The Future of Continuous Glucose Monitoring

Satish K. Garg, MD^{1,2} and Halis K. Akturk, MD^{1,2}

MORE THAN THREE decades ago, when self-monitoring of blood glucose (SMBG) was first made available, most people doubted its uptake by questioning “who, why, and when?” Debates were around about why patients would poke their fingers few times a day and moreover, what will they do with the data? Today, it is the standard of care and was successfully used in the Diabetes Complications and Control Trial especially in the intensive arm.¹ Most of the recent data from the type 1 diabetes (T1D) Exchange show increased SMBG monitoring results in better reduction of A1c in patients with T1D.²

Similar criticism surrounds continuous glucose monitoring (CGM) now. The first available retrospective CGM system was MiniMed iPro[®] (nearly two decades ago) followed by the real-time display GlucoWatch[®] in the year 2000 for 12 h using reversed iontophoresis.^{3,4} The next decade saw significant advances in CGM technologies by the Navigator (Abbott), Dexcom short-term sensor (STS), Gen 4 and 5[®], and Medtronic Enlite[®] and Guardian 3[®]. Most of the advances focused on improved accuracy where single digit mean absolute relative difference has become the standard, and in many instances, CGMs are now as accurate as SMBG.

The early adoption of CGM was slow as expected with any new technology innovation. More recent data show a rapid increase in adoption rate across the United States and Western Europe, in part, due to improved accuracy and better coverage by the payers.⁵ As the number of patients using CGM increases, one hopes that the cost will go down. In this supplement, Graham discussed the challenges in the global reimbursement of CGM.⁶ In the future, CGM data will be available (currently only Dexcom Gen 5[®]) on all mobile phones that use Bluetooth and insulin pumps without needing the data going through a receiver. Also, further advances in the technology will allow CGM to be used for 14 days without any calibration (factory calibration) or any need for an additional transmitter or receiver. After the 14-day use, the subject discards the whole CGM unit. As described by Hughes et al. in this supplement, once-daily calibrated real-time CGMs that have 10-day functional life may become available shortly.⁷

Currently, only FreeStyle Professional Libre (factory calibrated), flash glucose monitoring, is available in the US for

14 days for professional use.⁸ However, it is approved in Europe for personal use too.⁹ The flash glucose monitoring data are only available on demand and have no alarm feature. Please see the details of flash glucose monitoring in another supplement.¹⁰ It is also important to highlight that the future may see all CGM systems to be factory calibrated and data could be used to adjust insulin dose as a nonadjunctive device. Most patients do not use CGM as an adjunctive device to SMBG, and the Food and Drug Administration (FDA) recently approved Dexcom Gen 5[®] system data, which can be used as a nonadjunctive, except that it still needs calibration twice a day.¹¹ Just like all patients with new-onset T1D get an SMBG meter today, we hope in the very near future, all patients with new-onset T1D will receive CGM. Forlenza et al. also emphasized challenges of the use of CGM in children and older adults in this supplement.¹²

The availability of CGMs has highlighted the deficiencies in following diabetes care based on A1c estimations.⁵ Glucose control measured by A1c values is a snapshot of overall glucose values for the past 1–3 months. It does not detect hypoglycemia or hyperglycemia on a day-to-day basis where patients need that information on a continual basis. The availability of CGM data has allowed patients and providers to not only improve glucose control but also reduce hypoglycemia and hyperglycemia across all ranges.^{13,14} This concept is further discussed in detail by Rodbard in this supplement.¹⁵ The CGM data can be summarized as glucose ranges (time in the range 70–180 mg/dL) and time spent above and below the target. Late last year, the FDA held a meeting in Washington, DC where the discussion was about moving beyond A1c.¹⁶ We hope the future will see time in range, above target range, and below target range as important tools to quantify glucose control like A1c on a day-to-day basis. Since A1c gives only a snapshot of overall glucose control, a new composite metric for the assessment of glucose control based on CGM data is explained by Hirsch et al. in this supplement.¹⁷

Another advantage of CGM use is alerts and alarms where subjects can be alarmed for impending hypoglycemia and hyperglycemia based on the rate of change of glucose, and thus patients can act accordingly.^{18,19} Using CGM may have great

¹School of Medicine, University of Colorado Denver, Aurora, Colorado.

²Barbara Davis Center for Diabetes, Aurora, Colorado.

benefits for high-risk individuals such as pregnant patients with T1D (off-label use). Improved maternofetal outcomes are defined in detail by Polsky and Garcetti in this supplement.²⁰

Significant advances with CGM and insulin pumps have allowed CGM data to be used to drive insulin delivery.²¹ The first such system hybrid closed loop, also called as artificial pancreas by the FDA, was approved in September 2016.²² It was first made available in late March 2017 in the United States. Castle et al. highlighted the future of automated insulin delivery systems based on CGM performance, form factor, and adaptability in this supplement.²³ Since all insulin-requiring patients with diabetes will not go on to pump therapy, it is important to look into the needs of the vast majority of multiple daily injections (MDI) patients (>90%, globally). Improved outcomes in patients with T1D who use MDI with CGM are elaborated by McGill and Ahmann in this supplement.²⁴ Future research may include CGM data display on mobile devices and insulin pens. The mobile devices may have applications (Apps) for guiding patients on insulin dose.^{25,26}

We feel the future is bright for people with diabetes. We want to sincerely thank Dexcom for sponsoring this supplement, and we hope you all find this supplement useful for your clinical practice.

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Address correspondence to:

Satish K. Garg, MD

Professor of Medicine and Pediatrics

Barbara Davis Center for Diabetes

University of Colorado Denver

1775 Aurora Court, A140

Aurora, CO 80045

E-mail: satish.garg@ucdenver.edu