Applied carbohydrate counting

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Abstract

Carbohydrate counting or "carb counting" is a meal planning technique for persons with diabetes for managing blood glucose levels by tracking the grams of carbohydrate consumed at meals. With better patient education and awareness, carb counting has become an important step in diabetes management. People with all types of diabetes can be benefited with this approach via improved glycaemic control and quality of life. In the first part of this review basic principles of carbohydrate counting, its application in clinical practice and exchange lists pertaining primarily to South Asian populations have been discussed. Advanced carb counting involving equations which help in better understanding of insulin-to-carbohydrate ratio and insulin dose adjustment are also included in this review.

Keywords: Carbohydrate counting, Meal-time insulin, Basal insulin, Bolus insulin.

Introduction

Carbohydrates, both simple and complex, greatly affect postprandial blood glucose levels as compared to proteins and fats. Carbohydrate counting or "carb counting" is a meal planning technique for persons with diabetes for managing blood glucose levels by tracking the grams of carbohydrate consumed at meals. Basic carbohydrate counting is a structured approach that emphasizes consistency in the timing and amount of carbohydrate (CHO) consumed.[1] This review focusses on advanced carbohydrate counting, which primarily involves matching the amount of CHO consumed with an appropriate dose of insulin (usually rapid acting). It improves glycaemic control and helps in evaluating the impact of CHO intake and food choices on blood glucose and setting nutrition goals.[2]

Insulin-to-carbohydrate ratio (ICR) and sensitivity factor (SF)

To mimic normal pancreatic function in persons with

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Table-1: Equations for advanced carbohydrate counting.[4-8]

CASE STUDY: A 40 year old man with diabetes

Height : 5'8" (172 cm)
Weight : 72.5 kg
BMI : 24.57 kg/m2
Daily energy intake : 1600 kcal
Carbohydrate : 55% = 880 kcal i.e. 220gm
Protein : 20% = 320 kcal i.e. 80 gm
Fat : 25% = 400 kcal i.e. 44 gm

1. Calculating Total Daily Insulin dose (TDI)

◆ TDI = 0.55 × Weight in kg
So, 0.55 × 72.5 = 40 units of insulin/day

2. Calculating Basal and Bolus Insulin dose

◆ Bolus Insulin dose = 50% of TDI
So, 50% of 40 units = 20 units to cover total mealtime CHO/day

3. Calculating ICR / CHO Coverage Dose

By 450/500 Rule

■ 500 Rule for Users of aspart, lispro and glulisine

◆ 500 ÷ TDI = grams of carbohydrate that are approximately covered by 1 unit of insulin
So, 500 ÷ 40 = 12.5
i.e. 1 unit of insulin will cover approximately 12.5 grams of carbohydrate

■ 450 Rule for Users of Regular Insulin

◆ 450 ÷ TDI = grams of carbohydrate that are approximately covered by 1 unit of insulin
So, 450 ÷ 40 = 11.2
i.e. 1 unit of insulin will cover approximately 11.2 grams of carbohydrate

By Body weight

2.8 × body weight (in pounds) ÷ TDI
So, 2.8 × (72.5 kg× 2.2) ÷ TDI
2.8 × 159.5 lb ÷ 40 = 11
i.e. 1 unit of insulin will cover approximately 11.2 grams of carbohydrate

4. Calculating CHO coverage at particular meals

◆ Total grams of CHO in the meal ÷ grams of CHO disposed by 1 unit of insulin
So, 55 gm ÷ 12 = 4.5 i.e. 5 approx.

Meals	Early morning	Breakfast	Mid-morning	Lunch	Evening snack	Dinner	Post-dinner
Percent of total CHO/d	10%	20%	5%	25%	10%	25%	5%
Grams of total CHO/d	22gm	44gm	11gm	55gm	22gm	55gm	11gm
Bolus Insulin dose (20) to cover meal-time CHO		55 gm ÷ 12 5-6 units		80 gm ÷ 12 6-7 units		66 gm ÷ 12 5-6 units	

*Approximately, 6-7 units of bolus insulin before each major meal (TDS insulin regimen) to cover 20 units of bolus insulin i.e. short or rapid acting insulin/d and 20 units of basal insulin i.e. long acting insulin/d.

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5. Calculating Correction Factor (CF)

- CF = 1700/1800 ÷ TDI

  So, 1700 ÷ 40 = 42.5

  1800 ÷ 40 = 45

  1 unit of insulin will drop blood glucose level by 45 mg/dl (40-50 mg/dl)

- Difference between actual blood glucose level and target blood glucose level ÷ correction factor

  So, Actual blood glucose level before breakfast = 220

  Target blood glucose level before breakfast = 130

  220 - 130 ÷ 45 = 2 units

  Total dose before breakfast = CHO insulin dose (step 4) + 2 units

  Using CF, total meal-time insulin dose is 6 units+ 2 units = 8 units

Table-2: Limitations of CHO counting in clinical practice.[7]

Approach related	Individual related
◆ It is a tool for improvement but not the solution for people with diabetes	◆ Individual insulin sensitivity and insulin resistance is not considered
◆ Primarily used for carbohydrate based diet	◆ Lean, newly diagnosed and insulin sensitive patients may calculate higher doses of insulin
◆ Does not consider nutrients like protein, fat, vitamins and minerals obtained from food items	◆ Obese and insulin resistant patients may calculate lower doses of insulin
◆ Not a holistic approach as it does not take account exchange list of other food groups	◆ Inappropriate determination of quantity of carbohydrate containment or portion size
◆ Only tentative idea of total daily insulin dose and may need changes later	◆ Professional dieticians may be required to calculate amount and type of CHO in the diet
◆ Assumes constant response to insulin throughout the day	◆ May result in inappropriate calorie intake or insulin dose

diabetes, basal insulin is usually given as long acting insulin to counteract rises in blood glucose that occur independent of meal ingestion and bolus insulins are given by either rapid acting (lispro, aspart and glulisine) or regular insulin in relation to meals, which counteracts the rise in blood glucose after meals. Basal insulin requirement is usually constant from day to day and matching bolus insulin to carbohydrate intake using an ICR is optimal for post-meal blood glucose management. Once an ICR is established, patients can adjust their mealtime boluses based on their carbohydrate intake.

Every person responds differently to insulin. For most adults, one unit of rapid-acting insulin can usually cover 15 grams of CHO. A toddler may require 1/2 to 1 unit of rapid-acting or regular insulin for 30 to 45 grams of CHO, while a teenager may require 1 unit for each 7 to 15 grams of CHO. Also, it may further differ in pregnancy. However, other factors such as weight, activity level, gender and hormonal changes also determine the ICR.[3,4]

A premeal blood glucose level determines whether additional insulin should be added to the premeal bolus to cover premeal blood glucose excursions using a sensitivity factor (SF). It helps to bring high blood glucose levels to the target blood glucose levels. Blood glucose readings are taken following a meal (about two hours after starting meal) to assess the ICR. As the ICR is determined to be correct, postmeal readings can then be taken periodically as needed.

For better understanding, Table-1 discusses some quick equations with respective illustrations with a case study. Some limitations of CHO counting are summarized in Table-2.

Conclusion

Judicious calculations of ICR and SF, regular follow-ups and appropriate monitoring based on individual requirements with timely modifications of insulin doses makes it a helpful approach for the people with diabetes to develop an understanding of the principles of the basal-bolus insulin concept to achieve optimal blood glucose levels.

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