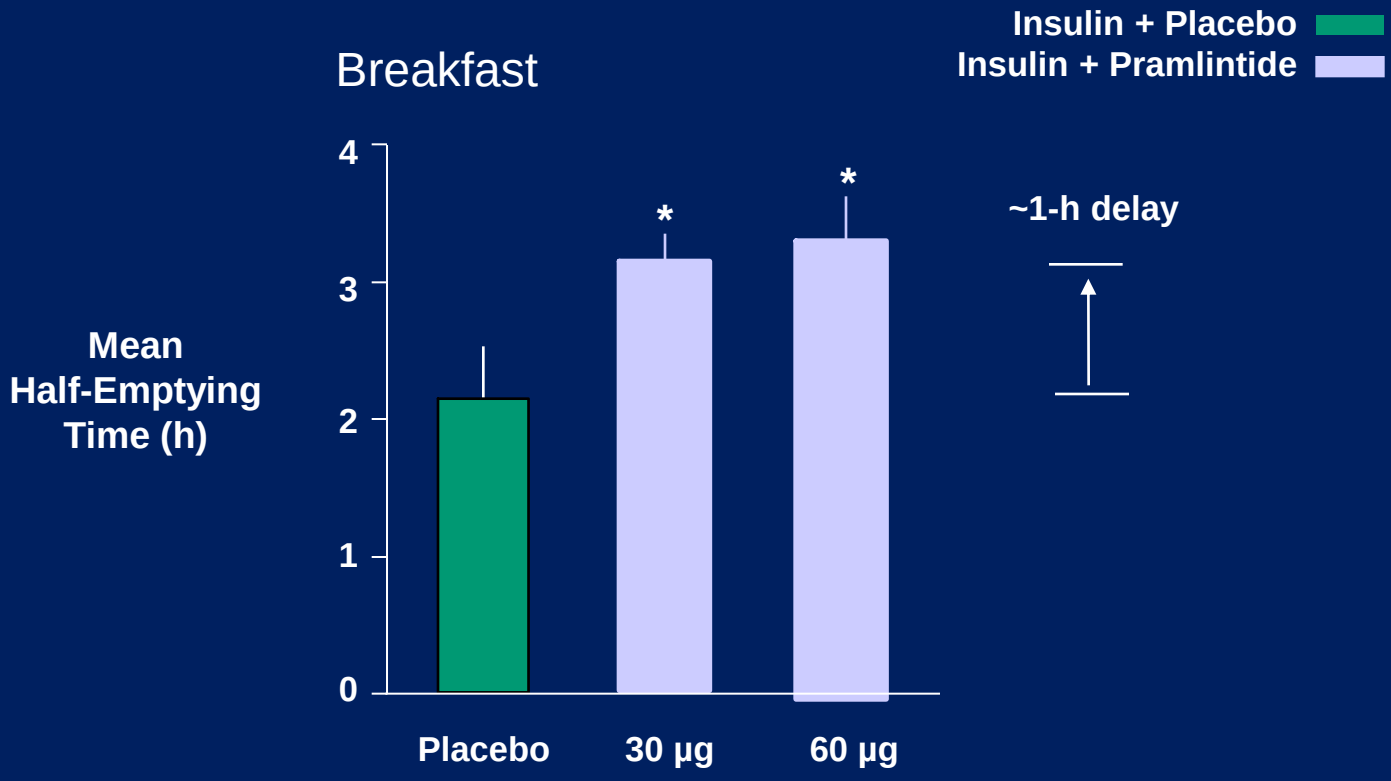
+ enhances satiety

+ slows gastric emptying

+ suppresses post-meal glucagon secretion

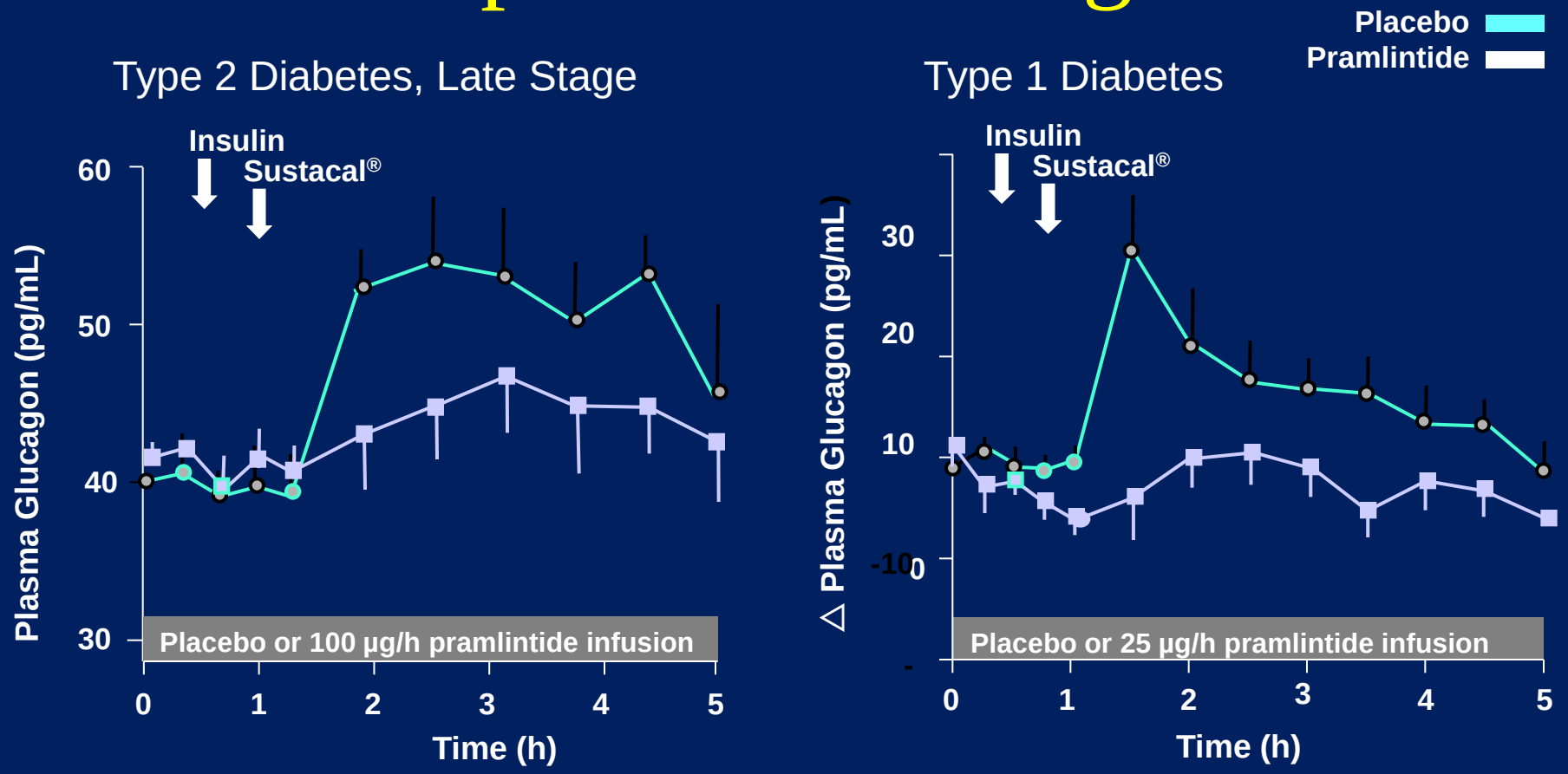
- may cause nausea

Effect of Pramlintide on Gastric Emptying in Type 1 Diabetes



