Can J Diabetes 42 (2018) S47–S53

Contents lists available at ScienceDirect

Canadian Journal of Diabetes

journal homepage: www.canadianjournalofdiabetes.com

2018 Clinical Practice Guidelines

Monitoring Glycemic Control

Diabetes Canada Clinical Practice Guidelines Expert Committee

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KEY MESSAGES

- Glycated hemoglobin (A1C) is a valuable indicator of glycemic treatment effectiveness and should be measured at least every 3 months when glycemic targets are not being met and when antihyperglycemic therapy is being adjusted. In some circumstances, such as when significant changes are made to therapy or during pregnancy, it is appropriate to check A1C more frequently.
- Awareness of all measures of glycemia—self-monitored blood glucose results, including self-monitored blood glucose (SMBG), flash glucose monitoring (FGM), continous glucose monitoring (CGM) and A1C—provides the best information to assess glycemic control.
- Self-monitoring of blood glucose, FGM and CGM should not be viewed as glucose-lowering interventions, but rather as aids to assess the effectiveness of glucose-lowering interventions and to prevent and detect hypoglycemia.
- Timing and frequency of SMBG may be determined individually based on the type of diabetes, the type of antihyperglycemic treatment prescribed, the need for information about blood glucose levels and the individual's capacity to use the information from testing to modify healthy behaviours or self-adjust antihyperglycemic agents.
- SMBG, FGM and CGM linked with a structured educational and therapeutic program designed to facilitate behaviour change can improve blood glucose levels and prevent hypoglycemia.

KEY MESSAGES FOR PEOPLE WITH DIABETES

- A1C is a measurement of your average blood glucose control for the last 2 to 3 months. Approximately 50% of the value comes from the last 30 days.
- You should have your A1C measured every 3 months when your blood glucose targets are not being met or when you are making changes to your diabetes management. In some circumstances, such as when significant changes are made to your glucose-lowering therapy or during pregnancy, your health-care provider may check your A1C more frequently.
- Checking your blood glucose with a glucose meter (also known as self-monitoring of blood glucose) or using a flash glucose meter or continuous glucose monitor will:
  - Determine if you have a high or low blood glucose at a given time
  - Show how your health behaviours and diabetes medication(s) affect your blood glucose levels
  - Help you and your diabetes health-care team to make health behaviour and medication changes that will improve your blood glucose levels.
- Discuss with your diabetes health-care team how often you should check your blood glucose level.

A1C Testing

Glycated hemoglobin (A1C) is a reliable estimate of mean plasma glucose (PG) levels over the previous 8 to 12 weeks (1). The mean blood glucose (BG) level in the 30 days immediately preceding the blood sampling (days 0 to 30) contributes 50% of the result and the prior 90 to 120 days contributes 10% (2,3). In uncommon circumstances, where the rate of red blood cell turnover is significantly shortened or extended, or the structure of hemoglobin is altered, A1C may not accurately reflect glycemic status (Table 1).

A1C is the preferred standard for assessing glycated hemoglobin, and laboratories are encouraged to use assay methods that are standardized to the Diabetes Control and Complications Trial (DCCT) reference (4–6). A1C is a valuable indicator of treatment effectiveness and should be measured at least every 3 months when glycemic targets are not being met and when diabetes therapy is being adjusted or changed. Testing at 6-month intervals may be considered in situations where glycemic targets are consistently achieved (4,7). In some circumstances, such as when significant changes are made to therapy, or during pregnancy, it is appropriate to check A1C more frequently (see Diabetes and Pregnancy chapter, p. S255).

A1C may also be used for the diagnosis of diabetes in adults (see Screening for Diabetes in Adults chapter, p. S16). In Canada, A1C is reported using the National Glycohemoglobin Standardization Program (NGSP) units (%). In 2007, a consensus statement from the American Diabetes Association, European Association for the Study of Diabetes and the International Diabetes Federation called for A1C reporting worldwide to change to dual reporting of A1C with the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) SI units (mmol/mol) and derived NGSP units (%) with the hope of fully converting to exclusive reporting in SI units (8). However, this has not been adopted worldwide, and both Canada and the United States still use the NGSP units (%) (9). Although there are some advantages to reporting in SI units, the most notable disadvantage is the massive education effort that would be required to ensure recognition and adoption of the new units. Canada is currently not performing dual reporting; therefore, throughout this document, A1C is still written in NGSP units (%). For those who wish to convert NGSP units to SI units, the following equation can be used: IFCC = 10.93 (NGSP) – 23.50 (10) (see Appendix 15. Glycated Hemoglobin Conversion Chart for conversion of A1C from NGSP units to IFCC SI units).

