Using Continuous Glucose Monitoring to Improve Outcomes for Your Patients

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The appropriate management of type 1 diabetes (T1D) requires the continuous assessment of glycemic control to facilitate self-care and titration of medications, especially insulin.[1] Glucose monitoring is also key to helping patients make decisions about diet and physical activity.[2]

Historically, glucose levels have been monitored with either a hemoglobin A1c (HbA1c) test or through self-monitoring of blood glucose (SMBG), using a blood glucose meter.[1] However, these tests are associated with certain limitations that make it difficult to truly understand an individual's level of glycemic control. Fortunately, recent advances in technology, such as the development of devices for continuous glucose monitoring (CGM), have helped overcome some of these limitations.[1] CGM use can enable patients to monitor their glucose levels more frequently, thereby allowing for a better understanding of trends in glycemic control (and specifically time spent in recommended ranges) and better glycemic management.[1,3] This publication reviews the benefits of CGM, describes the different types of available CGM devices, and provides strategies for starting and successfully using CGM.

LIMITATIONS OF THE HBA1C TEST AND SMBG

One of the main limitations of the HbA1c test is that it is an indirect measurement of blood glucose levels.[1] It measures the attachment of glucose (or glycation) to hemoglobin in red blood cells; as glucose levels increase in the blood, so, too, does the glycation of hemoglobin.[4] In addition, HbA1c values represent the long-term blood glucose average, typically over the past 2 to 3 months.[1,4] Because HbA1c reflects average blood glucose, it may not be a good indicator of how much glycemic variability a patient is experiencing.[1,4]

Because the test measures the glycation of hemoglobin, certain conditions and patient factors that influence hemoglobin glycation (and ultimately HbA1c levels) must be taken into account (Table 1).[1,4] These include conditions that modify the lifespan of red blood cells, certain medical interventions, and ethnicity.[4] For example, patients of African, Mediterranean, or Southeast Asian descent may carry a hemoglobin variant that can result in falsely high or low results.[4] Importantly, these hemoglobin variants must be considered when HbA1c levels are inconsistent with SMBG or CGM trends.[1]

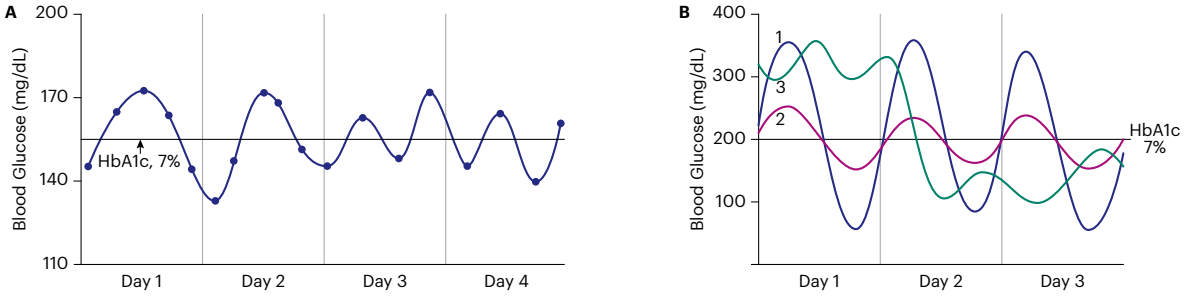
Even in the absence of these confounding factors, HbA1c may still not be a reliable indicator of the quality of glycemic control for some patients.[5] For example, a patient may experience significant glycemic variability, with frequent hypo- and hyperglycemia, and still have an HbA1c value that is consistent with "good" glycemic management (Figure 1A).[4,5] Similarly, different patients may have the same average HbA1c but very different glucose concentration patterns (Figure 1B).[6] Furthermore, HbA1c does not provide any insight into the frequency or severity of hypoglycemia.[1]

TABLE 1. Select Factors and Conditions that Can Influence HbA1c Levels

Conditions
• Recent blood loss
• Iron-deficiency anemia
• Sickle cell anemia
• Thalassemia
• G6PDH deficiency
• Pregnancy (2nd and 3rd trimesters)
• Kidney or liver failure
Medical Interventions
• Hemodialysis
• Transfusion
• HIV treatment
• Erythropoietin therapy
Hemoglobin Genetic Variants
• Those of African, Mediterranean, or Southeast Asian descent

Data derived from National Institute of Diabetes and Digestive and Kidney Diseases. The A1c test & diabetes. Last updated April 2018. www.niddk.nih.gov/health-information/diagnostic-tests/a1c-test. Accessed June 25, 2020; and American Diabetes Association. Glycemic targets: standards of medical care in diabetes—2020. *Diabetes Care*. 2020;43(Suppl 1):S66-S76.

