Putting Continuous Glucose Monitoring to Work for People With Type 1 Diabetes

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The recent development of reliable systems for continuously monitoring interstitial glucose levels has set the stage for a revolution in diabetes research and care. The ability to obtain real-time and summary displays of glycemic patterns of individuals with diabetes, together with rapidly obtained agreement on various definitions and ways of handling the resulting data (1,2), has led to both rapid acceptance of continuous glucose monitoring (CGM) devices and incorporation of CGM into clinical research studies.

At the clinical level, some practical and quality-of-life–related benefits of CGM are well documented (3,4). Newer systems offer improved accuracy, fewer (or no) fingersticks, and remote monitoring of potentially dangerous glycemic events. While access to and use of CGM are increasing, some important questions remain. Which groups of people with diabetes will benefit the most from CGM use? When is the best time to introduce CGM systems to diabetes care? How should use of CGM systems be taught and adjusted? What specific outcomes are most critical to improve and document? How can this technology be used most cost-effectively? All members of the diabetes community—people with diabetes themselves, caregivers of persons with diabetes, diabetes care providers, payers, and health system managers—will benefit from objective data addressing all these questions. The collection of articles presented in this issue of *Diabetes Care* offers information on some of these questions for people with type 1 diabetes.

Three reports describe CGM experiences in diverse populations. Miller et al. (5) display the recent dramatic increases in CGM use by both youth and adults with type 1 diabetes in the T1D Exchange in the U.S. (6) and the DPV (Diabetes Patienten Verlaufdocumentation) registry in Germany and Austria (7). CGM use among those <18 years old increased from <5% in 2011 to 31% in the T1D Exchange and 44% in the DPV in 2017; only slightly smaller increases were observed in adults. Prahalad et al. (8) examined the feasibility of using CGM immediately after diagnosis of type 1 diabetes in young people. After 44 individuals and their families were invited to participate in the study, 41 with mean age 9.7 years began CGM, with initiation a mean of 9 days after diagnosis. Three months later, 38 were still using the device, with a mean time in range (70–180 mg/dL) of 70%. Zhu et al. (9) studied a population of 107 youth <18 years of age with type 1 diabetes for at least 1 year; 88% were using pumps. The authors compared glycemic variability for three groups divided by pubertal status. Overall mean HbA_{1c} was 7.8% and mean time in range (70–180 mg/dL) was 45%, and these measures did not differ between the groups. However, variability as assessed by the mean SD for CGM glucose was significantly greater in the prepubertal subgroup (SD 86 mg/dL) than in the pubertal (SD 79 mg/dL) and postpubertal (SD 77 mg/dL) subgroups. These descriptive reports reflect CGM use across wide ranges of age and diabetes duration and illustrate early efforts to use CGM data to provide data on clinical practice–related concerns.

In contrast, Dovc et al. (10) used CGM to assess a pharmacodynamic outcome. They compared the CGM glycemic patterns observed during closed-loop sessions using a more rapidly absorbed faster insulin aspart to those seen using a usual insulin aspart formulation. The double-masked, randomized, crossover study enrolled 20 young adult participants who previously used pump therapy. Participants received each insulin formulation from a closed-loop dosing algorithm based on CGM values for a 27-h inpatient stay. Time in range (70–180 mg/dL) did not differ between treatment with faster aspart (53%)

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versus standard aspart (58%). However, glycemic increments after meals were slightly greater with faster insulin aspart under these conditions. These observations illustrate how CGM can provide a way to effectively measure experimental glycemic outcomes and suggest that insulin delivery algorithms in closed-loop devices will need to be refined in order to realize any potential advantages of rapidly absorbed insulins.

