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Continuous Glucose Monitoring in Adolescent, Young Adult, and Older Patients With Type 1 Diabetes

Shivani Agarwal, MD, MPH, Anne R. Cappola, MD, ScM

Fleischer Institute for Diabetes and Metabolism, Division of Endocrinology, Diabetes, and Metabolism, Albert Einstein College of Medicine, Bronx, New York (Agarwal); NY-Regional Center for Diabetes and Translational Research, Albert Einstein College of Medicine, Bronx, Nork (Agarwal); Perelman School of Medicine, Division of Endocrinology, Diabetes, and Metabolism, Department of Medicine, University of Pennsylvania, Philadelphia (Cappola); Associate Editor, JAMA (Cappola).

The advent of continuous glucose monitoring (CGM) technology has revolutionized outpatient diabetes care in the past decade. A CGM device consists of a sensor that continuously measures subcutaneous glucose and sends data wirelessly to a display device through a transmitter. CGM offers real-time blood glucose monitoring (BGM) with alerts for trends in blood glucose levels and decreases the need for fingerstick glucose monitoring for people with diabetes. Studies of CGM have shown improvement in glycemic control in adults and children with type 1 diabetes and equivalence to glucometers for self-monitoring of blood glucose.^{1–3} Coupled with recent advances in CGM technology to improve accuracy and ease of use, CGM has become a vital tool for glycemic management in individuals with type 1 diabetes.

Nevertheless, CGM use remains lower than expected. A US study showed that 38% of 22 697 children, adolescents, and adults with type 1 diabetes were using CGM in 2018, with the majority of users being younger than 13 years or aged 26 to 50 years.⁴ CGM use is limited in 2 of the highest-risk populations (ie, adolescents/young adults and older adults) who could each uniquely benefit from CGM. In this issue of *JAMA*, 2 clinical trials provide important data on the efficacy of CGM in these high-risk populations with type 1 diabetes.^{5,6}

The periods of adolescence and young adulthood (13–24 y) are distinctive developmental stages marked by transition of disease self-management tasks from family to self in the midst of tumultuous change in an individual's social, geographic, financial, and health care situations.⁷ As a result, adolescents and young adults exhibit the highest hemoglobin A_{1c} (HbA_{1c}) levels and rates of hospitalization of all age groups with type 1 diabetes.^{8,9} CGM use among adolescents and young adults provides much needed real-time glycemic data to capture the frequent fluctuations in blood glucose levels inherent in this age group and offers opportunities for course correction early and often. However, rates of CGM use remain low in these age groups.

Corresponding Author: Shivani Agarwal, MD, MPH, Albert Einstein College of Medicine, 1180 Morris Park Ave, Bronx, NY 10461 (shivani.agarwal@einsteinmed.org).

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To study whether CGM could improve glycemic control in adolescents and young adults (aged 14 to 24 years), Laffel and colleagues⁵ performed a randomized clinical trial that compared the effect of CGM (n = 74) with standard BGM (n = 79) use in adolescents and young adults (mean age, 17 years) with type 1 diabetes in 14 pediatric diabetes centers across the US. The primary outcome was change in HbA_{1c} at 26 weeks. The baseline population had diverse racial/ethnic backgrounds (38% Hispanic or non-white) and high baseline HbA_{1c} levels (mean HbA_{1c}, 8.9%), consistent with current clinical trends in the US. This trial showed improvement in HbA_{1c} in the CGM group (from 8.9% at baseline to 8.5% at 26 weeks) relative to the BGM group (8.9% at baseline and 26 weeks), with an adjusted between-group difference of -0.37% (95% CI, -0.66% to -0.08%). Time in glycemic range (70–180 mg/dL) also improved significantly with CGM, although severe hypoglycemia occurred in both groups (3 participants in CGM group and 2 in BGM group). Patients reported increased satisfaction with glucose testing in the CGM group compared with the BGM group, but there were no differences in diabetes distress, hypoglycemia confidence, or sleep quality.

