Healthcare providers and patients with diabetes evaluate the efficacy of glycemic control by 2 strategies. One strategy involves self-monitoring of blood glucose (SMBG) by patients, with portable meters and continuous glucose monitors or sensing devices. Patients use these glucose values for daily decision-making to adjust medication doses and/or modify food intake or exercise regimens. Blood glucose fluctuates widely over minutes to hours, depending on food intake, exercise, insulin, and physical and emotional stressors. Values obtained by SMBG, therefore, do not signify average glucose (AG) concentrations. When an estimate of glucose values over time is desired, cumulative results can be downloaded from the patient’s meter in the provider’s office. These data are useful for determining whether current diabetes therapies are appropriate or need adjustment. Unfortunately, a number of barriers to blood glucose monitoring that may exist in clinical practice make it difficult to obtain an adequate amount of reliable data from patient logbooks. Barriers to SMBG implementation, as identified by patients with diabetes and their healthcare teams, include not only physical, financial, cognitive, and emotional factors, but also time constraints and inconvenience (1). In addition, patient follow-through may be lacking because of inadequate education or communication between patient and healthcare provider regarding what information is needed and why it is necessary. For this reason, it is important that hemoglobin A1c (Hb A1c) be measured regularly.

The second strategy, measurement of Hb A1c, provides a more accurate assessment of long-term glycemia than that obtained from SMBG. The concentration of Hb A1c, which consists of glucose attached to the N-terminal valine of the hemoglobin β chain, is relatively stable, given that the mean erythrocyte life span is approximately 120 days. Therefore, the Hb A1c value reflects the integrated glucose concentration over the preceding 8–12 weeks (2). Clinically, Hb A1c measurement is used to assess whether a patient’s glycemic target has been reached and maintained. It also predicts the progression of microvascular complications. Most patients, however, perceive diabetes as a disease of high sugar in the blood and fail to understand the relevance of hemoglobin. To facilitate communication with their patients, many healthcare professionals translate Hb A1c values into average plasma glucose. Tables that convert Hb A1c to AG are available in print (e.g., the Clinical Practice Recommendations published annually by the American Diabetes Association), on Web sites, in hospitals, in doctors’ offices, and frequently in the laboratory coat pockets of members of the diabetes healthcare team.

The numbers most widely used in these Hb A1c/AG conversion charts were derived from the Diabetes Control and Complications Trial (3). Notwithstanding a fairly large population (1441 individuals) and the merits of this trial, the study was confined to patients with type 1 diabetes and was not designed to measure AG. In this trial, capillary glucose data were collected and recorded only from quarterly 7-point glucose profiles over a mean of 6.5 years, for a mean of approximately 182 values per patient (4). Therefore, a prospective multinational study was performed to evaluate the relationship between Hb A1c and AG (5, 6). AG was assessed by a combination of SMBG and continuous glucose monitoring, with approximately 2700 glucose measurements obtained for each participant. The results of the study revealed a strong linear relationship between AG and Hb A1c (5). The study provided a linear regression equation that allows Hb A1c values to be converted to AG. No significant differences in the equation were observed among individuals for any characteristic, including age, race, sex, presence or absence of diabetes, type of diabetes, or ethnicity (5). Analogous to essentially all clinical studies, this study had some limitations, including an inherent limitation to accurately measure AG, the small sizes of ethnic groups, and the absence of children and pregnant women. Nevertheless, the study provides the most accurate means to date for converting Hb A1c to AG.

Several publications reveal that only 25%–35% of patients with diabetes know their Hb A1c values (7, 8).
Although an increased Hb A1c value is a good indicator of a need to advance therapy to prevent diabetes complications, healthcare professionals may feel that making therapeutic changes is their responsibility and thus spend little time explaining the Hb A1c test to patients. Yet, it is clear that a patient’s understanding of their glucose targets and actually agreeing with a therapy change are critical to long-term success (9). In simple terms, the Hb A1c concentration indicates if a change in therapy is needed, but the SMBG results determine what specific changes are most appropriate for a given patient. Although there are numerous anecdotes about communicating Hb A1c results as AG to patients, objective data are limited. Perhaps the best publication is that of a survey performed in the UK among 111 patients attending a hospital diabetes clinic (10). Patients were provided with information relating to the association between Hb A1c and AG. At the end of the approximately 7-month study, patients with poorly controlled diabetes (Hb A1c > 9%) showed a significant reduction in Hb A1c values if they were unfamiliar with Hb A1c at the initiation of the study. The magnitude of the improvement in glycemic control was greatest in those patients with the most poorly controlled diabetes. These data underscore how critical it is for patients to be educated about Hb A1c and AG, and that their understanding of these data be assessed, because AG can be a powerful tool to improve glycemic control.

Many laboratories, including several large commercial laboratories in the US, report an AG value along with the Hb A1c value. To obtain objective information regarding current reporting of AG, investigators included supplemental questions with the College of American Pathologists (CAP) GH2-A survey sent in April 2009. Of the 2997 laboratories that responded, 500 (16.7%) indicated that they report AG; however, only 202 laboratories used the correct formula to calculate AG from Hb A1c values. Although the data reflect only laboratories that participate in CAP proficiency testing, it appears that AG is fairly widely used.

In conclusion, information about the relationship between Hb A1c and estimated AG will ultimately benefit the patient’s management of diabetes. The following will facilitate this process: (a) Clinical laboratories should report an AG estimate along with Hb A1c values for those who find this information useful in guiding diabetes management; (b) it is essential that laboratories use the correct formula to calculate AG; and (c) it is important for clinical laboratorians to communicate with clinicians, diabetes educators, and other healthcare providers to enhance the care of patients with diabetes. Enhanced communication between laboratory clinicians, healthcare providers, and patients regarding the value of Hb A1c and its relationship to estimated AG will promote positive patient outcomes, as well as enhance each individual’s understanding and ability to manage his or her diabetes more effectively.

Author Contributions: All authors confirmed they have contributed to the intellectual content of this paper and have met the following 3 requirements: (a) significant contributions to the conception and design, acquisition of data, or analysis and interpretation of data; (b) drafting or revising the article for intellectual content; and (c) final approval of the published article.

Authors’ Disclosures of Potential Conflict of Interest: Upon manuscript submission, all authors completed the Disclosures of Potential Conflict of Interest form. Potential conflicts of interest:

Employment or Leadership: None declared.
Consultant or Advisory Role: R.M. Bergenstal, Eli Lilly, Novo Nordisk, Sanofi-Aventis, Abbott Laboratories, Bayer, Intuity, Roche, LifeScan, Takeda, and Valeritas.
Stock Ownership: R.M. Bergenstal, Merck.
Honoraria: D.B. Sacks, Bio-Rad.
Research Funding: R.M. Bergenstal, Eli Lilly, Novo Nordisk, Sanofi-Aventis, Takeda, Medtronic, Bayer, Amylin, Abbott Laboratories, Intarcia, MannKind, and Roche.
Expert Testimony: None declared.

Role of Sponsor: The funding organizations played no role in the design of study, choice of enrolled patients, review and interpretation of data, or preparation or approval of manuscript.

References