FIGURE 1. Challenges with Using HbA1c as an Indicator of Glycemic Control



(A) Variations in blood glucose measurements compared with HbA1c measurement in a single patient over time; (B) Glycemic variability in three patients (1,2,3) who have the same mean HbA1c. Patient 1 has significant blood glucose variations on the same day, Patient 2 has small variations on the same day and on different days, and Patient 3 has significant variations on different days.

Like the HbA1c test, SMBG also has specific limitations. Although SMBG provides a snapshot or "point-in-time" measurement of blood glucose, it does not inform the patient on the direction or rate of blood glucose change and whether blood glucose levels are rising or falling.[7,8] This information is particularly important for those on insulin regimens who have a higher risk of hypoglycemia, as SMBG cannot predict drops in blood glucose levels or an imminent hypoglycemic event.[8] This scenario is especially concerning in the setting of patients with nocturnal or asymptomatic hypoglycemia.[8] SMBG also requires a fingerstick, which can reduce adherence; estimates indicate that nearly two-thirds of patients with T1D are not performing sufficient daily SMBG.[8,9]

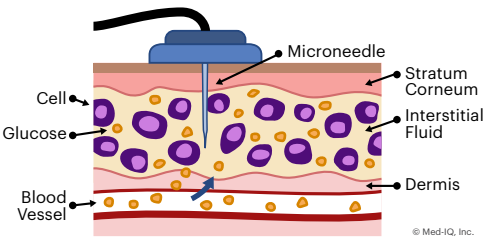
CGM

CGM systems offer additional details on glycemic trends that SMBG and HbA1c values cannot.[3,10] The first CGM system was approved by the United States Food and Drug Administration (US FDA) more than 20 years ago, and the technology has rapidly progressed since then.[11] So much so, in fact, that the American Diabetes Association (ADA) recommends that CGM be considered in all patients with T1D as an additional method to improve glucose control.[10]

CGM devices address many of the inherent limitations of HbA1c and SMBG. They monitor whether a patient's glucose is rising or falling, as well as the rate of that change.[3,8] With that information, patients can better manage glucose levels, have fewer hypoglycemic emergencies, and require fewer fingersticks.[3]

Unlike HbA1c and SMBG, which measure glucose concentrations directly in the blood, CGM devices measure glucose in the interstitial fluid using a small sensor placed under the skin (Figure 2).[3,8] The sensor measures glucose every few minutes, and a wireless transmitter then sends the data to a monitor or receiver.[3] The CGM may also be connected to an insulin pump or transmit information to a separate device, such as a smartphone application. These devices continuously record CGM data while the device is worn, including during work, exercise, and sleep.[3] Several types of CGM devices are available[10]:

FIGURE 2. CGM Illustration



- **Real-time CGM**—Measures glucose levels continuously; alerts and alarms can be set to notify the patient of rapidly changing glucose levels and/or when glucose levels are not within pre-set thresholds
- **Intermittently scanned CGM**—Measures glucose levels continuously; patient must actively engage the CGM device with a smartphone application or the reader itself to see glucose values
- **Blinded (professional) CGM**—Measures glucose levels continuously; the patient cannot see the values; these devices are usually clinic-owned and worn for up to 2 weeks to assess glycemic trends
- **Unblinded CGM**—Measures glucose levels; these values are displayed directly to the patient

In addition to monitoring glucose levels, notable common features of CGM devices include alarm notifications for hypo- and hyperglycemia, the ability to download data directly to computers or smartphones/tablets to monitor glycemic patterns, and meal, activity, and antihyperglycemic medication tracking.[3] Many devices are also able to integrate with web-based diabetes management platforms such as Glooko (www.glooko.com) and Tidepool (www.tidepool.org).[10,12] Examples of different CGM devices and their common features are provided in Table 2.[12]