In this study, only 68% of participants used the CGM device for the recommended amount of time (5 d/wk) by the end of the trial, which may have attenuated the magnitude of primary outcome effects, but also may reflect realistic CGM use in this population. Nevertheless, this modest glycemic improvement is encouraging with even suboptimal use of CGM. The studied population faces challenges in improving glycemic control by any means. Moreover, the effect seen in this study is greater than or equal to effects of insulin pump use on glycemic control.¹⁰ Newer models of CGM devices that eliminate fingerstick calibration have become commercially available, which should lead to improved wearability and glycemic control even beyond the measured benefit observed in this trial. Potential long-term benefits from improved glycemic control and variability early in diabetes duration include prevention of diabetes complications later in adulthood,¹¹ making CGM an attractive option for this population.

Older adults (aged >60 y) with type 1 diabetes are at increased risk hypoglycemia unawareness due to cognitive impairment or dementia and autonomic neuropathy as a result of long diabetes duration.^{12,13} Older populations are more prone than younger populations to severe hypoglycemic episodes, which in turn contribute to dementia, risk of falls, glycemic variability, and mortality.¹⁴

To study whether CGM could reduce hypoglycemia incidence, Pratley and colleagues⁶ performed a randomized clinical trial that compared the effect of CGM (n = 103) with BGM (n = 100) in older adults (median age, 68 years) with type 1 diabetes in 22 diabetes centers across the US. The primary outcome was reduction in hypoglycemia (glucose <70 mg/dL) over 6 months. Results showed that the median time in hypoglycemia was reduced from 73 minutes to 39 minutes per day in the CGM group compared with no change (from 68 minutes to 70 minutes per day) in the BGM group, an adjusted between- group reduction of 27 minutes per day (95% CI, -40 to -16 min/d). Additionally, the median percentage of time with blood glucose levels below the range for severe hypoglycemia (glucose <54 mg/dL) reached the goal per international guidelines(<14min/d in older adults),although total time below range remained above recommended levels (glucose was <70 mg/dL for 39

minutes per day). The decrease in time with hypoglycemia occurred concomitantly with a decrease in HbA_{1c} (adjusted between-group difference, −0.3% [95% CI, −0.4% to −0.1%]). Additionally, only 1 severe hypoglycemic event (glucose <54 mg/dL) occurred in the CGM group vs 10 in the BGM group, with 5 of those events involving seizure or loss of consciousness. Results did not differ by level of cognitive impairment, education level, or age. Moreover, CGM use had no effect on cognition, hypoglycemic unawareness, or quality of life.

Although hypoglycemia rates were low at baseline in both trial groups and reduction of hypoglycemia by trial end was modest, this study suggests several key future considerations for older adults with type 1 diabetes. CGM reduced the time spent in the severe hypoglycemic range, which has health care use, mortality, morbidity, and economic benefits.¹⁵ In addition, high rates of consistent CGM wear bodes well for acceptability of more advanced CGM technologies and future artificial pancreas systems in older adults, which could have profound effects on glycemic control.

CGM technology has advanced substantially in recent years and expanded the ability to care for children and adults with type 1 diabetes. The 2 trials published in this issue of *JAMA* demonstrate the benefit of CGM to populations at high risk of complications. Together, the data support CGM as an important component of care in individuals with type 1 diabetes. However, several barriers remain for widespread use of CGM. Strict eligibility criteria set by insurance companies, especially by Medicare and Medicaid, still exist for 4 daily fingerstick checks, which may contribute to racial/ethnic and age disparities in use. State coverage for CGM varies widely and may be based on cost per CGM unit. Innovative solutions to reduce costs are needed. Patient factors likely also play a large part, necessitating more research on tailoring technology to individual needs. In addition, shortages in the endocrinology workforce and lack of training and support for primary care to implement CGM into practice limit capacity for expansion. With CGM innovation happening at a rapid pace and the imminent commercial release of artificial pancreas systems, CGM offers a new outlook for patients with type 1 diabetes and for the clinicians and communities caring for them. More effort is needed to overcome current barriers and provide better access to this beneficial technology.