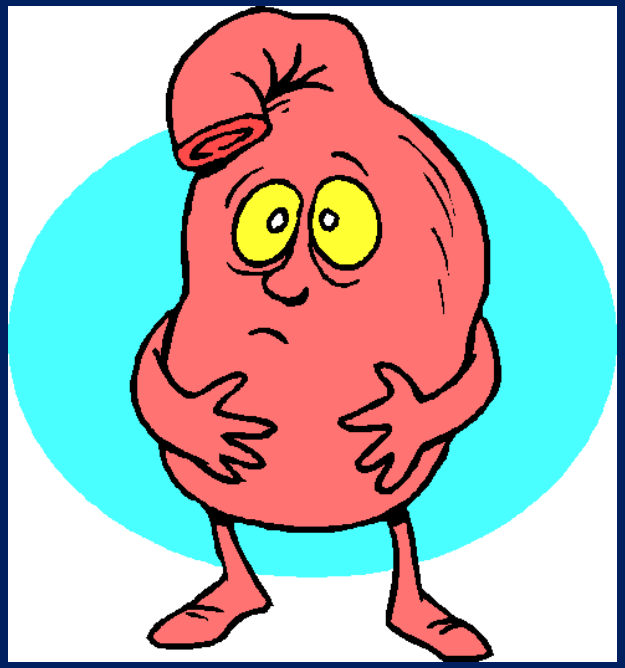
Single SC pramlintide doses: n = 11, crossover; *P<0.004; ^{99m}Tc labelled pancake; solid component measured
Data from Kong MF, et al. *Diabetologia* 1998; 41:577-583

