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# The Impact of a Color-Classified $HbA_{1c}$ Graph for Self-Monitoring and Self-Adjustment of Long-Term Glycemic Control

During the previous 4–8 wk (1,2), accumulating evidence has revealed that long-term glycemic control as expressed by $HbA_{1c}$, the value of which is closely related to the mean level of blood glucose, is closely associated with the progression of diabetic complications (3–5). Thus, $HbA_{1c}$ can serve as the most important marker for long-term glycemic control.

Some difficulties arise when teaching patients about the meaning of $HbA_{1c}$ and the relationship between $HbA_{1c}$ levels and the progression of diabetic complications. Therefore, we attempted to introduce a color-classified $HbA_{1c}$ graph in which the $HbA_{1c}$ level was color-classified according to the relative risk of the $HbA_{1c}$ level on the progression of complications. In this study, it soon became clear that the $HbA_{1c}$ graph allowed patients to visualize their $HbA_{1c}$ levels and, therefore, better understand their conditions. Thus, they were also encouraged to take some positive actions to lower their levels.

From 1989 to 1990, 108 Japanese NIDDM patients were analyzed. They completed a 6-mo follow-up before and after the graph was given without any alteration of the treatment regimen. The NIDDM patients included 48 males and 60 females with a mean age of 59.3 ± 10.2 yr, a mean diabetes duration of 8.5 ± 6.9 yr, and a mean BMI of 23.0 ± 0.3 kg/m$^2$. All patients had previously received the usual diabetes education program, which included an educational program to show the meaning and significance of $HbA_{1c}$.

$HbA_{1c}$ was assayed by HPLC on a monthly basis for 1 yr. The normal range of this assay system is 4.5–6.0%. The mean of every 3 mo was calculated and compared both before and after the graph was given.

The color-classified $HbA_{1c}$ graph was color-grouped according to the $HbA_{1c}$ level, which demonstrates the relative risk of long-term diabetic complications with an appropriate color image of the relative risk: $HbA_{1c}$ <6%, green, normal; 6–7%, yellow-green, fair; 7–8%, yellow, risky; 8–10%, red, poor; and >10%, purple, critical (Fig. 1). A monthly recording of $HbA_{1c}$ for 1 yr was possible, and monthly variations of $HbA_{1c}$ levels can be seen at a glance. One month after the graph was given, a patient questionnaire was distributed to examine the psychological and behavioral effect of the graph and to determine whether the graph contributed to an increased awareness of $HbA_{1c}$ or helped motivate patients to obtain better glycemic control.

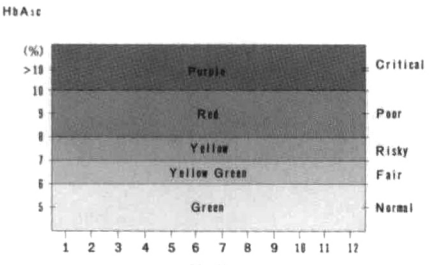


**Figure 1**—*Color-classified $HbA_{1c}$ graph. The graph was color-grouped according to the level of $HbA_{1c}$, which demonstrates the relative risk of long-term diabetic complications with an appropriate image of the relative risk: $HbA_{1c}$ <6%, green, normal; 6–7%, yellow-green, fair; 7–8%, yellow, risky; 8–10%, red, poor; and >10%, purple, critical.*

A paired Student's *t* test (BMDP 3D) was done before and after the graph was used. The degree of decrease in the $HbA_{1c}$ level was also compared by either the Wilcoxon rank-sum test or the Kruskal-Wallis test. All statistical analyses were done using the statistical package BMDP XX on an IBM system 3090 computer.

Before the graph was used, only 41% of the patients understood the importance of the $HbA_{1c}$ level, whereas the rate increased to 89% after its use. In addition, only 37% were motivated to improve their $HbA_{1c}$ level before the graph whereas the rate increased to 85% after using the graph. Consequently, the graph users showed evidence of improvement in long-term glycemic control. The improvement in $HbA_{1c}$ was observed independently irrespective of age, sex, duration of diabetes, BMI, control level, or the presence of complications. In addition, poorly controlled patients showed better improvement of $HbA_{1c}$ than fairly well-controlled patients ($P < 0.001$). Of graph users, 69% modified their behavior by either maintaining diet control, increasing exercise, or eliminating alcohol intake.

Surprisingly, ~50% of the patients did not realize the clinical significance of $HbA_{1c}$ before introducing them to the graph. The patients had been taught the meaning of $HbA_{1c}$ during the usual course of the diabetes education program and had been informed about the value of $HbA_{1c}$ during every outpatient visit. This may suggest that the patients were not sufficiently instructed in the importance of $HbA_{1c}$, even though the normal educational program had been provided. Nevertheless, after observing the color-classified $HbA_{1c}$ graph, they realized the significance of $HbA_{1c}$ as a marker of long-term glycemic control and took some action to improve their $HbA_{1c}$ levels, which resulted in an improvement of hyperglycemia. Indeed, a

change of action is generally achieved based on the perception and reflection of self action (6–8). This graph helped patients understand both the treatment goal and long-term variations of diabetes control level, which effectively enabled them to adhere to the appropriate therapeutic regimens by modifying their behavior.

The significant improvement of glycemic control was observed irrespective of age, sex, duration of diabetes, BMI, complications, or treatment regimens, indicating the evident impact of the graph among all patient groups. The Wilcoxon rank-sum test revealed that the impact of the $HbA_{1c}$ graph was stronger in younger patients and in patients with neuropathy. A greater improvement in $HbA_{1c}$ was also observed in poorly controlled patients, which suggests that poorly controlled patients are more highly motivated to improve their control levels. In addition, fairly well-controlled people were able to maintain their even control, which also suggests that this graph is useful in maintaining a good control level.

We should be careful, however, when advising patients with advanced retinal complications, because a rapid lowering of glucose levels might aggravate the retinal complications (9,10). We experienced some poorly controlled patients who, upon seeing a poor result, became depressed. Therefore, appropriate modification in the education for those patients is required to avoid a rapid progression of complications and prevent psychological depression. At least, during our study, we did not observe any rapid progression of complications.

The color-classified $HbA_{1c}$ graph is, therefore, considered useful not only for the instruction of $HbA_{1c}$ but also to motivate patients to improve their glycemic control. The color-classified $HbA_{1c}$ graph serves as a fundamental device for helping diabetic patients reach an appropriate control goal. Furthermore, similar educational strategies can potentially be applied to patients with other chronic diseases, including hypertension, hyperlipidemia, and hyperuricemia.

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NIDDM, non-insulin-dependent diabetes mellitus; BMI, body mass index; HPLC, high-performance liquid chromatography.

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## An Unsuspected Factor Contributing to Pizza Hyperglycemia

We read with interest the article by Ahern et al. (1) regarding the hyperglycemic effect of pizza in diabetic patients. This effect of pizza is a well-known phenomenon in our practice. Quite recently the father of one of our diabetic children, a 9-yr-old boy who uses an insulin infusion pump, conducted an isolated search for an explanation of this pizza-effect. This study revealed an unsuspected explanation for the post-pizza hyperglycemia: 9 of 11 pizza-makers interviewed admitted surreptitiously adding some cane sugar to the dough to give the pizza its peculiar