REFERENCES

1. Juvenile Diabetes Research Foundation Continuous Glucose Monitoring Study Group. Effectiveness of continuous glucose monitoring in a clinical care environment: evidence from the Juvenile Diabetes Research Foundation continuous glucose monitoring (JDRF-CGM) trial. *Diabetes Care*. 2010;33(1):17–22. doi:10.2337/dc09-1502 [PubMed: 19837791]
2. Beck RW, Riddlesworth T, Ruedy K, et al.; DIAMOND Study Group. Effect of continuous glucose monitoring on glycemic control in adults with type 1 diabetes using insulin injections: the DIAMOND randomized clinical trial. *JAMA*. 2017;317(4):371–378. doi:10.1001/jama.2016.19975 [PubMed: 28118453]
3. Battelino T, Conget I, Olsen B, et al.; SWITCH Study Group. The use and efficacy of continuous glucose monitoring in type 1 diabetes treated with insulin pump therapy: a randomised controlled trial. *Diabetologia*. 2012;55:3155–3162. doi:10.1007/s00125-012-2708-9 [PubMed: 22965294]

4. Foster NC, Beck RW, Miller KM, et al. State of type 1 diabetes management and outcomes from the T1D exchange in 2016–2018. *Diabetes Technol Ther.* 2019;21(2):66–72. doi:10.1089/dia.2018.0384 [PubMed: 30657336]
5. Laffel LM, Kanapka LG, Beck RW, et al. Effect of continuous glucose monitoring on glycemic control in adolescents and young adults with type 1 diabetes: a randomized clinical trial. *JAMA.* Published 6 16, 2020. doi:10.1001/jama.2020.6940
6. Pratley RE, Kanapka LG, Rickels MR, et al. Effect of continuous glucose monitoring on hypoglycemia in older adults with type 1 diabetes: a randomized clinical trial. *JAMA.* Published 6 16, 2020. doi:10.1001/jama.2020.6928
7. Arnett JJ. Emerging adulthood: a theory of development from the late teens through the twenties. *Am Psychol.* 2000;55(5):469–480. doi:10.1037/0003-066X.55.5.469 [PubMed: 10842426]
8. Clements MA, Foster NC, Maahs DM, et al.; T1D Exchange Clinic Network. Hemoglobin A1c (HbA1c) changes over time among adolescent and young adult participants in the T1D exchange clinic registry. *Pediatr Diabetes.* 2016;17(5):327–336. doi:10.1111/pedi.12295 [PubMed: 26153338]
9. Miller KM, Foster NC, Beck RW, et al.; T1D Exchange Clinic Network. Current state of type 1 diabetes treatment in the U.S.: updated data from the T1D Exchange clinic registry. *Diabetes Care.* 2015;38(6):971–978. doi:10.2337/dc15-0078 [PubMed: 25998289]
10. Yeh H, Brown TT, Maruthur N, et al. Comparative effectiveness and safety of methods of insulin delivery and glucose monitoring for diabetes mellitus. *Ann Intern Med.* 2012;157(5):336–347. doi:10.7326/0003-4819-157-5-201209040-00508 [PubMed: 22777524]
11. Nathan DM; DCCT/EDIC Research Group. The diabetes control and complications trial/epidemiology of diabetes interventions and complications study at 30 years: overview. *Diabetes Care.* 2014;37(1):9–16. doi:10.2337/dc13-2112 [PubMed: 24356592]
12. Chiang JL, Kirkman MS, Laffel LMB, Peters AL; Type 1 Diabetes Sourcebook Authors. Type 1 diabetes through the life span: a position statement of the American Diabetes Association. *Diabetes Care.* 2014;37(7):2034–2054. doi:10.2337/dc14-1140 [PubMed: 24935775]
13. Sinclair AJ, Conroy SP, Bayer AJ. Impact of diabetes on physical function in older people. *Diabetes Care.* 2008;31(2):233–235. doi:10.2337/dc07-1784 [PubMed: 18024850]
14. Bertoni AG, Krop JS, Anderson GF, Brancati FL. Diabetes-related morbidity and mortality in a national sample of US elders. *Diabetes Care.* 2002; 25(3):471–475. doi:10.2337/diacare.25.3.471 [PubMed: 11874932]
15. Sussman M, Sierra JA, Garg S, et al. Economic impact of hypoglycemia among insulin-treated patients with diabetes. *J Med Econ.* 2016;19(11): 1099–1106. doi:10.1080/13696998.2016.1201090 [PubMed: 27292016]