Pramlintide Reduces Postprandial Glucagon



Type 2 diabetes, n = 12; $AUC_{1\text{-}4\ h}$: $P = 0.005$
Type 1 diabetes, n = 9; $AUC_{1\text{-}5\ h}$: $P<0.001$;
Data from: Fineman M, et al. *Metabolism* 2002; 51:636-641; Fineman M, et al. *Horm Metab Res* 2002; 34:504-508

Slowing Food 7:
Avoiding Pre-Meal Hypoglycemia

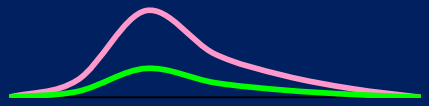


Symptomatic hypoglycemia produces "Sieve Effect"

Accelerates gastric emptying of liquids and solids

Produces more rapid BG rise after meal

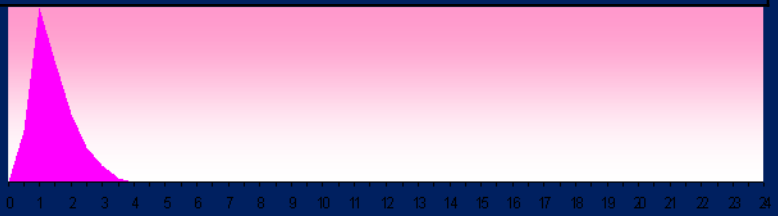
J Clin Endo Metab 2005; 90: 4489-95



Speeding Insulin 1:
Choice of Bolus Insulin

Aspart,
Glulisine,
Lispro

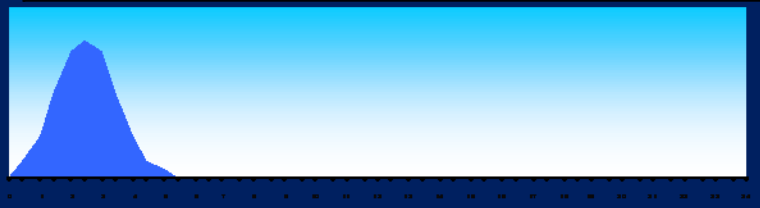
- 1-hr. peak
- 3-4 hr. effective duration

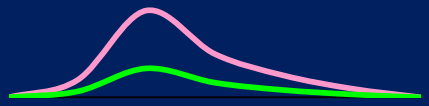


Vs.

Regular Insulin

- 2-3 hr. peak
- 4-6 hr. effective duration



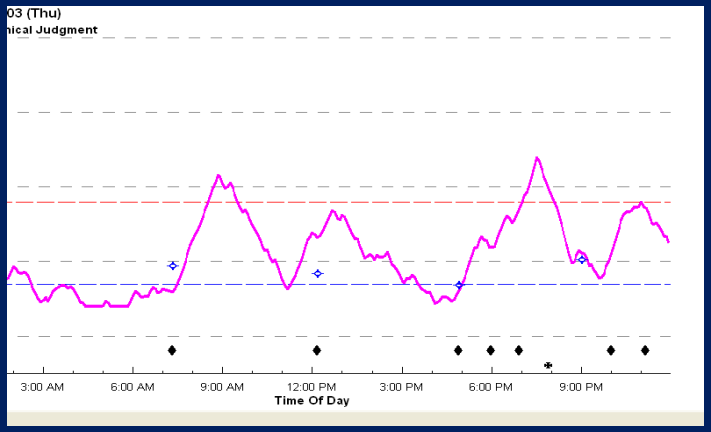


Speeding Insulin 2:
Timing of Bolus Insulin
(rapid analog)

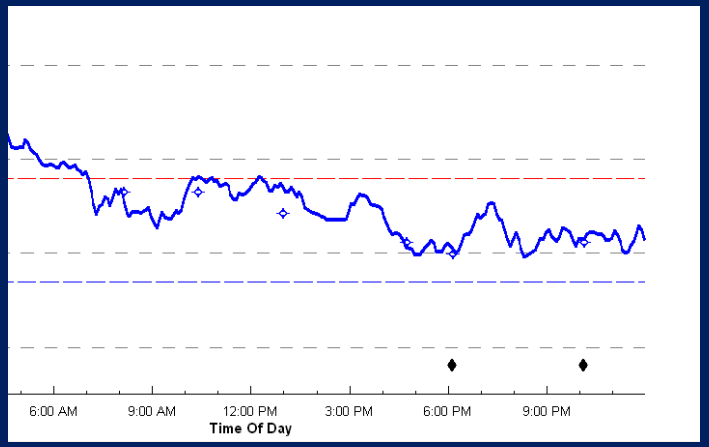
	High GI	Moderate GI	Low GI
BG Above Target Range	**30-40 min. prior**	**20-30 min. prior**	**10-15 min. prior**
BG Within Target Range	**20-30 min. prior**	**10-15 min. prior**	**0 min. prior**
BG Below Target Range	**0 min. prior**	**5-10 min. after**	**15-20 min. after**

