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Continuous Glucose Monitoring

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Hemoglobin A_{1c} (HbA_{1c}) and fingerstick testing with a blood glucose meter (BGM) have been the mainstay of monitoring glucose levels since the Diabetes Control and Complications Trial was published in 1993.[1] Continuous glucose monitoring (CGM) may be utilized to complement HbA_{1c} testing and replace fingerstick monitoring. This article focuses on CGM use in type 2 diabetes, because primary care clinicians often prescribe and manage CGM in this population.

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CGM Devices

Commonly used CGM devices consist of a sensor attached to the skin with a subcutaneous sensor filament to measure interstitial glucose levels, which are closely correlated with blood glucose levels. Glucose data are transmitted every 1 to 5 minutes from the sensor to a mobile phone or dedicated receiving device, where the glucose values can be visualized, and then to a cloud-based repository. Configurable alerts warn of impending hyperglycemia or hypoglycemia, with a fixed alarm at 55 mg/dL (to convert glucose from mg/dL to mmol/L, multiply by 0.0555). Most patients can learn to insert the CGM by viewing online educational materials.

Evidence of CGM Effectiveness

Although CGM use is standard care for management of type 1 diabetes, randomized clinical trials (RCTs) report similar benefit for patients with type 2 diabetes treated with multiple daily doses and basal insulin regimens. In an RCT[2] of 158 adults with type 2 diabetes receiving multiple daily injections of insulin, mean HbA_{1c} decreased from 8.5% to 7.7% at 24 weeks with CGM vs 8.5% to 8.0% with BGM (P = .02; to convert HbA_{1c} to mmol/mol, use the following equation: [10.93 × HbA_{1c}] − 23.50). In an RCT[3] of 175 adults using basal insulin alone, mean HbA_{1c} improved from 9.1% to 8.0% at 8 months with CGM vs 9.0% to 8.4% with BGM (P = .02). While evidence from large RCTs is not yet available for patients with non–insulin-treated type 2 diabetes, a meta-analysis with 12 RCTs and 1248 participants reported a mean HbA_{1c} difference of −0.31% (95% CI, −4.75% to −2.11%) comparing CGM vs BGM across the spectrum of type 2 diabetes regimens, with consistency of benefit for insulin, noninsulin, and mixed treatments.[4] An observational study conducted in the Veterans Affairs Healthcare System evaluated 5-year mortality in 2752 patients who used CGM, of whom 407 (14.8%) died; higher mean glucose, time in glucose range of greater than 180 mg/dL, coefficient of variation in glucose values, and lower time in target range of 70 to 180 mg/dL were associated with all-cause mortality (adjusted hazard ratios of 1.27 [95% CI, 1.09-1.47], 1.27 [95% CI, 1.09-1.48], 1.17 [95% CI, 1.04-1.32], and 0.77 [95% CI, 0.66-0.90], respectively).[5]

The American Diabetes Association (ADA) recommends CGM for individuals with type 1 or type 2 diabetes using any type of insulin regimen (level A evidence) and recommends consideration of CGM for those with non–insulin-treated type 2 diabetes (level B evidence). Based on low certainty of evidence, CGM is suggested for outpatients with type 2 diabetes who take sulfonylureas and are at increased risk of hypoglycemia.[6]

CGM as a Self-Management Tool

Individuals using mealtime insulin can adjust doses if CGM readings are high or increasing quickly before meals as indicated in trend arrows. Additionally, patients can observe effects of food choices on postmeal glucose excursions and of exercise; the association between self-management behaviors and reduced hyperglycemia is evident as early as the first week after initiating CGM.[7]

