Continuous Glucose Monitoring Initiation Within First Year of Type 1 Diabetes Diagnosis Is Associated With Improved Glycemic Outcomes: 7-Year Follow-Up Study

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OBJECTIVE

To evaluate long-term glycemic outcomes of continuous glucose monitoring (CGM) initiation within the first year of type 1 diabetes diagnosis.

RESEARCH DESIGN AND METHODS

Patients with type 1 diabetes (*N* = 396) were divided into three groups: *1*) CGM (CGM use within 1 year of diabetes diagnosis and continued through the study), *2*) no-CGM (no CGM use throughout the study), and *3*) new-CGM (CGM use after 3 years since diabetes diagnosis). Patients were followed up to 7 years.

RESULTS

A1c was significantly lower in the CGM compared with the no-CGM group throughout 7 years of follow-up (least squares mean A1c values: 6 months, 7.3% vs. 8.1%; 1 year, 7.4% vs. 8.6%; 2 years, 7.7% vs. 9.1%; 3 years, 7.6% vs. 9.3%; 4 years, 7.4% vs. 9.6%; 5 years, 7.6% vs. 9.7%; 6 years, 7.5% vs. 10.0%; and 7 years, 7.6% vs. 9.8%; for all, $P < 0.001$) adjusting for age at diagnosis, sex, and insulin delivery method.

CONCLUSIONS

CGM initiation within first year of type 1 diabetes diagnosis results in long-term improvement in A1c.

Continuous glucose monitoring (CGM) improves A1c and reduces hypoglycemia regardless of age, sex, and insulin delivery methods in patients with type 1 diabetes (1–4). Observational studies by our group and others have suggested that initiation of CGM soon after type 1 diabetes diagnosis is feasible and results in short-term improvements in A1c (5–8). In a previously published study by our group, we evaluated glycemic control up to 3 years among patients with type 1 diabetes who initiated CGM within the first year of type 1 diabetes diagnosis (n = 81) relative to patients who did not initiate CGM (n = 225) (6). Irrespective of insulin delivery methods, CGM users had a significantly greater improvement in glycemic control than did non-CGM users over 2.5 years of follow-up (6). To evaluate long-term

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(7 years) glycemic outcomes of early CGM initiation in patients recently diagnosed with type 1 diabetes, we followed this previously published cohort (6) for up to 7 years.

RESEARCH DESIGN AND METHODS

This is an extension of a previously published study (6). In brief, we searched electronic medical records of patients with type 1 diabetes, between 1 and 35 years of age, diagnosed between January 2013 and December 2015. Only nonpregnant patients who had at least two clinic visits per year for 3 years and had 70% of device use during the study period were included in the parent study. The details of the original study with first 3 years of follow-up are published (6) and provided in the Supplementary Appendix.

For the extension study, we collected baseline information on age, sex, ethnicity, insurance type, BMI, presence of other autoimmune disease, A1c, and CGM use (yes/no) at each visit from the onset of type 1 diabetes through a 7 year follow-up period by CGM groups. Patients who initiated CGM within the first year of diagnosis and continued using CGM through the study period were included in the CGM group, and patients who never used CGM during the study period were included in the no-CGM group. With increasing use of CGM, there were many patients who started CGM later during this ongoing observational study, so we defined the new-CGM group as patients who were not using CGM during the original study but started CGM during the extension phase. The Colorado Multiple Institutional Review Board approved the protocol under the exempt category.

The primary outcome of the study was the change in A1c over time between the CGM and no-CGM groups. The secondary outcome was the difference in A1c between the new-CGM group and the no-CGM group. A1c values at diagnosis were determined from the electronic medical record. A1c values at subsequent visits were averaged within each 6-month period through the first 3 years of the study and then annually through 7 years. Continuous data were presented as mean and SD, and categorical data were presented as a percentage. Linear mixed models were used to examine A1c levels by time points and by the three CGM groups adjusted for age, sex, insulin delivery methods, race or ethnicity, and insurance status.

RESULTS

A total of 396 patients with type 1 diabetes (n = 372 children aged $<$18 years; n = 24 adults aged $\geq$18 years) were included in this analysis and followed up to 7 years. There were no significant differences in patients' age at diagnosis (10.4 ± 7 years vs. 10.2 ± 4.7 years) and in A1c at diagnosis (11.5% ± 2.3% vs. 11.6% ± 2.3%) between the CGM and no-CGM groups. Other baseline characteristics by CGM use are shown in Supplementary Table 1. The number of participants followed over the 7 years, by the three CGM groups and insulin pump use among these participants, is provided in Supplementary Tables 2 and 3.

Mean A1c at diagnosis did not differ between groups. There was significant improvement in A1c in the CGM group at 6 months, and this was maintained throughout the 7-year follow-up period, adjusting for age at diagnosis, sex, and insulin delivery method (Fig. 1). Among patients who did not initiate CGM within the first year of type 1 diabetes diagnosis but started CGM later (i.e., the new-CGM group), there was a significant reduction in A1c after CGM initiation. However, mean A1c was higher in the new-CGM group compared with those who initiated CGM within the first year of type 1 diabetes diagnosis (Fig. 1). Results of primary outcome did not differ after adjusting for age, sex, insulin delivery methods, race or ethnicity, and insurance status (Supplementary Table 4).