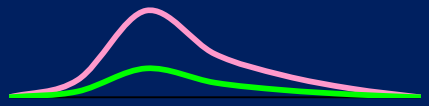
Does Timing Matter?

- Bolus w/meal

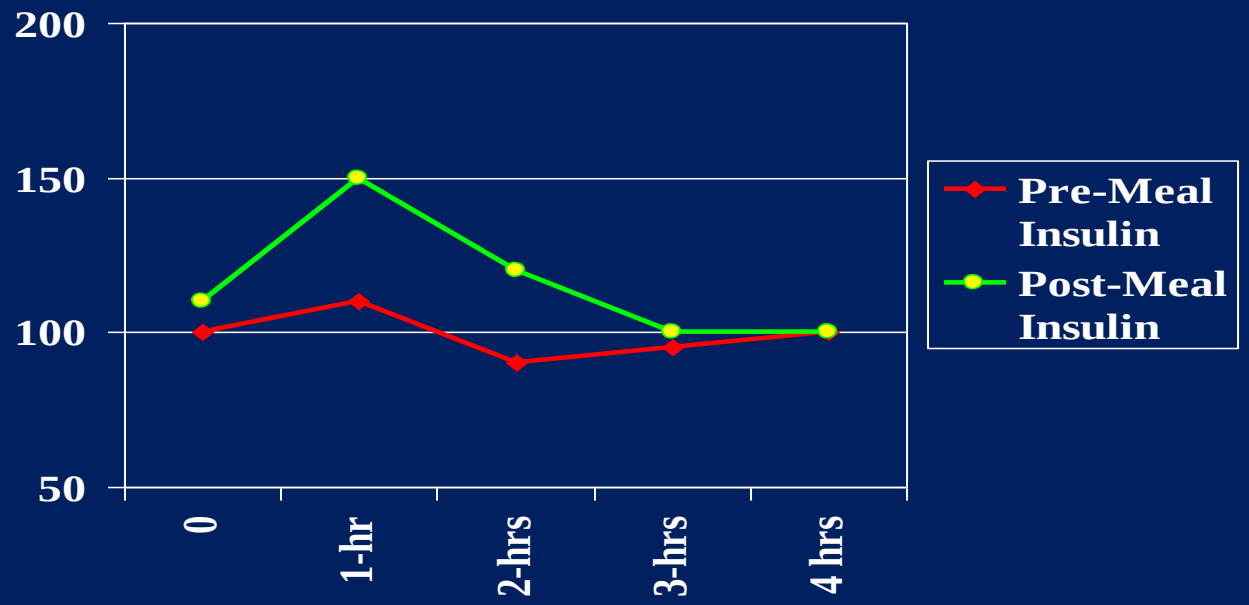


- Bolus pre-meal





Does Timing Matter?

