An Innovative Use of the Ambulatory Glucose Profile to Reveal the Glycemic Effect of Food

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Background & Aims

The Ambulatory Glucose Profile (AGP), created by Mazze and colleagues[1], has been proposed as a standard reporting system for continuous glucose monitoring (CGM) by an expert panel of diabetes specialists.[2] The AGP provides a comprehensive picture of the glycaemic progression from pre to post-prandial periods and may aid in refining nutrition and insulin therapy. Exploration of the AGPs expanded utilization in determining pre and post-prandial patterns and corresponding interventions is presented.

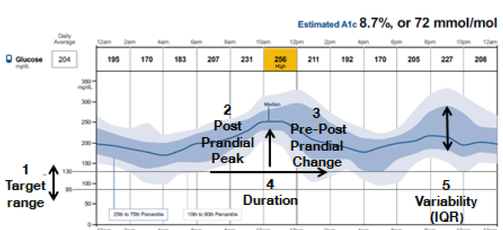
Materials & Methods

AGP reports were evaluated from an intervention group in a 100 day, 9 UK site, prospective study (SIGN). Subjects (n=53) aged 18-82 with type 1 or type 2 diabetes, HbA1c 7.5-12%, treated with multiple daily injections of insulin (MDI) used CGM with the alarms disabled. AGP reports using >14 days of CGM data, similar to Figures 2 & 3, were evaluated to support therapy adjustments.

Results

Five key metrics were identified to aid in prandial assessment and decision making.

Figure 1: Prandial assessment metrics



1) Target Range identifies whether the pre-prandial and post-prandial median glucose levels are within target. When pre-prandial glucose is outside of target, assess basal insulin dose and pre-prandial events or snacks. When the post-prandial glucose value is outside target, assess carbohydrate (carb) portions or carb grams, insulin to carb ratio (ICR), and the timing of prandial insulin.

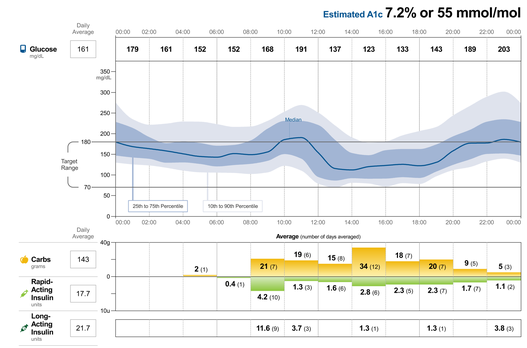
2) Post-Prandial Peak is the highest point on the median curve. It typically occurs 1-3 hours after the start of the meal. Peak times may differ depending on meal composition. Meals containing higher fat content may exhibit a delayed post-prandial peak. Peak time can aid in planning for the timing of prandial insulin. Ideally, the insulin action peak should match the post-prandial peak.

3) Prandial Glucose Change at each meal is determined as median pre-prandial level – median peak level = change. This reflects the balance of prandial insulin dose and carb. Carbs may need to be decreased or the prandial insulin increased for excessive glucose change at meals (> 50 mg/dL, 2.7 mmol/L) [3].

4) Duration of the Post-Prandial Curve is the amount of time after a meal to reach pre-prandial glucose levels. Longer durations can indicate high fat or high protein meals, gastroparesis, or inadequate prandial insulin coverage. The amount and timing of prandial insulin can be adjusted to lessen the duration of post-prandial rise. If post-prandial glucose levels do not return to baseline within the typical 3-5 hours, the next pre-prandial glucose starts at a higher level, and an adjustment of basal and bolus insulin doses may be required.

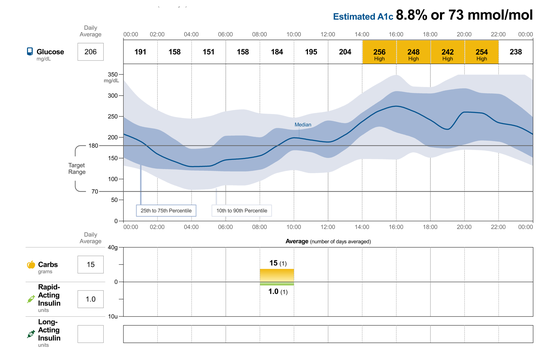
5) Mealtime Glucose Variability is represented as the difference after a meal between the 25th-75th percentile or the interquartile range (IQR). When carb type or amount varies on multiple days, the AGP may show greater variability or wider IQR. Evaluation of sources of variability such as food-insulin balance and the timing of meals across multiple days may help explain the cause of excessive variability. Decreasing variability or IQR may reduce the risk of hypo or hyperglycemia.

Figure 2: T1 subject, 16 days of CGM data



Metric	T1 Subject Assessment	T2 Subject Assessment
Target Range	Within target	Above target
Post-prandial Peak	Breakfast peak identified, but no lunch or dinner peaks identified. ❖Late evening peak could be due to high fat content at dinner or post-dinner snack.	Apparent peaks at breakfast, lunch, & dinner, despite the lack of carb or insulin data.
Prandial Change	Pre-prandial median glucose and postprandial peaks reveal a change of 50 mg/dL (2.8 mmol/L) at breakfast, 10-20 mg/dL (0.6-1.1 mmol/L) at lunch, 10-40 mg/dL (0.6-2.2 mmol/L) at dinner. ❖ If the risk of post-prandial hypo becomes a concern due to small prandial changes, consider increasing carb or reducing the prandial insulin &/or assess the insulin timing.	Pre-prandial median glucose and postprandial peaks reveal a change of 30 mg/dL (1.7 mmol/L) at breakfast, 80 mg/dL (4.4 mmol/L) at lunch, 25 mg/dL (1.4 mmol/L) at dinner. The excessive change at lunch contributes to pre-dinner hyperglycemia. ❖What is the lunch carb content? Can the carb be reduced or meal insulin increased?
Duration	Breakfast appears to have 3-4 hour duration, whereas, lunch, dinner, snack durations seem to overlap. ❖Does lunch or dinner contain a high fat or protein content, or both? Is dinner eaten a few hours after lunch?	Duration for breakfast, lunch, and dinner appears to be 3-4 hours, 6-7 hours, and 3 hours, respectively. ❖Lunch fat content may contribute to this protracted duration. Lunch time insulin coverage may have dissipated, contributing to pre-dinner hyperglycemia. What is the fat content at lunch? Can it be decreased?
Variability	The width of the darker blue band (IQR) is fairly consistent over the 24-hour period. ❖This can indicate consistent meal times, carb intake, and appropriate ICR.	The width of the darker blue band (IQR) is fairly consistent until 3 pm. The increase in width indicates variability. ❖What are the eating patterns late afternoon into evening? Are snacks eaten? Does the dinner carb content vary?

Figure 3: T2 subject, 15 days of CGM data



Conclusions

Analysis of AGP prandial periods can reveal the glycaemic effects of food and insulin. AGPs can assist in refining nutrition and insulin therapy relative to type and amount of carb, amount of dietary fat and protein, timing and amount of prandial insulin and meal times. Further research focusing on nutrition therapy & utilizing AGP reports are needed.

References

1. Mazze RS et al. Ambulatory glucose profile: Representation of verified self-monitored blood glucose data. Diabetes Care 1987;10:111–117.

2. Bergenstal R et al. Recommendations for standardizing glucose reporting and analysis to optimize clinical decision making in diabetes: The Ambulatory Glucose Profile (AGP). Diabetes Technology and Therapeutics 2013;15:198-211.

3. International Diabetes Center. Guide to starting and adjusting insulin for type 2 diabetes. Minneapolis, MN, 2014.

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