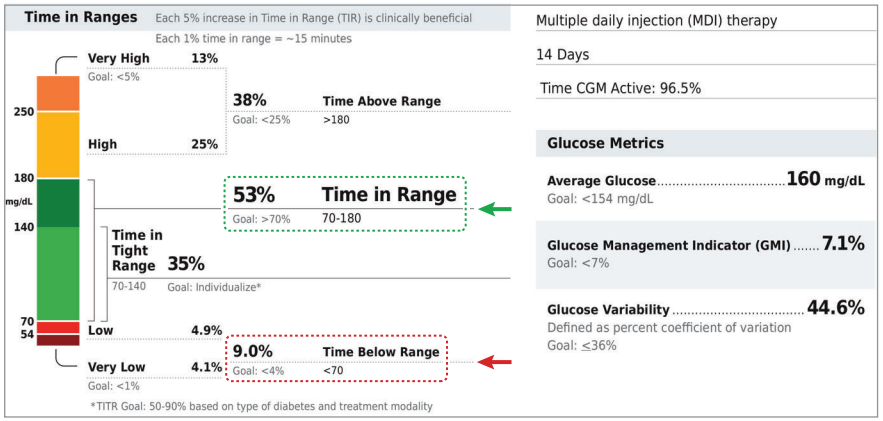
CGM Data Reports

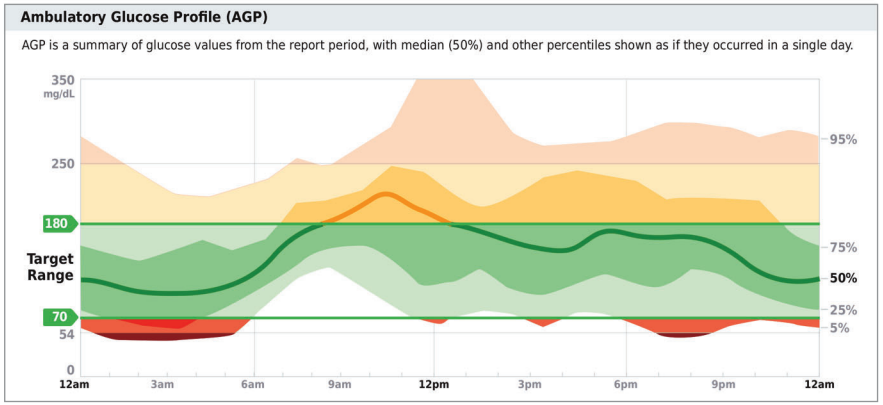
Clinicians can review CGM data in standardized reports, recommended by the ADA, that aggregate data over the prior 14 days in a single-page, 3-panel report—the Ambulatory Glucose Profile (AGP) (**Figure**). The first panel of the AGP displays the 8 core CGM metrics and their management goals as defined by an international expert consensus panel. The initial clinical assessment should evaluate whether patients are reaching goals of more than 70% time in range glucose levels of 70 to 180 mg/dL, which approximates the ADA target for HbA_{1c} of 7.0%, as well as achieving less than 4% time below range glucose levels of less than 70 mg/dL (mild but often symptomatic hypoglycemia) and less than 1% of glucose levels less than 54 mg/dL (when neuroglycopenia symptoms are likely to occur and require immediate action to prevent seizure or loss of consciousness). The middle panel is a 24-hour picture of glucose values over the past 14 days, displaying median glucose and variability of glucose values. The AGP glucose profile curve shows where the glucose values are high (yellow), low (red), or in target range (green). The third panel shows daily profiles over the 14 days. The daily views in the lower panel help identify differences in glucose control based on variable daily routines, eg, between weekends and weekdays.

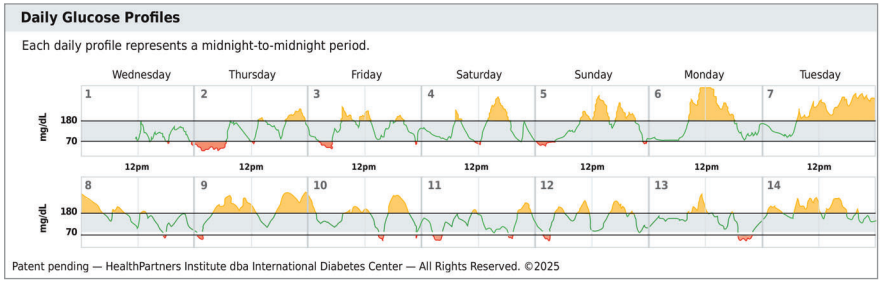
Information about glycemic patterns obtained with CGM complements HbA_{1c}, which reflects mean glycemia over the preceding 2 to 3 months but provides no information on hypoglycemia or times of day when hyperglycemia is occurring. To assist in interpreting CGM data in relation to HbA_{1c}, the AGP report includes an additional metric, the glucose management indicator, which is a transformation of CGM-measured mean glucose into HbA_{1c} units.[8] The Healthcare Effectiveness Data and Information Set allows either CGM-based glucose-management indicator or HbA_{1c} to be reported for measuring quality of glycemic management at the health care system/population level.