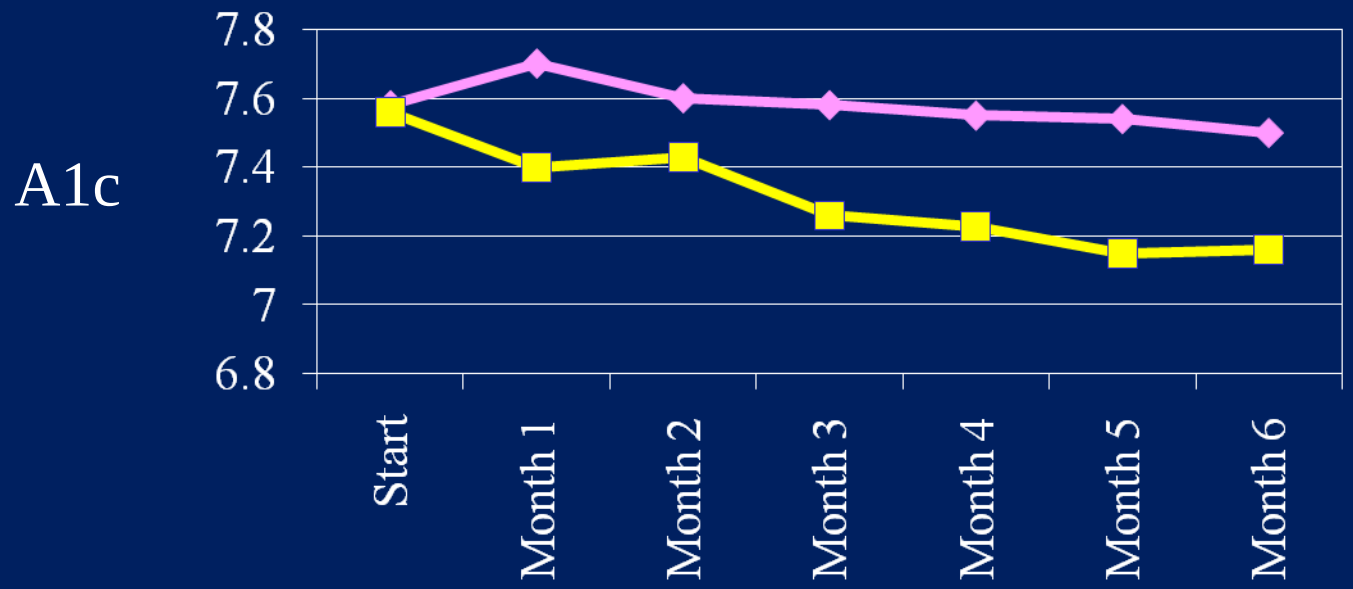


Note: Carbs estimated w/pre-meal insulin.
Carbs known with post-meal insulin.

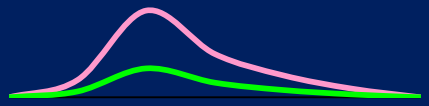
Source: Clinical Therapeutics 2004; 26:1492-7.

Does Timing Matter?

- Insulin taken with meal
- Insulin taken 15-30 min Pre-Meal (if >150)



Duran-Valdez, et al (U of New Mexico). Insulin Timing—A Beneficial Addition to Intensive Insulin Therapy in Type-1 Diabetes. Presented at the American Diabetes Association Scientific Sessions 2012, poster 964-P.



Speeding Insulin 3:
Choice of Insulin Program

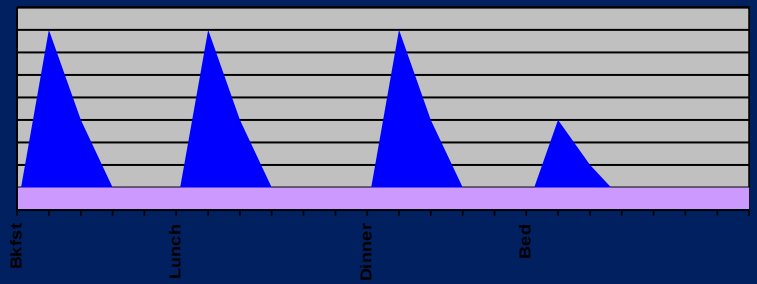
Pump & MDI

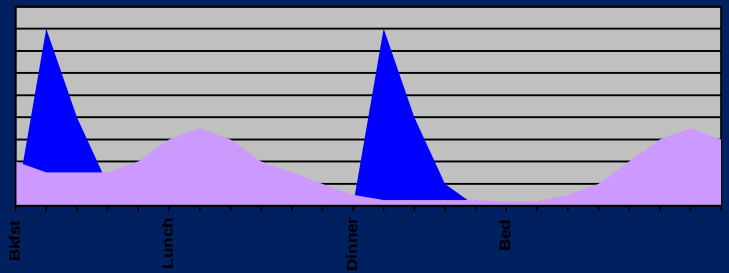
- Meal/snack boluses

Vs.

Daytime NPH

- Prolonged peak covers midday meals/snacks





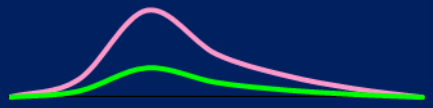
Speeding Insulin 4:

