Monitoring Glycemia in Diabetes

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KEYWORDS

• Glucose monitor • Self-monitored blood glucose • Continuous glucose monitoring • HbA1c

KEY POINTS

- Hemoglobin A1C (HbA1c) is the most important global measure of glucose control but must be interpreted with caution in some circumstances.
- Capillary glucose self-monitoring should be performed in patients requiring complex insulin regimens and in patients who are properly trained to interpret and use the results for adjusting therapy.
- Professional continuous glucose monitoring requires little training and may be useful for patients with type 1 or type 2 diabetes who are not meeting glucose targets.
- Personal continuous glucose monitoring may be beneficial for adults and children with type 1 diabetes who can demonstrate near-daily use. As technology advances, however, its use will likely expand.

INTRODUCTION

Monitoring of glycemia has evolved substantially since the first home glucose monitor became available in the late 1970s. Since then, monitoring of glycemic control has become an indispensable component of any diabetes therapeutic regimen, whether it consists of periodic hemoglobin A1C (HbA1c) measurement or continuous interstitial glucose monitoring. This article highlights the advantages, disadvantages, indications, and implementation of approaches for monitoring glycemia.

MARKERS OF GLUCOSE CONTROL

Hemoglobin A1c

HbA1c is a stable hemoglobin variant formed by nonenzymatic attachment of glucose to the beta chain of hemoglobin and reflects mean glycemia during the previous

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3 months. Although the average lifespan of an erythrocyte is 120 days, more recent glycemic levels contribute more to the HbA1c level.[1] The Diabetes Control and Complications Trial (DCCT) and the United Kingdom Prospective Diabetes Study demonstrated that HbA1c has strong predictive value for diabetes complications. HbA1c may be used to diagnose diabetes (cutoff point $\geq$6.5% for diagnosis) and monitor overall control 2 to 4 times per year. Point-of care testing for HbA1c is recommended to facilitate timely treatment changes.

Correlating hemoglobin A1c with average plasma glucose

The National Glycohemoglobin Standardization Program began in 1996 to standardize HbA1c results to those of the DCCT.[2] The internationalA1c-Derived Average Glucose trial[3] derived an average glucose level from HbA1c based on data from frequent self-monitored blood glucose (SMBG) and continuous glucose monitoring (CGM) in 507 adults with type 1, type 2, and no diabetes, most of whom were non-Hispanic whites (**Table 1**). There were no significant differences among racial and ethnic groups between HbA1c and mean glucose, although there was a trend among African or African American compared with non-Hispanic white groups. There are no current recommendations for different interpretations of HbA1c in these groups, although this is widely debated.[4]

Limitations of hemoglobin A1c and alternative markers of glycemia

HbA1c does not indicate the degree of glucose fluctuations or hypoglycemia and, because it only provides an estimate of average glucose levels, it cannot direct specific treatment changes targeted to any glucose pattern, particularly among patients who are receiving insulin therapy. Also, hemoglobinopathies and clinically silent hemoglobin variants, as well as disorders affecting erythrocyte turnover, may cause spurious results.[5] Inaccuracies due to hemoglobin variants may be assay-dependent, whereas those due to erythrocyte turnover are not.[6] Factors affecting HbA1c are listed in **Box 1**. HbA1c values that are inconsistent with the clinical presentation should be further investigated with SMBG or CGM. Alternative markers of glycemic control, such as fructosamine, glycated albumin, and 1,5-anhydroglucitol, may also be considered. These tests are useful for reflecting shorter term changes in glycemia or as alternate glucose markers in the setting of discrepant HbA1c and glucose testing. Longitudinal data are becoming available for their use in predicting diabetes diagnosis and complications, but the evidence for their use is not nearly as robust

Table 1
Correlation of hemoglobin A1c and estimated average glucose

	Estimated Average Glucose	
A1c (%)	**mg/dL**	**mmol/L**
6	126 (100–152)	7.0 (5.5–8.5)
7	154 (123–185)	8.6 (6.8–10.3)
8	183 (147–217)	10.2 (8.1–12.1)
9	212 (170–249)	11.8 (9.4–13.9)
10	240 (193–282)	13.4 (10.7–15.7)
11	269 (217–314)	14.9 (12.0–17.5)
12	298 (240–347)	16.5 (13.3–19.3)

Data in parentheses are 95% CIs.
Data from Refs.[3,4,57]