Monitoring and Carbohydrate Counting: The Cornerstones of Diabetes Control

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Objectives

- Understand the relationship between insulin, carbohydrate intake, and blood glucose levels
- Understand a rational approach to blood glucose monitoring
- Understand the rationale for carbohydrate counting
- Understand how to use blood glucose monitoring and carbohydrate counting to improve diabetes control
• Normal glucose metabolism
• Diabetes
• Blood glucose monitoring
• Carbohydrate counting
• Putting the cornerstone in place
• Normal glucose metabolism
• Diabetes
• Blood glucose monitoring
• Carbohydrate counting
• Putting the cornerstone in place
Normal Glucose Metabolism

Fed State:
- Absorption of glucose from the gut
- ↑ Blood Glucose
- ↑ Hepatic Glucose Release
- ↓ Plasma Glucagon
- ↓ Hepatic Glucose Release
- ↓ Glycogen stores
- ↓ Glucose entry into liver & muscle cells
- ↓ Plasma Insulin
- ↑ Plasma Insulin
- ↓ Glucose entry into liver & muscle cells
- ↓ Glycogen stores
- ↓ Blood Glucose

Fasting State:
- Absorption of glucose from the gut
- ↓ Blood Glucose
- ↓ Hepatic Glucose Release
- ↓ Plasma Glucagon
- ↓ Plasma Insulin
- ↓ Glucose entry into liver & muscle cells
- ↓ Glycogen stores
- ↓ Blood Glucose

Exercise:
- ↑ Blood Glucose
- ↑ Plasma Glucagon
- ↓ Plasma Insulin
- ↑ Glycogen stores

Adapted from Concepts of Human Physiology, 1997, Malvin, Johnson, Malvin
Normal Insulin Response to Glucose
Normal Insulin Secretion

Mean 24 hour insulin secretion profile
(The hatched areas represent +/- 1 standard error of the mean)

Polonsky et al. Journal of Clinical Investigation, 1988
Normal Insulin Secretion

Meals at 9am, 1pm, and 6pm
Normal Insulin Secretion

Meals at 7am, 1pm, and 6pm
Snack at 10am
Normal Insulin Secretion

Meals at 9am and 6pm

Clock Time

Insulin Concentration

µU/mL

6:00 10:00 14:00 18:00 22:00 2:00
Normal Insulin Secretion

Meal = 45g carbohydrate
Normal Insulin Secretion

Snack = 15g carbohydrate
Normal Insulin Secretion

Meal = 100g carbohydrate

![Graph showing normal insulin secretion after a meal containing 100g of carbohydrates. The graph plots insulin concentration in μU/mL against time.]
Normal Insulin Secretion

- The body works without you having to think about it
Outline

- Normal glucose metabolism
- Diabetes
  - Blood glucose monitoring
  - Carbohydrate counting
  - Putting the cornerstone in place
• Type 1 diabetes
  – Pancreas secretes no insulin
• Type 2 diabetes
  – Cellular resistance to insulin
  – Impaired pancreatic insulin secretion
  – Inappropriate hepatic glucose release
Insulin Secretion: Type 1 Diabetes

Meals at 9am, 1pm, and 6pm
• Type 1 diabetes
  – Pancreas secretes no insulin

• Type 2 diabetes
  – Cellular resistance to insulin
  – Impaired pancreatic insulin secretion
  – Inappropriate hepatic glucose release
Cellular Insulin Resistance

Mean 24 hour insulin secretion profile
(The hatched areas represent +/- 1 standard error of the mean)

Polonsky et al. Journal of Clinical Investigation, 1988
Cellular Insulin Resistance

![Graph showing the relationship between blood glucose and plasma insulin over time.](image)
Impaired Insulin Secretion

**Figure 1** Pattern of insulin secretion in normal individuals and patients with type II diabetes (Adapted from Polonsky *et al*³).
Cellular Insulin Resistance + Impaired Insulin Secretion

![Graph showing glucose and insulin levels over time](graph.png)

- **Blood Glucose**
- **Insulin**

*Graph depicts the relationship between glucose levels and insulin secretion over time.*
If the pancreas doesn’t secrete any insulin (type 1 diabetes) or doesn’t secrete enough insulin (type 2 diabetes) what can you do?

Learn to think like a pancreas!
Think Like A Pancreas

• How does the pancreas determine how much insulin to secrete?
  – Blood glucose level

• What determines the blood glucose level?
  – Prior blood glucose
  – Carbohydrate intake
Think Like A Pancreas

• What information do you need in order to think like a pancreas?
  – Blood glucose value
  – Carbohydrate content of your meal

• How are you going to get this information?
  – Blood glucose monitoring
  – Carbohydrate counting
• Normal glucose metabolism
• Diabetes
• **Blood glucose monitoring**
• Carbohydrate counting
• Putting the cornerstone in place
Why Monitor?

• Insulin Users:
  – Intensified blood glucose monitoring improves glycemic control
  – Self-monitoring of blood glucose provides a strong stimulus for improved self-care resulting in clinically important and sustained reductions in HbA1c
    Murata et al, Diabetes Care 2003

• Non-Insulin Users:
  – Self-monitoring of blood glucose is statistically associated with a better quality of metabolic control than usual traditional recommendations alone in type 2 diabetes
    Guerci et al, Diabetes Metabolism 2003
Why Monitor?