Warming The Injection/Infusion Site

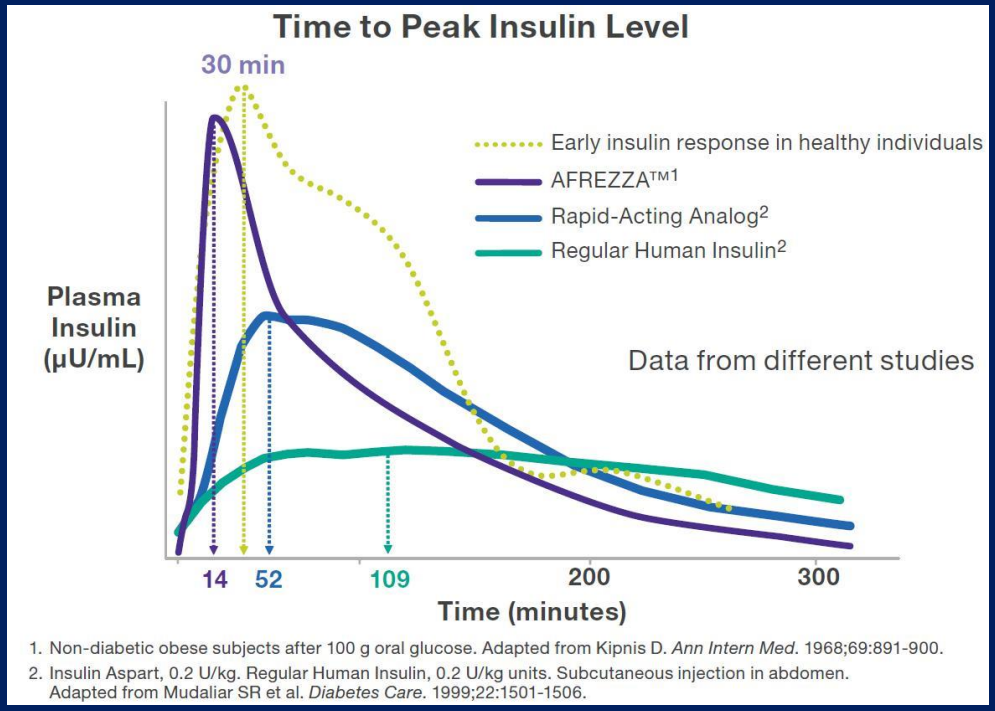
Warming The Injection/Infusion Site

"Insupatch" (experimental)

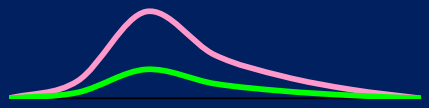
- Heating element in pump infusion site
- Warms site to 38-40°C
- 30-40 minute earlier insulin peak