Two other articles report long-term study results comparing the effects of CGM versus routine self-monitoring of blood glucose (SMBG) and of delivery of insulin by pump or by multiple daily injections (MDI). Šoupal et al. (11) report a follow-up of the Comparison of Sensor Augmented Insulin Regimens (COMISAIR) study (12). The main COMISAIR protocol enrolled 65 adults with type 1 diabetes using MDI into four groups, without randomization but with efforts to match baseline characteristics. The groups were: pump therapy augmented with CGM, continued MDI with CGM, pump therapy with SMBG, and continued MDI with SMBG. After 1 year, HbA_{1c} improved more with the CGM-assisted regimens than with either insulin regimen accompanied by SMBG. The current report from COMISAIR added more participants, similarly divided into treatment groups. Eighty-eight of the 94 participants completed 3 years of follow-up. Optimal glycemic control was sustained in both groups using CGM (HbA_{1c} 6.9% with pump therapy and 7.0% with MDI). HbA_{1c} values were higher for those who used SMBG, with no differences observed between the pump therapy and MDI groups (8.0% vs. 7.7%).

Long-term follow-up from the previously completed HypoCOMPASS (Comparison of Optimised MDI versus Pumps with or without Sensors in Severe Hypoglycemia) trial was reported by Flatt et al. (13). HypoCOMPASS was a 6-month randomized, 2 × 2 factorial–design comparison of CGM with SMBG and MDI with pump therapy in 96 adults with type 1 diabetes and impaired hypoglycemia awareness. Unlike COMISAIR, where HbA_{1c} reduction was the primary end point, HypoCOMPASS sought to improve hypoglycemia awareness through meticulous glycemic management designed to minimize episodes of severe hypoglycemia. After the intervention period, the participants recovered awareness independently of the means of glucose monitoring and also the form of insulin delivery, presumably due to expert assistance with making clinical glycemic management decisions. The current report provides data from 2 years of follow-up of a subgroup of participants in the original study, of whom 61% experienced no further severe hypoglycemia. Those who did experience severe hypoglycemia again were more likely to have neuropathy and—surprisingly—greater fear of hypoglycemia but not different HbA_{1c} levels or time in range by CGM.

Finally, and of considerable interest, Oliver et al. (14) analyzed hypoglycemia and CGM data from over 300 adults with type 1 diabetes who used MDI and had participated in the completed DIAMOND (Multiple Daily Injections and Continuous Glucose Monitoring in Diabetes) and HypoDE studies. They found lower hypoglycemia risk for persons who achieved lower, in-target glucose values when real-time CGM was used compared with SMBG. This is an important observation because it supports using CGM in this older (mean age 47 years) population, which is a large proportion of all individuals with type 1 diabetes requiring basal-bolus insulin.

As a whole, these articles offer messages that support that CGM can safely and effectively be used for people with type 1 diabetes in a variety of clinical and novel research settings. CGM use is rapidly increasing, with favorable experiences for newly diagnosed children, as well as in young and older adults. The study by Oliver et al. (14), which demonstrated that CGM use can permit substantial reductions in mean daily glucose without increasing the risk of severe hypoglycemia, illustrates visually how CGM can assist in attainment of goals. The longer-term observations in the article by Flatt et al. (13) highlight that factors specific to the person with diabetes and the expertise of the diabetes care providers contribute to the success of control in ways beyond CGM use alone.

Creative ways to utilize CGM are highlighted in this special section. We expect that clinicians and investigators will continue to study how this tool contributes to care of the groups of people with type 1 diabetes with whom they work. Of course, barriers to using CGM remain. Cost and access pose substantial difficulties for many persons with type 1 diabetes, especially in resource-constrained environments. Even when CGM is clinically available, not all people with type 1 diabetes will choose to adopt it; access to constant glycemic data can be associated with burden and burnout, and the cost-to-benefit ratios for different clinical populations and for key clinically relevant outcomes remain to be directly defined.

However, we strongly believe CGM is now proving its clinical and research value. We challenge those in the diabetes community—people with diabetes, providers, and payers, in particular—to ask themselves, why isn't CGM offered and tried by most people with type 1 diabetes? Growing evidence suggests it should be accessible and used more widely.

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