Point-of-care A1C analyzers are bench-top instruments that use a finger-prick capillary blood sample. They are designed for use in a health-care provider's office, a treatment room or at a bedside. The blood is applied to a test cartridge and the sample is analyzed

Conflict of interest statements can be found on page S51.

https://doi.org/10.1016/j.jcjd.2017.10.007

Table 1
Factors that can affect A1C

Factor	Increased A1C	Decreased A1C	Variable change in A1C
Erythropoiesis	Iron deficiency B12 deficiency Decreased erythropoiesis	Use of erythropoietin, iron or B12 Reticulocytosis Chronic liver disease	
Altered hemoglobin			Fetal hemoglobin Hemoglobinopathies Methemoglobin Genetic determinants
Altered glycation	Alcoholism Chronic renal failure Decreased erythrocyte pH	Ingestion of aspirin, vitamin C or vitamin E Hemoglobinopathies Increased erythrocyte pH	
Erythrocyte destruction	Increased erythrocyte lifespan: Splenectomy	Decreased erythrocyte lifespan: Chronic renal failure Hemoglobinopathies Splenomegaly Rheumatoid arthritis Antiretrovirals Ribavirin Dapsone	
Assays	Hyperbilirubinemia Carbamylated hemoglobin Alcoholism Large doses of aspirin Chronic opiate use	Hypertriglyceridemia	Hemoglobinopathies

A1C, glycated hemoglobin.

within several minutes (11). Point-of-care A1C testing has several potential advantages over laboratory A1C testing, including rapid test results to expedite medical decision-making, convenience for people with diabetes, potential improved health system efficiency and improved access to testing for underserved populations (12). A number of point-of-care A1C devices are commercially available for monitoring glycemic control; however, a United Kingdom systematic review concluded that evidence of the impact of using point-of-care A1C testing on medication use, clinical decision-making and participants' outcomes is lacking, and that a randomized trial with economic evaluation is needed (13). Currently, no point-of-care A1C analyzers are approved for the diagnosis of diabetes.

Several studies have shown that A1C concentrations are higher in some ethnic groups (African, Asian, Hispanic) than in Caucasian persons with similar plasma glucose concentrations (14–19). In 1 cross-sectional study, A1C was 0.13 to 0.47 percentage points higher in African American than in Caucasian persons, with the difference increasing as glucose intolerance worsened. However, all of these studies estimated mean glucose levels on the basis of very limited measurements and, as a result, it is not clear whether the higher A1C observed in certain ethnic groups is due to worse glycemic control or racial variation in the glycation of hemoglobin. If differences in A1C between ethnic groups exist, the differences appear to be small and have not been shown to significantly modify the association between A1C and cardiovascular outcomes (20), retinopathy (21) or nephropathy (22).

Self-Monitoring of Blood Glucose

Monitoring blood glucose levels, whether using traditional self monitoring of blood glucose (SMBG) devices or more recent flash glucose monitoring (FGM), can serve as a useful adjunct to other measures of glycemia, including A1C. Most people with diabetes benefit from monitoring BG for a variety of reasons (23,24). Monitoring BG is the optimal way to confirm and appropriately treat hypoglycemia. It can provide feedback on the results of healthy behaviour interventions and antihyperglycemic pharmacological treatments. It can increase one's empowerment and adherence to treatment. It can also provide information to both the person with diabetes and their diabetes health-care team to facilitate longer-term treatment modifications and titrations as well as shorter-term treatment decisions, such as insulin dosing for people with type 1 or type 2 diabetes. Finally, in situations where A1C does not accurately reflect glycemia (Table 1), monitoring BG is necessary to adequately monitor glycemia (25).

Monitoring BG is most effective when combined with an education program that incorporates instruction for people with diabetes on healthy behaviour changes in response to BG values and for health-care providers on how to adjust antihyperglycemic medications in response to BG readings (26–30). As part of this education, people with diabetes should receive instruction on how and when to perform self-monitoring; how to record the results in an organized fashion; the meaning of various BG levels and how behaviour and actions affect BG results.

Frequency of SMBG

The recommended frequency of monitoring BG may be individualized to each person's unique circumstances. Factors influencing this recommendation include type of diabetes, type of antihyperglycemic therapy, changes to antihyperglycemic therapy, adequacy of glycemic control, literacy and numeracy skills, propensity to hypoglycemia, awareness of hypoglycemia, occupational requirements and acute illness.

Type 1 and type 2 diabetes treated with insulin. For people with type 1 diabetes, monitoring BG is essential to achieving and maintaining good glycemic control. In a large cohort study, performance of ≥3 self-tests per day was associated with a statistically and clinically significant 1.0% absolute reduction in A1C (8). The evidence is less certain in people with type 2 diabetes treated with insulin, although the above principle likely applies (8). In a large, non-randomized study of individuals with stable type 2 diabetes using insulin, testing at least 3 times a day was associated with improved glycemic control (31). More frequent testing, including preprandial and 2-hour postprandial PG (31,32) and occasional overnight BG measurements,