What Do You Need to Know About Continuous Glucose Monitoring?

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Q. What is a continuous glucose monitor (CGM)?

A. CGM is a system that includes a small sensor inserted subcutaneously, typically in the arm or abdomen. It measures interstitial glucose levels, approximating plasma glucose levels. The sensor can measure glucose levels every 5 to 15 minutes, sending the information to a receiver device that displays results for the patient and health care provider to review. Most CGM devices no longer require blood glucose finger sticks for calibration and can be used alone to guide treatment decisions. Thus, CGM reduces the frequency of finger sticks, provides a more comprehensive blood glucose record, and improves patient awareness of hyperglycemia and hypoglycemia.

Q. What types of CGM devices are available?

A. The 2 types of CGMs for outpatient use are real-time CGM (rtCGM) and intermittently scanned CGM (isCGM). The rtCGM systems measure glucose levels continuously and provide the user with automated alarms and alerts at specific glucose levels. The isCGM systems measure glucose levels continuously but display glucose values only when swiped by a reader or smart phone, which reveals the glucose levels.[1]

The most recently available CGMs are listed in the Table.

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CGM should be strongly considered in adults and children with type 1 diabetes, particularly those who are not meeting glycemic targets, have hypoglycemia unawareness, and/or have frequent episodes of hypoglycemia.

Q. What types of patients would benefit from CGM?

A. Although most studies of CGM devices have been in patients with type 1 diabetes, the American Association of Clinical Endocrinology (AACE) states that rtCGM should be available to all insulin-using patients regardless of which type of diabetes they have.[2]

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Although more studies need to be done, CGM likely has benefit in other patient populations, as well. One study showed that CGM in conjunction with noninsulin medical management improved glucose control.[3] Additionally, AACE states that other patients with diabetes and who are at risk for hypoglycemia—including the older persons, persons with renal impairment, and athletes—should be considered for CGM when able. Although CGM is not yet approved in the United States specifically for pregnant patients, this population is likely to benefit as well, given the need for close glucose control and frequent monitoring.

Table. Comparison of CGMs

	FreeStyle Libre	Dexcom G6	Guardian Connect	Eversense
CGM Type	isCGM (Libre 2 system is rtCGM)	rtCGM	rtCGM	rtCGM
Duration	Combined sensor and transmitter lasts 14 days	Transmitter lasts 3 months; sensor lasts 10 days	Sensor lasts 7 days, rechargeable transmitter lasts 12 months	Combined sensor is implanted by trained provider and lasts 90 days
Finger stick calibration	No	No	Yes, approximately twice daily	No
On-body equipment	Sensor on arm	Sensor on abdomen; patients aged 2-17 years can also place on upper buttocks	Sensor on arm or abdomen	Sensor on arm
Wirelessly share reports	Yes	Yes	Yes	Yes
Smartphone app reading	Yes, Android and Apple	Yes, Android and Apple	Yes, Android and Apple	Yes, Android and Apple
Glucose alarms	Only for Libre 2 system, not for 14-day system	Yes	Yes	Yes
Approved in children	Libre 2 system, children older than 4 years of age	Children aged 2 years and older	Children older than 14 years	No, only adults older than 18 years
Mean absolute relative difference	12.3%[11]	9.8% in adults, 7.7% in children[12]	8.7% (on arm, with 2 calibrations daily)[13]	8.8%[14]

Abbreviations: CGM, continuous glucose monitor; isCGM, intermittently scanned continuous glucose monitor; rtCGM, real-time continuous glucose monitor.

Q. Does CGM improve glucose control?

A. Reductions in hemoglobin A1c levels have been observed, although results have been variable depending on adherence to the device, patient population, and baseline A1c levels.

Type 1 diabetes. Two studies assessed the benefit of rtCGM in patients with type 1 diabetes on multiple daily injections (MDI). There were reductions in A1c levels of 0.6% in the DIAMOND randomized clinical trial[4] and 0.43% in the GOLD randomized clinical trial.[5] It is important to consider that the reduction in A1c levels was observed in patients with higher A1c levels at baseline; in both studies, the average baseline A1c level was 8.6%.

Type 2 diabetes. The findings in one study with MDI alone[6] and in 2 studies in patients using oral agents with or without insulin[7,8] showed significant reductions in A1c levels ranging from 0.3% to 1%.

Q. Does CGM decrease hypoglycemia?

A. In the DIAMOND study of patients with type 1 diabetes, the median duration of hypoglycemia was 43 minutes per day in the CGM group compared with 80 minutes per day in the control group.[4] In one study of patients with impaired awareness of hypoglycemia and higher risk for episodes of hypoglycemia, the number of severe hypoglycemic events was lower (14 events vs 34 events).[9] In contrast, 2 other studies did not show a reduction in hypoglycemia.[7,8]

Despite inconsistent study results regarding lower risk of hypoglycemia with CGM, most studies of standalone CGMs (ie, CGMs not integrated with an insulin pump) have shown A1c reductions without increased risk of hypoglycemia.

Q. Who may not benefit from CGM?

A. CGMs are not yet approved specifically for persons who are pregnant, on dialysis, or critically ill. CGM is likely to provide significant benefits to these patients, but more studies are needed.

Some CGMs are approved for use in children (Table).

Q. How is CGM better than standard self-monitoring of glucose?

A. It is recommended that patients with type 1 diabetes and type 2 diabetes on MDI or insulin pump therapy assess

glucose levels using self-monitoring of blood glucose (SMBG) prior to meals, at bedtime, before exercise, and before driving. The close monitoring and work involved in managing diabetes and insulin can be challenging for patients, affecting patient adherence to therapy. CGMs are becoming more widely available to patients for the purposes of closer glucose monitoring, often without finger sticks.