TABLE 2. Key Features and Functions of Common CGM Devices

Product Name	Dexcom G6	Medtronic Guardian	Abbott FreeStyle Libre 14 Day	Abbott FreeStyle Libre 2[a]	Eversense
					
Product Type	Real-time	Real-time	Intermittently scanned	Real-time	Real-time
Warm-Up Time	2 hours	2 hours	1 hour	1 hour	24 hours
Maximum Sensor Duration	10 days	≤ 7 days	14 days	14 days	≤ 90 days
Proactive Alarms/Alerts	✓	✓	✘	✓	✓
Calibration Requirements	None	Calibrate every 12 hours; glucose levels must be between 40 and 400 mg/dL to calibrate	None	None	Calibrate every 12 hours; glucose levels must be between 40 and 400 mg/dL to calibrate
Tidepool Compatible	✓	✓	✓	Not available yet	✘
Glooko Compatible	✓	✘	Europe only	Not available yet	✓
Approved Age Range	Adults and children (≥ 2 years of age)	Adults and adolescents (≥ 14 years of age)	Adults (≥ 18 years of age)	Adults and children (≥ 4 years of age)	Adults (≥ 18 years of age)

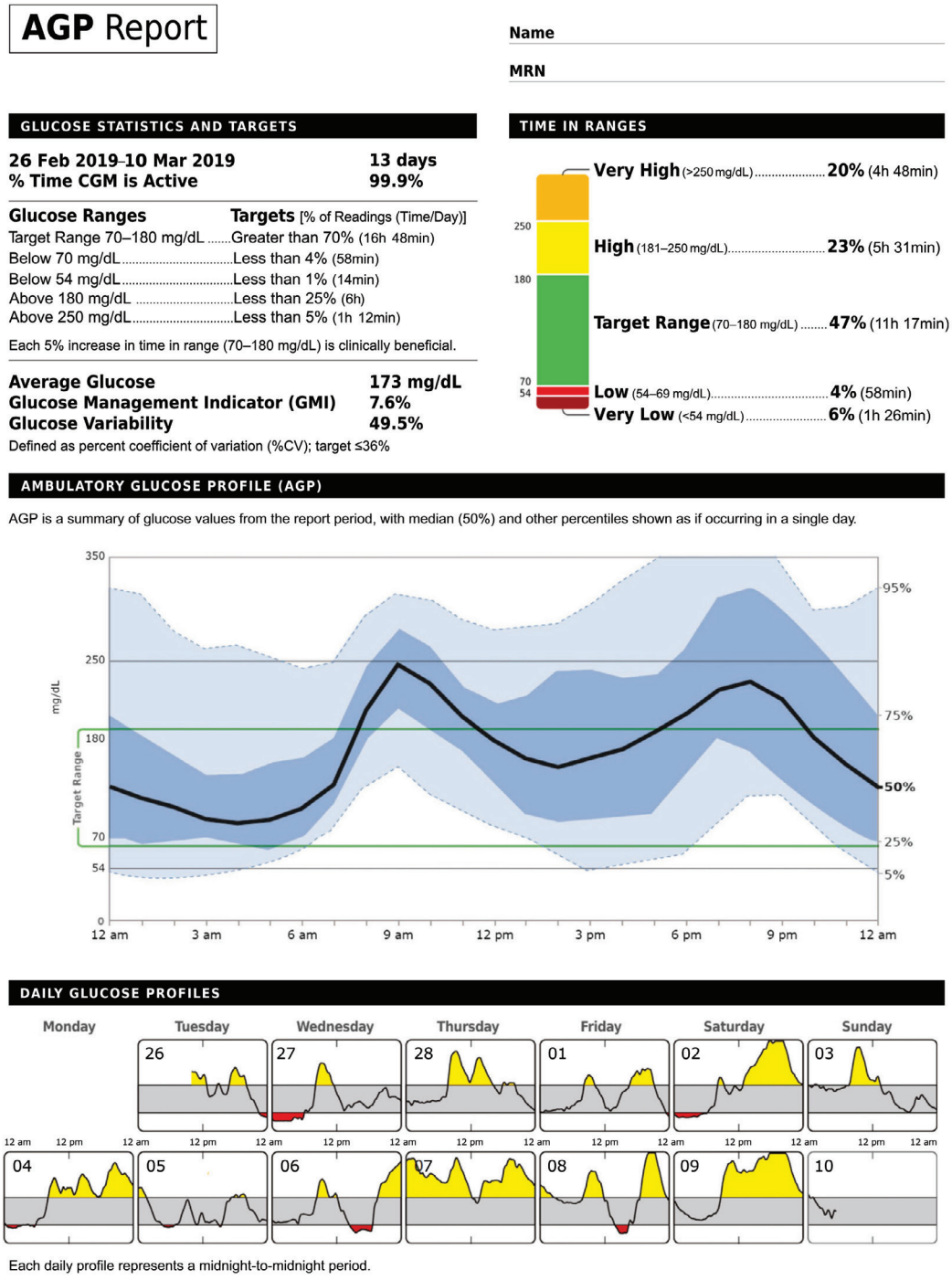
[a]This CGM device was approved by the FDA on June 15, 2020. At the time of publication, the FreeStyle Libre 2 was not available to patients, and Tidepool and Glooko compatibility information was not yet available. .