Even when the time-in-range target of greater than 70% is not achieved, incremental increases in time in range, if achieved without increasing hypoglycemia, can decrease risk of long-term complications. In the Diabetes Control and Complications Trial, 271 of 1440 participants (19%) developed progression of retinopathy during a 10-year period.[1] An analysis of fingerstick blood glucose data

Figure. Using Continuous Glucose Monitoring Data to Inform Type 2 Diabetes Management







Ambulatory glucose profile (AGP) report of a patient using multiple daily injections of insulin who has been unable to tolerate a GLP-1RA medication

The top panel shows that the time in range is below goal (goal >70%) and there is excessive hypoglycemia (goal <4%).

The middle and bottom panels show that the hypoglycemia is predominantly in the evening and overnight. An appropriate first step is to reduce the basal and predinner insulin doses by about 10%. Breakfast rapid-acting insulin may need to be increased but first evaluate if morning hyperglycemia was rebound hyperglycemia from nocturnal hypoglycemia.

In a few weeks repeat the AGP **Determine Where to Act** evaluation, adjusting the insulin doses, and asking the patient with diabetes what they are learning, using tools like **Know, Learn, and Act**, regarding the impact of food choices and exercise routines on staying in target glucose range.

The 3 steps of the Determine Where to Act evaluation

1 Determine if action is needed using upper panel

- Review glucose values for **time in range (70-180 mg/dL)** and **time below range (<70 mg/dL)**
  Marked by arrows and dashed boxes for illustrative purposes
- Action is needed if time in range is not >70% or time below range is not <4%

2 Determine where action is needed using middle and lower panels

- Review the AGP curve and daily glucose profiles to assess what time of day glucose values are **low (<70 mg/dL)** or **high (>180 mg/dL)**
- Assess whether there are certain days of the week (eg, weekdays vs weekends) on which glucose values are not in range

3 Act on the data to improve time in target glucose range

1. **Address any hypoglycemia (<70 mg/dL) for people who take insulin and sulfonylureas**
   - Reduce rapid-acting insulin (or basal insulin 10%-20%, if nocturnal hypoglycemia) prior to low glucose readings or reduce or stop sulfonylurea therapy, if prescribed
2. **Address hyperglycemia (time in range of 70-180 mg/dL)**
   - Consider starting or adjusting glucagon-like peptide-1 receptor agonist (GLP-1RA) or sodium-glucose cotransporter 2 (SGLT2) inhibitor therapy prior to starting insulin
   - For insulin users: if fasting glucose >130 mg/dL on awakening, increase basal insulin (by 10%-20%); if postmeal glucose values are consistently **>180 mg/dL**, add or increase prandial insulin (by 10%-20%)
3. **Ask patients to follow data** on phone or receiver to identify type and amount of food that helps avoid glucose spikes after meals to maximize time in target glucose range
4. **Follow-up contact** (2-4 wk) if medication change was made to determine need for further titration

Adapted with permission from 2025 HealthPartners Institute. Clinicians can refer to the Determine Where to Act tool and patients with diabetes can use the Know, Learn, and Act tool for additional resources.

collected in that study at 7 points over 24 hours every 3 months showed that mean (SD) time in range was 32% (15%) in the 271 participants with retinopathy progression vs 44% (15%) in the 1169 participants without retinopathy progression.[1] The adjusted hazard ratio for retinopathy progression was 1.64 (95% CI, 1.51-1.78) for each 10–percentage point decrease in time in range.[9]

Adverse Effects and Contraindications

Skin reactions can limit use of CGM in some individuals. A cross-sectional multicenter study[10] of 851 patients found self-reported skin reaction in up to 28% of patients; 3.2% of patients discontinued CGM. Skin reactions can be managed with barrier adhesives and films and other strategies. Acetaminophen, high-dose vitamin C, and hydroxyurea can interfere with glucose measurement for some sensors; manufacturer guidance should be followed as these interactions vary by sensor.

Conclusions

Individuals with diabetes who use insulin or medications that may cause hypoglycemia (eg, sulfonylurea and meglitinide classes) can benefit from CGM to guide dietary choices, exercise routines, and medication changes based on the pattern of their glucose profiles. CGM use can decrease hyperglycemia (keeping >70% of glucose readings from 70 to 180 mg/dL) and decrease hypoglycemia (keeping <4% of glucose readings <70 mg/dL) to improve both the safety and efficacy of diabetes management.

ARTICLE INFORMATION

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