The control group in most studies included conventional therapy with SMBG. In addition to improved glycemic control, the GOLD study showed that patients using CGM instead of SMBG reported improvement in overall well-being, improvement in treatment satisfaction, and less hypoglycemia fear.[5] Another study showed higher rates of glucose control and higher patient satisfaction in participants using CGM instead of traditional standard SMBG.[10]

Q. How reliable is CGM?

A. Most CGMs are compared with capillary or venous blood glucose levels, while CGM measures interstitial glucose levels. CGM reliability is typically measured by mean absolute relative difference (MARD) between CMG glucose levels and blood glucose. Reliable therapeutic decisions can be made based on CGM readings if MARD is less than 10%.

Typically, MARD is improved after the first day of wear across all CGMs. The Freestyle Libre and Dexcom G6 have shown stable MARD over the approved duration of wear for each device—14 days and 10 days, respectively.[11,12] The Guardian has also shown stable MARD; however, it does require blood glucose calibration at least twice daily. It has improved reliability when additional calibrations are done.[13] The Eversense CGM is unique in that it is an implanted sensor that remains in place for 90 days. With the exception of day 1 and day 90, this CGM has also shown stable MARD.[14]

Q. Are there any potential adverse effects or medication interactions?

A. Cutaneous adverse effects have been reported, the most common being erythema, pruritus, rash, and edema. Pain and bleeding have been reported, with low incidence of hematomas.[15] Most newer models of CGMs are not affected by acetaminophen use, with the exception of the Guardian CGM, which may show falsely elevated glucose levels in the setting of high-dose administration.[16] ■

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REFERENCES:

1. American Diabetes Association. 7. Diabetes Technology: Standards of Medical Care in Diabetes-2020. *Diabetes Care.* 2020;43(suppl 1):S77-S88. doi:10.2337/dc20-S007
2. Fonseca VA, Grunberger G, Anhalt H, et al. Continuous glucose monitoring: a consensus conference of the American Association of Clinical Endocrinologists and American College of Endocrinology. *Endocr Pract.* 2016;22(8):1008-1021. doi:10.4158/EP161392.CS
3. Cox DJ, Banton T, Moncrief M, Conaway M, Diamond A, McCall AL. Minimizing glucose excursions (GEM) with continuous glucose monitoring in type 2 diabetes: a randomized clinical trial. *J Endocr Soc.* 2020;4(11):bvaa118. doi:10.1210/jendso/bvaa118
4. 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
5. 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(4):379-387. doi:10.1001/jama.2016.19976
6. Beck RW, Riddlesworth TD, Ruedy K, et al. Continuous glucose monitoring versus usual care in patients with type 2 diabetes receiving multiple daily insulin injections: a randomized trial. *Ann Intern Med.* 2017;167(6):365-374. doi:10.7326/M16-2855
7. Ehrhardt NM, Chellappa M, Walker MS, Fonda SJ, Vigersky RA. The effect of real-time continuous glucose monitoring on glycemic control in patients with type 2 diabetes mellitus. *J Diabetes Sci Technol.* 2011;5(3):668-675. doi:10.1177/193229681100500320
8. Yoo HJ, An HG, Park SY, et al. Use of a real time continuous glucose monitoring system as a motivational device for poorly controlled type 2 diabetes. *Diabetes Res Clin Pract.* 2008;82(1):73-79. doi:10.1016/j.diabres.2008.06.015
9. van Beers CAJ, DeVries JH, Kleijer SJ, et al. Continuous glucose monitoring for patients with type 1 diabetes and impaired awareness of hypoglycaemia (IN CONTROL): a randomised, open-label, crossover trial. *Lancet Diabetes Endocrinol.* 2016;4(11):893-902. doi:10.1016/S2213-8587(16)30193-0
10. Yaron M, Roitman E, Aharon-Hananel G, et al. Effect of flash glucose monitoring technology on glycemic control and treatment satisfaction in patients with type 2 diabetes. *Diabetes Care.* 2019;42:1178-1184
11. Bailey T, Bode BW, Christiansen MP, Klaff LJ, Alva S. The Performance and usability of a factory-calibrated flash glucose monitoring system. *Diabetes Technol Ther.* 2015;17(11):787-794. doi:10.1089/dia.2014.0378
12. Shah VN, Laffel LM, Wadwa RP, Garg SK. Performance of a factory-calibrated real-time continuous glucose monitoring system utilizing an automated sensor applicator. *Diabetes Technol Ther.* 2018;20(6):428-433. doi:10.1089/dia.2018.0143
13. Christiansen MP, Garg SK, Brazg R, et al. Accuracy of a fourth-generation subcutaneous continuous glucose sensor. *Diabetes Technol Ther.* 2017;19(8):446-456. doi:10.1089/dia.2017.0087
14. Christiansen MP, Klaff LJ, Brazg R, et al. A prospective multicenter evaluation of the accuracy of a novel implanted continuous glucose sensor: PRECISE II. *Diabetes Technol Ther.* 2018;20(3):197-206. doi:10.1089/dia.2017.0142
15. Asarani NAM, Reynolds AN, Boucher SE, de Bock M, Wheeler BJ. Cutaneous complications with continuous or flash glucose monitoring use: systematic review of trials and observational studies. *J Diabetes Sci Technol.* 2020;14(2):328-337. doi:10.1177/1932296819870849
16. Guardian Sensor (3) User Guide. Medtronic. Accessed December 21, 2020. https://www.medtronicdiabetes.com/sites/default/files/library/download-library/user-guides/Guardian%20Sensor%203%20User%20Guide.pdf