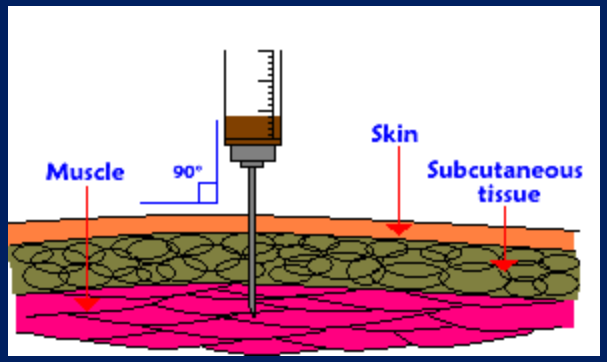
Speeding Insulin 5:
Afrezza

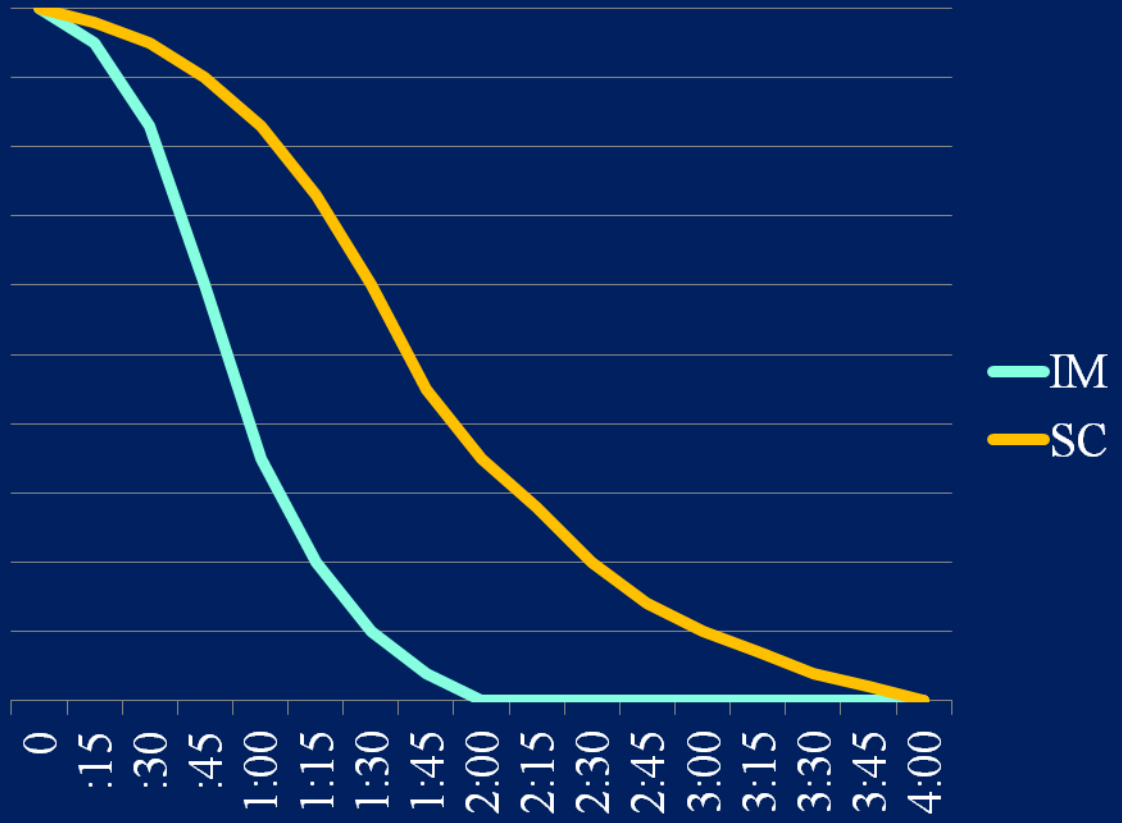


1. Non-diabetic obese subjects after 100 g oral glucose. Adapted from Kipnis D. *Ann Intern Med.* 1968;69:891-900.
2. Insulin Aspart, 0.2 U/kg. Regular Human Insulin, 0.2 U/kg units. Subcutaneous injection in abdomen. Adapted from Mudaliar SR et al. *Diabetes Care.* 1999;22:1501-1506.