Importantly, these CGM devices and their features are not strictly a convenience. In adults with T1D, data from randomized trials have shown that the use of CGM has demonstrated significant improvements in:

- **HbA1c—**Reductions in HbA1c ranged from -0.43% to -0.6% in clinical trials with the use of real-time CGM in patients with T1D taking multiple daily injections[13,14]
- **Risk of hypoglycemia—**The use of CGM has been associated with a reduced number of hypoglycemic episodes (< 70 mg/dL), overall reduction in the rate of all levels of hypoglycemia, and reduced time spent in hypoglycemia[15,16]
- **Time in range (TIR)—**Patients with T1D who used CGM had significantly longer periods of TIR (70-180 mg/dL) than those who did not use CGM (736 min/day vs 650 min/day)[13]
- **Quality of life—**CGM can improve glycemic control and quality of life in both children and adults with T1D by enhancing treatment satisfaction, reducing the frequency of hypoglycemic episodes, and lowering the need for SMBG testing[8]

CGM offers patients and their healthcare teams additional information to help optimize diabetes management. For example, CGM data can be used to create a visual ambulatory glucose profile (AGP, Figure 3), which summarizes glucose patterns over time and identifies specific times during the day when patients are more likely to experience hypo- or hyperglycemia.[17] An overall AGP report can also identify the percentage of time spent in, above, and below target range.[17] Other metrics can also be calculated, including the glucose variability (eg, the coefficient of variation [%CV]), and the glucose management indicator, an estimated value of HbA1c.[17,18]

FIGURE 3. Sample AGP



Battelino T, Danne T, Bergenstal R, et al. Clinical targets for continuous glucose monitoring data interpretation: recommendations from the international consensus on time in range. *Diabetes Care*. 2019:42(8):1593-1603

Given that the AGP report can provide a complex output of data, it is important to understand how to best interpret the report and engage patients in shared decision making. For optimal glycemic control, healthcare teams should discuss AGP data with patients and address areas of concern.[19,20]

Finally, healthcare professionals should be mindful of the following considerations for patients who are contemplating using CGM[3,10,21]:

- Education, training, and support are required for successful CGM implementation and use
- Even when using CGM, SMBG sometimes cannot be eliminated; some devices require calibration via SMBG, and SMBG may be needed to verify any discordant readings
- For maximum benefit, real-time CGM devices should be used daily to obtain the most accurate data; intermittent devices should be scanned at least once every 8 hours

- CGM is more expensive than using a standard glucose meter
- Patients may be subject to "alarm fatigue," which occurs when they are frequently exposed to false or unnecessary alarms over time; eventually, patients may become less likely to respond to true alarms or not respond at all
- Sensors may fall off and/or patients may have skin reactions, which may prevent optimal use
- There are sometimes transmission concerns at night

ADDITIONAL RESOURCES

We hope you found this information to be a helpful summary of how CGM devices can improve outcomes for individuals with T1D. For additional information on this topic, please visit the JDRF website:

- Accredited Learning for Healthcare Professionals (www.jdrf.org/t1d-resources/hcp/)
- Type 1 Diabetes Resources and Support (www.jdrf.org/t1d-resources/)
- Interpreting AGP Data (www.agpreport.org/agp/about)

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Developed in Collaboration

Supported by an educational grant from *Abbott Diabetes Care*.