CONCLUSIONS

To our knowledge, this is the first study to demonstrate improvement in A1c over 7 years with CGM initiation within first year of diabetes diagnosis in patients with type 1 diabetes. Our study findings suggest improvement in A1c regardless of CGM initiation timing. However, sustained improvement in A1c was significantly better in those who initiated CGM within the first year of diabetes diagnosis compared with CGM initiation after 3 years of type 1 diabetes. Studies have suggested that glycemic control may settle into long-term patterns within the first 5 years after diabetes diagnosis (9,10); therefore, initiating CGM early may set a better glycemic trajectory. In addition, early glycemic control may offer protection against microvascular complications (11,12).

Disparity in diabetes care and in initiation of diabetes technologies such as insulin pumps and CGM is well known (13,14). There was significant disparity in CGM initiation in our study, with more non-Hispanic White patients than people of color initiating CGM within the first year of type 1 diabetes diagnosis. CGM coverage has been expanded in the last 5 years, and government insurance such as Medicaid and Medicare is now covering CGM for people with type 1 diabetes. Thus, differences in insurance coverage may not fully explain the disparity in CGM initiation we observed between non-Hispanic Whites and people of color. In regard to higher diabetes-related morbidity and mortality rates in ethnic and minority populations (15), early initiation of CGM may have a key role in optimizing glycemic control and decreasing long-term complications.

Long-term follow-up and rigorously collected data on a large number of patients with type 1 diabetes are major strengths of this study. The single-center, retrospective study design and small sample size during the end of the study are major limitations. The possibility of selection bias in initiating CGM by providers on the basis of insurance coverage, household income, access to health care, and/or status of patients' or families' diabetes knowledge cannot be excluded. We did not collect data on differences in health care use (e.g., emergency visits for hyperglycemia or hypoglycemia) among CGM users versus nonusers. Our previous study showed significantly reduced health care use among early CGM users with type 1 diabetes (6). We also did not collect the data on the use of automated insulin delivery systems. It is possible that patients using both an insulin pump and CGM may be using an automated insulin delivery system, which may confound A1c differences between two groups. We followed patients who initiated CGM during the 2013–2015 period; CGM during that period used older-generation devices. Newer CGM devices are more accurate, smaller, and do not require finger-stick blood glucose samples for

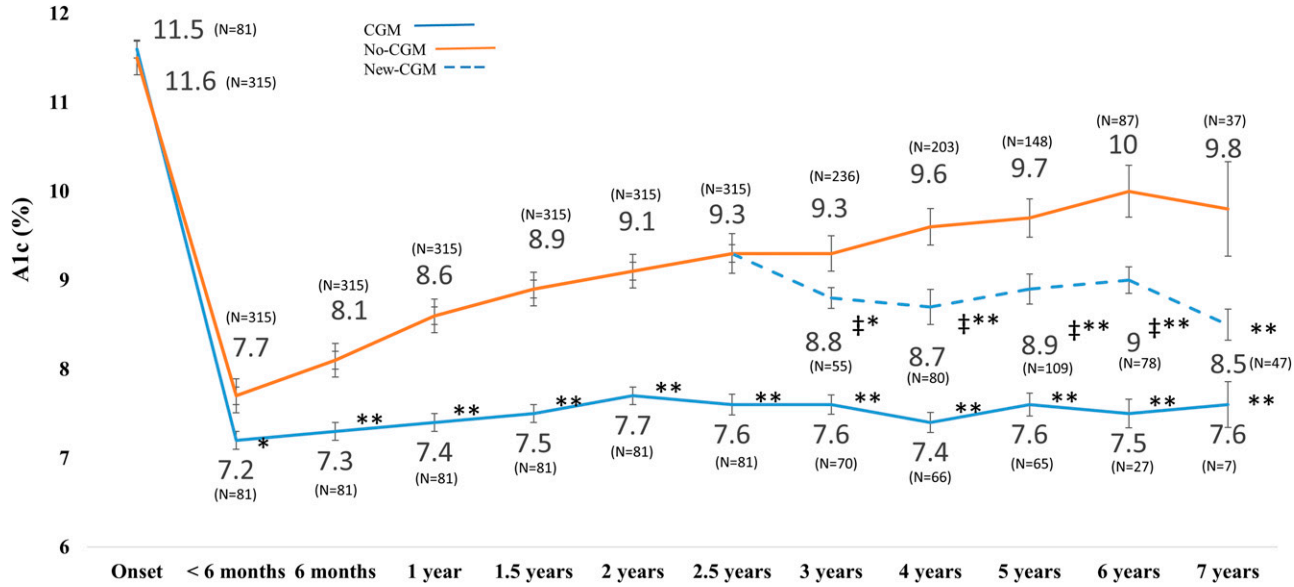

Figure 1—Change in A1c over 7 years in patients with type 1 diabetes who initiated CGM (solid blue line) compared with those who did not initiate CGM (no-CGM group; solid orange line) within the first year of diabetes diagnosis. Effect of late initiation of CGM (dotted blue line; new-CGM group) on A1c is also shown. Data presented as least square mean and standard errors adjusted for age at onset, sex, and insulin delivery method (insulin pump vs. multiple daily injections). Number in parenthesis indicates sample size. Reduced participant numbers in the CGM group (and new-CGM during year 6 and 7) due to variable length of follow-up. *$P < 0.05$, **$P < 0.001$ between CGM (or new-CGM) vs. no-CGM group, ‡$P <$ 0.001 between new-CGM vs. early CGM group.