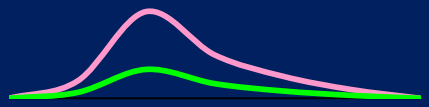


Speeding Insulin 6:
IM Injection

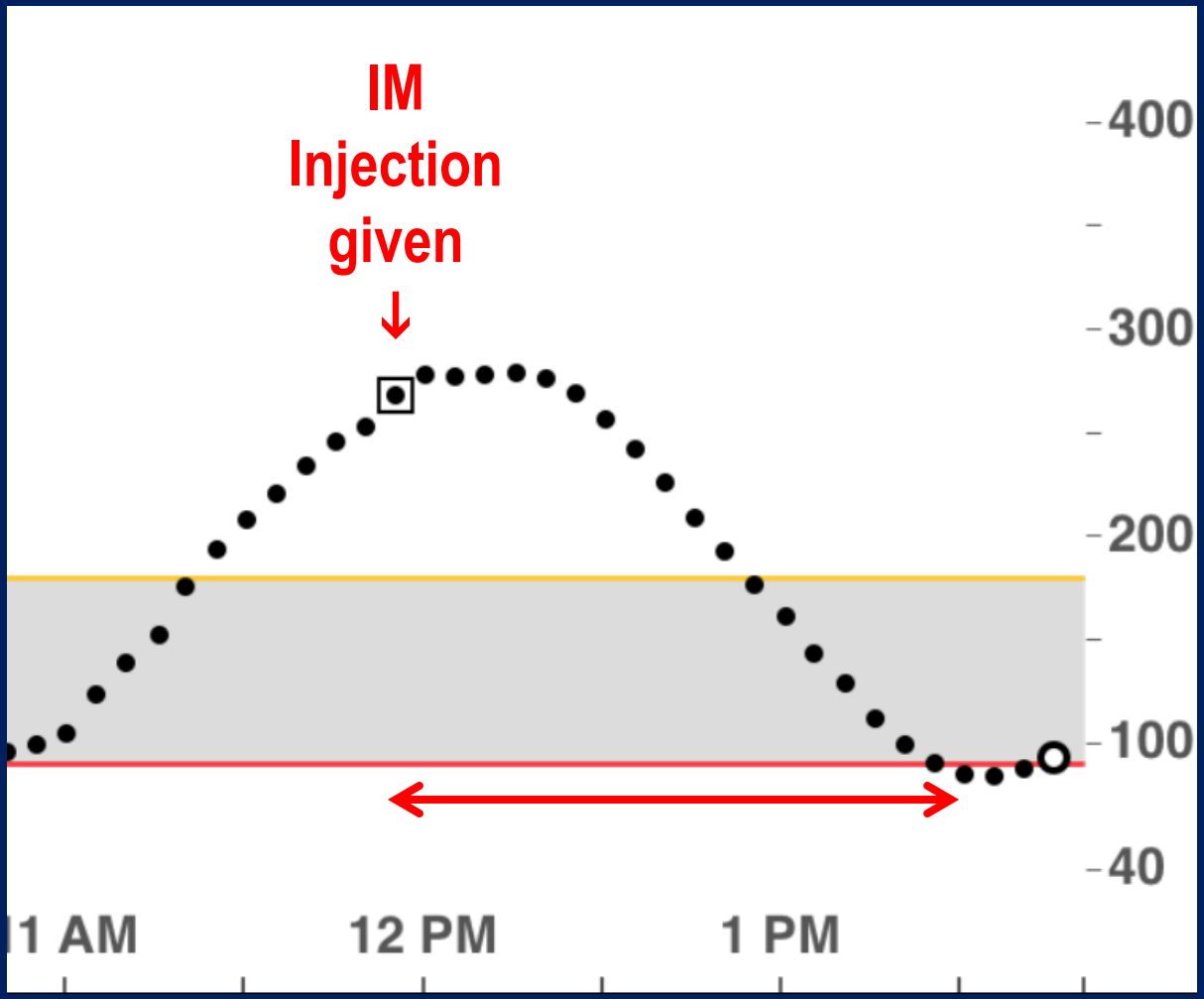


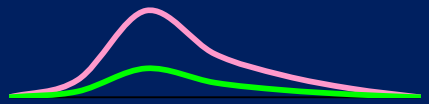


Diabet Med. 1990 May;7(4):335-42. Intramuscular versus subcutaneous injection of unmodified insulin: consequences for blood glucose control in patients with type 1 diabetes mellitus. Vaag A, Pedersen KD, Lauritzen M, Hildebrandt P, Beck-Nielsen H.



Speeding Insulin 6:
IM Injection





Speeding Insulin 7:
Sulfonylurea Substitutes

Meglitinides:
(repaglinide, nateglinide)

+ Stimulates pancreatic insulin secretion

+ **Rapid-acting** (1-2 hour peak)

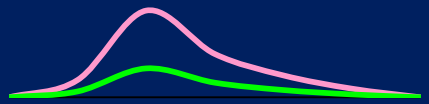
- ↑ Risk of hypoglycemia

- Must have beta-cell function

Meglitinide Comparisons

	Mean max BG at peak	% of time >200 mg/dl
Repaglinide	210	1%
Glimepiride	256	5%

Li et al, *Diabetes*, June 2008, V57 suppl. 1, 1970-PO.



Speeding Insulin 8:
Post-Meal Physical Activity

Muscle Use Soon After Eating

Accelerated Insulin Absorption

Delayed Digestion

Glucose Uptake/ Utilization

Improved After-Meal Control

Effects of Post-Meal Walking

30 Minutes of casual stop & go walking after meals

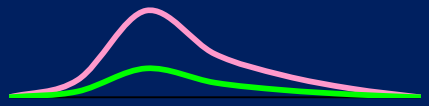
- ✓ **Avg. 30 mg/dl (1.75 mmol/L) BG reduction**
- ✓ **Peak post-meal glucose 45% higher when not walking**

Kudva, et al. Diabetes Care, published online Aug 8, 2012

Examples:
After-Meal Activity

- Walking Pets
- Household Chores
- Planned Exercise
- Shopping
- Gardening
- Casual Stroll
- Dancing
- Bowling
- Mini Golf
- Skating

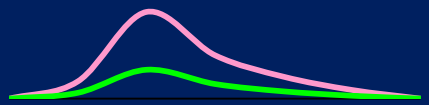
“Ze Art of Making Romance”



Summary

After-Meal Blood Sugar Levels Are:

- ✓ Important to Control
- ✓ Measurable
- ✓ Manageable



Post-Meal Mgt Summary

To Slow Food:

1. Choose Low-GI
2. Split Meal
3. Sequence Properly
4. Add Acidity
5. Use αGlucosidase Inhibitor
6. Use GLP1/Amylin
7. Post-Meal Activity

To Speed Insulin:

1. Use rapid analogs
2. Pre-Bolus
3. Warm Site
4. Inhaled Insulin
5. Intramuscular Injection
6. Use Meglitinide (oral)
7. Post-Meal Activity

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