• If you take insulin:
  – Monitoring allows you to adjust insulin to account for a high or low pre-meal blood glucose
  – Data can be used to determine accurate insulin doses
Insulin Dose: 10 units prior to each meal

- Pre-meal BG = 140
- No adjustment for high BG

- Pre-meal BG = 140
- Extra insulin for high BG
Accurate Insulin Doses

- Determine how many grams of carbohydrate are covered by 1 unit of insulin (insulin to carbohydrate ratio)
- Determine how far 1 unit of insulin will drop the blood glucose (correction factor)
Insulin to Carbohydrate Ratio

Ratio: 1u insulin for 12g carbohydrate
→ 5u for 60g carbohydrate breakfast

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<th>Pre-Meal</th>
<th>3h Post-meal</th>
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<tbody>
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<td>104</td>
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</table>

Is the ratio correct?
Correction factor: 1u insulin drops BG 35mg/dL → 3u for BG of 221mg/dL

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Is the correction factor correct?
Why Monitor?

• If you don’t take insulin:
  – Monitoring allows you to take into account your pre-meal blood glucose when you plan your next meal
  – Data can be used to determine your carbohydrate threshold
Meal Planning

- Have a low carb or no carb meal or snack if blood glucose is high
- Limit or don’t eat cookies if blood glucose is high
- Go for a walk before or after your meal to lower your blood glucose
Carbohydrate Threshold

100g carbohydrate breakfast

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<td>298</td>
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</table>

45g carbohydrate breakfast

<table>
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<tr>
<th>Pre-Meal</th>
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</tr>
</thead>
<tbody>
<tr>
<td>104</td>
<td>126</td>
</tr>
</tbody>
</table>

Meals should be limited to 45g carbohydrate
Outline

- Normal glucose metabolism
- Diabetes
- Blood glucose monitoring
- Carbohydrate counting
- Putting the cornerstone in place
Why Count Carbohydrates?

• The carbohydrate content of the meal determines the rise in blood glucose following the meal.

• Injected insulin has a delayed effect, so insulin must be injected prior to the meal to prevent hyperglycemia.
Why Count Carbohydrates?

- If you take insulin:
  - Carbohydrate counting allows you to match your insulin dose to the carbohydrate content of the meal
  - Carbohydrate counting allows you to avoid overtreatment of a low blood glucose
Adjust Insulin

Insulin Dose: 10 units prior to each meal

• Pre-meal BG = 100
• Carbs in meal = 45g

• Pre-meal BG = 100
• Carbs in meal = 100g
Adjust Insulin

Insulin Dose: 10 units prior to each meal

- Pre-meal BG = 100
- Carbs in meal = 45g

- Pre-meal BG = 100
- Carbs in meal = 15g
Why Count Carbohydrates?

• If you don’t take insulin:
  – Carbohydrate counting allows you to plan your meals to stay within your carbohydrate threshold to avoid high blood glucose levels
  – Carbohydrate counting allows you to avoid overtreatment of a low blood glucose
• Count carbs to avoid eating more carbs than your pancreas can handle
• Count carbs to avoid eating too much when your pre-meal blood glucose is high
• Count carbs to avoid overtreatment of a low blood glucose
Outline

• Normal glucose metabolism
• Diabetes
• Blood glucose monitoring
• Carbohydrate counting

• Putting the cornerstone in place
• Alice has type 2 diabetes that she controls with exercise and monitoring her carb intake
• Alice wants to have a piece of birthday cake, but she just ate a large meal and she’s worried about her blood glucose
• What are Alice’s options?
• Joe treats his diabetes with metformin and glipizide
• He knows that he can handle about 60 grams of carbohydrate per meal
• Joe is dismayed to find the Thanksgiving table laden with high carb foods
• What are Joe’s options?
  • What if his glucose is 200?
  • What if his glucose is 100?
  • What if his glucose is 70?
Pumpkin Pie

- Lynn has type 1 diabetes and takes insulin: 1 unit for every 15 grams carbohydrate and 1 unit for every 30 mg/dL above her target blood glucose.
- Lynn is invited to her friend’s house for pumpkin pie.
- Her friend cuts a huge piece of pie and sets it down in front of Lynn.
- What are Lynn’s options?
Mid-morning Meeting

• Edward has type 2 diabetes treated with metformin and Actos
• Edward goes to a 10:00 a.m. meeting where bagels are being served
• He knows that if he eats a bagel his blood sugar will be way too high by lunchtime
• What are Ed’s options?
• Ben has type 1 diabetes and takes insulin: 1 unit for every 10 grams carbohydrate and 1 unit for every 25 mg/dL above his target blood glucose

• Ben checks his blood glucose before leaving home and finds that it’s 65 mg/dL

• What are Ben’s options?
Summary

Monitoring blood glucose and counting carbohydrates are essential tools for achieving diabetes control.
Resources

• Preventive Health
  – Individual nutrition appointments
  – Carbohydrate Counting Class

• Disease Management Clinic
  – Individual appointments
  – Diabetes Group Class
  – Intensive Insulin Therapy Group