CGM calibration and insulin dosing decisions. Therefore, we believe that findings of our study would be replicable and may show even better A1c reduction with early initiation of the newer-generation of CGM devices.

In conclusion, our study demonstrated significant improvements in A1c among CGM users compared with non-CGM users. The long-term improvement in A1c was significant with early initiation of CGM within first year of type 1 diabetes diagnosis compared with CGM initiation after 3 years since type 1 diabetes diagnosis. Therefore, CGM initiation soon after type 1 diabetes diagnosis may be a good strategy for improving glycemic outcome in people with type 1 diabetes, among whom one in every three patients does not meet the American Diabetes Association recommended glycemic targets (A1c <7%).

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References

1. 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;317:371–378
2. Lind M, Polonsky W, Hirsch IB, et al. Continuous glucose monitoring vs conventional therapy for glycemic control in adults with type 1 diabetes treated with multiple daily insulin injections: the GOLD Randomized Clinical Trial. JAMA 2017;317:379–387
3. Aleppo G, Ruedy KJ, Riddlesworth TD, et al.; REPLACE-BG Study Group. REPLACE-BG: a randomized trial comparing continuous glucose monitoring with and without routine blood glucose monitoring in adults with well-controlled type 1 diabetes. Diabetes Care 2017;40:538–545
4. Pratley RE, Kanapka LG, Rickels MR, et al.; Wireless Innovation for Seniors With Diabetes Mellitus (WISDM) Study Group. Effect of continuous glucose monitoring on hypoglycemia in older adults with type 1 diabetes: a randomized clinical trial. JAMA 2020;323:2397–2406
5. Shah VN, Gallo TL, Marker M, Snell-Bergeon JK. Glycemic control with early initiation of continuous glucose monitoring system in adults with recently diagnosed type 1A diabetes. J Diabetes Sci Technol 2018;12:228–229
6. Mulinacci G, Alonso GT, Snell-Bergeon JK, Shah VN. Glycemic outcomes with early initiation of continuous glucose monitoring system in recently diagnosed patients with type 1 diabetes. Diabetes Technol Ther 2019;21:6–10
7. Prahalad P, Addala A, Scheinker D, Hood KK, Maahs DM. CGM initiation soon after type 1 diabetes diagnosis results in sustained CGM use and wear time. Diabetes Care 2020;43:e3–e4
8. Patton SR, Noser AE, Youngkin EM, Majidi S, Clements MA. Early initiation of diabetes devices relates to improved glycemic control in children with recent-onset type 1 diabetes mellitus. Diabetes Technol Ther 2019;21:379–384
9. Patton SR, Feldman K, Majidi S, Noser A, Clements MA. Identifying HbA1c trajectories and modifiable risk factors of trajectories in 5- to 9-year-olds with recent-onset type 1 diabetes from the United States. Diabet Med 2021;38:e14637
10. Nirantharakumar K, Mohammed N, Toulis KA, Thomas GN, Narendran P. Clinically meaningful and lasting HbA_{1c} improvement rarely occurs after 5 years of type 1 diabetes: an argument for early, targeted and aggressive intervention following diagnosis. Diabetologia 2018; 61:1064–1070

11. Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Effect of intensive therapy on the microvascular complications of type 1 diabetes mellitus. JAMA 2002;287:2563–2569
12. Writing Team for the Diabetes Control and Complications Trial/Epidemiology of Diabetes Interventions and Complications Research Group. Sustained effect of intensive treatment of type 1 diabetes mellitus on development and progression of diabetic nephropathy: the Epidemiology of Diabetes Interventions and Complications (EDIC) study. JAMA 2003;290: 2159–2167
13. Agarwal S, Schechter C, Gonzalez J, Long JA. Racial-ethnic disparities in diabetes technology use among young adults with type 1 diabetes. Diabetes Technol Ther 2021;23: 306–313
14. Akturk HK, Agarwal S, Hoffecker L, Shah VN. Inequity in racial-ethnic representation in randomized controlled trials of diabetes technologies in type 1 diabetes: critical need for new standards. Diabetes Care 2021;44: e121–e123
15. Ezzatvar Y, Ramírez-Vélez R, Izquierdo M, García-Hermoso A. Racial differences in all-cause mortality and future complications among people with diabetes: a systematic review and meta-analysis of data from more than 2.4 million individuals. Diabetologia 2021;64: 2389–2401